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Operation TEAPOT

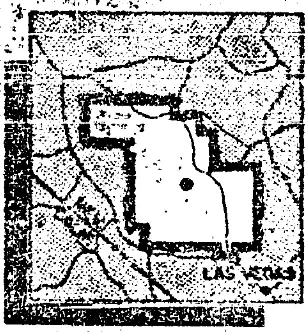
NEVADA TEST SITE

February—May 1955

Project 35.5

EFFECTS OF A NUCLEAR EXPLOSION ON RECORDS AND RECORDS STORAGE EQUIPMENT

Issuance Date: June 18, 1958



CIVIL EFFECTS TEST GROUP

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This report is published in the interest of providing information which may prove of value to the reader in his study of effects data derived principally from nuclear weapons tests.

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Oak Ridge, Tennessee

Report to the Test Director

EFFECTS OF A NUCLEAR EXPLOSION ON RECORDS AND RECORDS STORAGE EQUIPMENT

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Battle Creek, Michigan

April 1956

ABSTRACT

The objectives of Project 35.5 were to determine the effects of a nuclear explosion on various types of records and records storage equipment.

In Apple II shot, materials and storage equipment normally found in government, business, and archival institutions were placed at 11 different unshielded distances from Ground Zero in a zone where severe damage to surface structures was expected. Other records and equipment were placed within different type structures located (1) in a zone where severe damage was expected and (2) in a zone where little damage was expected.

Of 22 units of unshielded storage equipment containing records, only six units were accessible with contents intact.

The records and equipment placed within the structures were virtually undamaged. This would indicate that records housed within the type of equipment tested would survive if protected by some type of structure, except for damage resulting from debris, fire, and water. However, the best protection was afforded by the basement (below ground level) of the structures even though the upper stories collapsed and were destroyed.

PREFACE

The existence of nuclear devices able to inflict widespread damage to business records and storage facilities caused the National Records Management Council to accept the invitation of the Federal Civil Defense Administration to participate in a project that would assess the effects of nuclear explosion on business records and records storage equipment.

Business records are the memory of an organization. Preservation of important business records in a disaster can help ensure survival of managerial direction and continuity of enterprise. If essential records are available after a catastrophe, management has the information required to resume operations with minimum delay.

Management uses various types of equipment to provide orderly storage of its records and protect them against damage or loss. In evaluating nuclear effects on records, it was therefore necessary to consider effects on records storage equipment. The manufacturers of storage materials and equipment cooperated with the sponsors in setting specifications and conditions for a test of equipment.

The secondary effects of nuclear explosions, such as fire and flood, present a hazard to records and records storage and should be considered along with primary effects. The results obtained from estimating these secondary effects will be applicable to fire and floods caused by natural disasters. To provide a perspective on the entire subject of records protection, this report describes the results of Project 35.5 and their application to the natural hazards to records.

ACKNOWLEDGMENTS

The authors wish to express their sincere appreciation to the individuals and organizations who contributed to this study and report.

At the test site the project staff included:

- Robert J. Bascom, project officer, National Records Management Council, Inc.
- William J. Lloyd, Western Union Telegraph Co.
- James L. Gear, General Services Administration
- John J. Rutherford, Sperry Gyroscope Co. Division of Sperry Rand Corporation
- Carl P. Bartels, Mosler Safe Co.
- Fred J. Bremer, Mosler Safe Co.
- Arthur Barcan, National Records Management Council, Inc.

Associations and companies which cooperated in this study include:

- Safe Manufacturers National Association and its members:
  - Diebold, Inc.
  - Herring-Hall-Marvin Safe Co.
  - Mellink Steel Safe Co.
  - Mosler Safe Co.
  - Remington Rand Division of Sperry Rand Corporation
  - Shaw-Walker Co.
- Art Metal Construction Co.
- The General Fireproofing Co.
- The Paige Company
- Western Union Telegraph Co.

The excellent help of Albert H. Stevenson, Director, Program 35, Federal Civil Defense Administration, in initiating the project and participating in the report preparation is gratefully acknowledged.

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ILLUSTRATIONS (Continued)

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Chapter 1

INTRODUCTION

1.1 OBJECTIVE

The objective of Project 35.5 was to determine the effects of a nuclear explosion on records materials and records storage equipment (shielded and not shielded by buildings).

1.2 PROCEDURE

A complete variety of records storage equipment was exposed at varying ranges from Ground Zero (GZ), both inside and outside structures. All equipment contained typical records and records materials such as correspondence, paper samples, documents, microfilm, and sample telegraph messages.

1.3 PARTICIPATION

Participation was scheduled for one shot only. It was completed during Apple II shot, which had a yield approximately 50 per cent greater than nominal (a nominal atomic bomb has an energy release equivalent to 20 kilotons of TNT).

1.4 DEFINITIONS

The Federal Government, according to the Records Disposal Act of July 7, 1943, as amended (57 Stat. 380 and 59 Stat. 434), defines records as: "All books, papers, maps, photographs, or other documentary materials, regardless of physical form or characteristics, made or received by any agency of the United States Government in pursuance of Federal law or in connection with the transaction of public business and preserved or appropriate for preservation by that agency or its legitimate successor as evidence of the organization, functions, policies, decisions, procedures, operations, or other activities of the Government or because of the informational value of data contained therein."

Similar definitions have been used by several state governments and industrial firms in establishing records management programs.

A vital record is a record that contains information absolutely essential to protect the interests of stockholders, employees, and the public. Normally, vital records are those necessary to reconstruct the previous position of the organization and to permit immediate resumption of operations after a disaster.

Records storage equipment is defined as any unit or group of units designed to house any type of record material. This definition includes equipment for use in an active office area and equipment for use in a semiactive or inactive records storage area.

Chapter 2

PROJECT DESIGN AND INSTRUMENTATION

2.1 BACKGROUND

Project 35.5 was designed to obtain data about the effects of a nuclear explosion with relation to:

1. Various types of records and records materials, ranging from standard office correspondence to photographic film

2. Various types of records storage equipment, ranging from steel shelving and corrugated cardboard boxes to Class A safes

3. The degree of protection provided by the position of equipment in unshielded locations, in various types of structures, and at varying distances from GZ

2.2 PLACEMENT OF RECORDS AND EQUIPMENT

Table 2.1 summarizes the placement of records and equipment in relation to GZ and structures.

All equipment placed up to 4700 ft from GZ (and one unit at the 4700-ft line) was unshielded. All equipment at 4700 ft (with the exception noted) and beyond was shielded by structures of various types. The money chest at the 500-ft line was embedded in a concrete block. The telegraph paper (at the 1840-ft line) was placed both inside and behind the file safe. The telegraph tape (2250-ft line) was behind the file safe. The telegraph tape and Teledeltos paper at the 4700-ft line were placed both behind the safe file outside the building and inside the cardboard and aluminum-foil boxes in the basement of the brick-veneer building. The motion-picture film at the 1840-ft line was processed cellulose nitrate film in two 900-ft reels.

Figure 2.1 is a schematic representation of the placement of equipment in relation to GZ.

2.3 DATA ACCUMULATION FOR ANALYSIS

The measurement of the effects of a nuclear explosion on the records and equipment was accomplished as described in the following sections.

2.3.1 Thermal Intensity

Sensitized strips for measuring maximum temperature were inserted in selected units of equipment at distances of 500 to 4700 ft from GZ (Fig. 2.2). Evaluation was made of damage due to scorching and charring of the records, as well as of thermal mutilation of the equipment.

2.3.2 Nuclear Radiation

Dosimeters for measuring gamma radiation were placed in 41 units of equipment (Fig. 2.2). Evaluation was made of the amount of radiation entering the records storage boxes. Radiation measurements on the interior of structures was a function of Project 39.1.

TABLE 2.1—PLACEMENT OF RECORDS AND EQUIPMENT

Distance from GZ, ft	Type of record	Type of records storage equipment
500	Correspondence, microfilm, sample telegrams, and old documents	Class A safe; Class B safe; Class C safe; and money chest, OOX(c)
1050	Correspondence, microfilm, and sample telegrams	Class A safe; Class B safe; Class C safe; and money chest, OOX
1270	Correspondence, microfilm, telegraph tape, and sample telegrams	Class A safe; Class B safe; and Class C safe
1840	Motion-picture film, correspondence, microfilm, and sample telegrams	Two Class C safes; Class C insulated file safe; and money chest, OOX
2250	Correspondence, film, sample telegrams, telegraph tape, Teledeltos paper	Class A safe; Class C safe; and Class C insulated file safe
2750	Correspondence, sample telegrams, telegraph tape, and Teledeltos paper	Uninsulated file cabinet
3750	Correspondence, sample telegrams, microfilm, telegraph tape, and Teledeltos paper	Uninsulated file cabinet and Class C insulated file safe
4700	Correspondence, sample telegrams, microfilm, telegraph tape, and Teledeltos paper	Class C insulated file safe
4700 (basement of two-story frame house with brick veneer)	Correspondence, sample telegrams, microfilm, telegraph tape, Teledeltos paper, old documents, and paper samples	Insulated file cabinet, uninsulated file cabinet, microfilm cabinet, document boxes, corrugated cardboard boxes, aluminum-foil containers, and steel shelving
4700 (second floor of two-story frame house with brick veneer)		Uninsulated file cabinet
4700 (behind brick-veneered frame house)	Telegraph tape and Teledeltos paper	Corrugated cardboard boxes
4700 (one-story frame house)	Correspondence, sample telegrams, and microfilm	Insulated file cabinet, uninsulated file cabinet, and wall safe
5500 (basement of two-story frame house)	Correspondence, sample telegrams, telegraph tape, microfilm, transfer copy paper, developer, and Teledeltos paper	Class C insulated file cabinet, uninsulated file cabinet, microfilm cabinet, corrugated cardboard boxes, and wooden boxes

TABLE 2.1 — (Continued)

Distance from GZ, ft	Type of record	Type of records storage equipment
10,500 (garage of one-story precast concrete house)	Correspondence, sample telegrams, microfilm, and old documents	Steel shelving, document boxes, corrugated cardboard boxes, transfer files, insulated file cabinet, and uninsulated file cabinet
10,500 (inside one-story frame house)	Correspondence, sample telegrams, and microfilm	Wall safe, insulated file cabinet, and uninsulated file cabinet

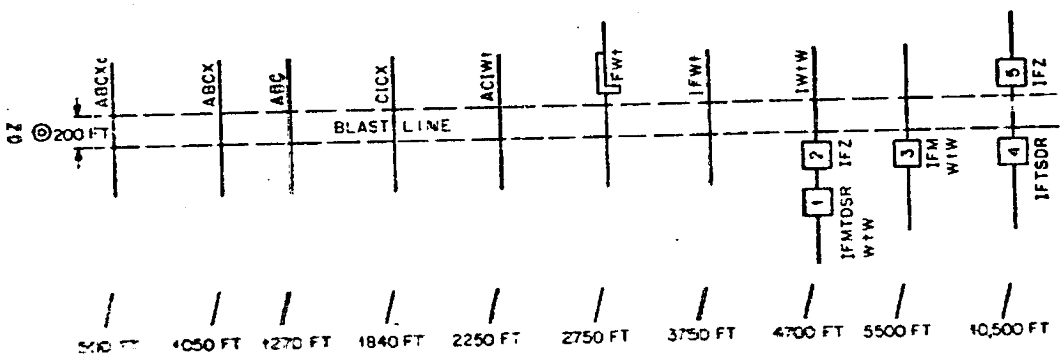

Fig. 2.1 — Schematic representation of placement of equipment.

Records storage equipment

A, Class A safe
B, Class B safe
C, Class C safe
D, Document containers (aluminum foil and standard)
F, File cabinet
I, Insulated file safe
M, Microfilm cabinet
R, Record storage boxes (1 cu ft; corrugated)
S, Steel shelving
T, Steel transfer cases
W, Telegraph paper (in cartons)
Wt, Telegraph tape (in cartons)
X, Money chest
Xc, Concrete-block money chest
Z, Wall safe

Structures

[1], Basement of two-story frame house with brick veneer
[2], One-story frame house
[3], Basement of two-story frame house
[4], Garage of one-story precast concrete
[5], One-story frame house
Concrete-block wall 60 in. high

2.3.3 Blast Pressure

Overpressures exerted on records and equipment were measured in the field. Actual pressure and distance curves were supplied by Project 39.2. Evaluation of damage due to blast pressure was made in the field.

2.3.4 Paper Analysis

Paper samples of known physical and chemical composition were placed at 4700 ft from GZ in the basement of a brick-veneered house; at 5500 ft, in the basement of a two-story frame house; and at 10,500 ft, in the garage of a precast concrete structure. Postexplosion analysis of these samples was made by the National Archives to determine the physical and chemical effects of exposure to nuclear weapons. Four types of paper were utilized: new rag, old rag, soda sulfite, and purified sulfite.

2.3.5 Telegraph Tape and Paper Analysis

Samples of oiled telegraph tape, Teledeltos paper (sensitized for facsimile use), and message blanks (some with sample messages) were exposed at varying ranges from GZ. Post-explosion analysis was conducted by the Western Union Telegraph Co. to determine the effects on both the paper and the ink normally used in telegraph operations.

2.3.6 Microfilm and Photographic Paper

Table 2.1 notes the placement of all microfilm and photographic paper contained in the equipment listed on the chart. Microfilm was placed in equipment located at all the various ranges from GZ.

2.3.7 Equipment and Records Evaluation

Evaluation of the gross effects of the nuclear device on equipment and records exposed was made as soon after the explosion as access was permitted to the varying ranges from GZ. The project staff, technical consultants, and industrial advisers assessed the damage.

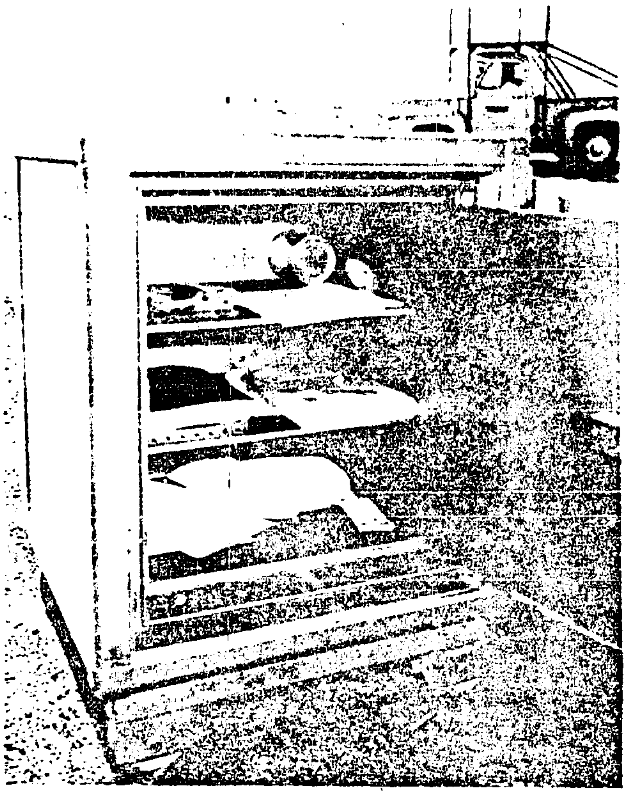

Fig. 2.2 — Dosimeter and thermal strips for interior of Class A safe 500 ft from GZ.

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Chapter 3

RESULTS OF THE TEST

3.1 GENERAL SUMMARY

The device detonated during Apple II shot had a yield approximately 50 per cent greater than nominal and was detonated from a 500-ft tower. Because of the height from which the test device was detonated, there was no crater effect at GZ.

Table 3.1 summarizes the physical effects of the blast on the records storage equipment tested.

Of the 22 units of equipment placed in the open at ranges of 500 to 4700 ft from GZ, 14 were completely destroyed by the blast. All the equipment placed at the 4700-ft line and beyond was recovered. There was no damage to the 12 units of equipment placed at the 5500- and 10,500-ft lines.

Records were recovered from one unit placed at the 1050-ft line, one at the 1840-ft line, and two at the 2250-ft line and from all units of equipment placed 2750 ft from GZ and beyond.

Cartons of telegraph paper and tape were recovered from ranges of 3750, 4700, and 5500 ft from GZ. These were returned to the Western Union Telegraph Co. for evaluation.

Paper samples were recovered at the 4700-, 5500-, and 10,500-ft lines and were sent to the National Archives for evaluation.

3.2 DETAILS OF TEST RESULTS AT DIFFERENT RANGES

A detailed picture of the physical effects of the explosion on records and records storage equipment is given in this section. For purposes of simplicity, certain ranges from GZ are grouped together.

3.2.1 Ranges of 500 and 1050 Ft

Seven of the eight units of equipment placed in the open at the 500- and 1050-ft ranges were completely destroyed (Figs. 3.1 and 3.2). Although small pieces of metal were scattered about the test site, the remains could not be identified. The contents of these seven units were not found. The eighth unit, a money chest (Fig. 3.3) was thrown about 350 ft from its original location at the 1050-ft range. The exterior was burned, and the lock dial was broken off (Fig. 3.4). A new dial was attached after the unit was returned to the manufacturer. The contents, which were in excellent condition, included a gold watch case, paper, United States postage stamps, loose microfilm, and microfilm in a sealed can.

3.2.2 Range of 1270 Ft

All three units (Class A, B, and C safes) placed at the 1270-ft range, where there was about 45 psi overpressure, were destroyed and scattered. The interior door panel of the Class B safe was discovered 700 ft from its original location. The sensitized thermal strips were intact and indicated that the interior temperature had reached more than 490°F after the detonation. None of the contents of these units were recovered.

TABLE 3.1—SUMMARY OF PHYSICAL EFFECTS OF BLAST AT DIFFERENT RANGES FROM GZ

Records storage equipment	Distances from GZ, ft 500	1050	1270	1340	2250	2750	3750	4700	5500	10,500
Class A safe	Destroyed and scattered	Destroyed and scattered	Destroyed and scattered		Damaged by missiles, usable					
Class B safe	Destroyed and scattered	Destroyed and scattered	Destroyed and scattered							
Class C safe	Destroyed and scattered	Destroyed but identified	Destroyed and scattered	(1) Blasted apart, identified (2) Blasted apart, identified	Damaged by missiles					
Insulated safe file				Destroyed and scattered	Blasted apart, identified		No damage	Damaged, usable (unshielded) No damage (basement, brick) No damage (frame rambler)	No damage (basement, two-story (frame)	No damage (frame rambler) No damage (garage, concrete)
Money chest in concrete block	Destroyed and scattered									
Money chest		Damaged		Charred, usable						
Uninsulated file cabinet						Damaged, unusable	Damaged, unusable	Damaged (frame rambler) Unusable (second floor, brick) No damage (basement, brick)	No damage (basement, two-story (frame)	No damage (frame rambler) No damage (garage, concrete)
Wall safe								No damage (frame rambler)		No damage (frame rambler)
Microfilm cabinet								No damage (basement, brick)	No damage (basement, two-story frame)	
Transfer files								No damage (basement, brick)		No damage (garage, concrete)
Steel shelving								Top shelves damaged by debris (basement, brick)		No damage (garage, concrete)
Corrugated boxes								No damage (basement, brick)		No damage (garage, concrete)
Document boxes, (1 standard and aluminum foil)								Crushed by debris (basement, brick)		No damage (garage, concrete)

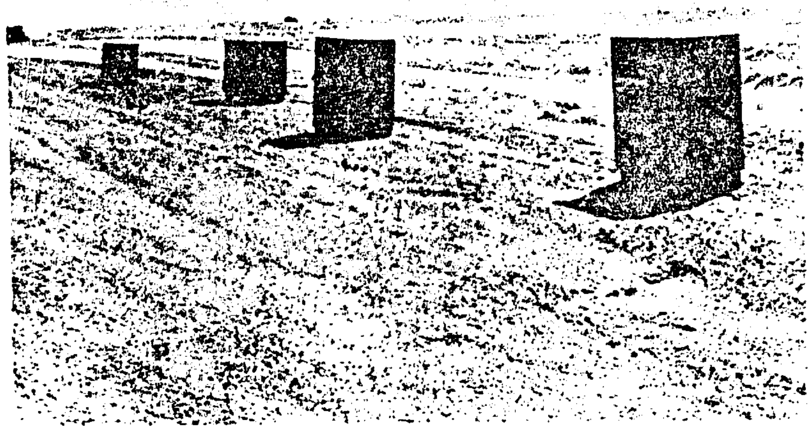


Fig. 3.1 — Placement of equipment 500 ft from GZ.

3.2.3 Range of 1840 Ft

The two Class C safes placed at the 1840-ft range were destroyed (Figs. 3.5 and 3.6). Two exterior panels were discovered 560 ft away from the original position of the units. The motion-picture film (at 1800 ft) was strewn across the desert floor. The reels were not recovered. The film was broken and cracked, and the emulsion was badly scratched; the film was determined to be unusable.

The insulated file cabinet (Fig. 3.7) was destroyed, but two side pieces and two drawer fronts were identified (Fig. 3.8). The records placed in this unit were not found.

The money chest was recovered in excellent condition, although it was charred. There was a little difficulty in working the lock, but it opened on combination without undue trouble. The contents of this unit, recovered in excellent condition, included paper, United States postage stamps, microfilm (both loose and sealed in a can), and a gold watch chain.

3.2.4 Range of 2250 Ft

The Class A and Class C safes placed at the 2250-ft range (Fig. 3.9) were found about 500 ft from their original location. The angle base and wheels of the Class A safe were missing and could not be found (Fig. 3.10). The side that had faced in the direction of the blast had two indentations in the outer steel plate penetrating into the insulation; this was probably caused by flying rocks (Fig. 3.11). The lock worked with difficulty but opened on combination.

The back of the Class C safe, which had faced the blast, was thoroughly dented from flying rock or gravel. The safe was found lying on its face. The lock opened easily.

The contents of both safes were found in good condition, although there was a good deal of dust and dirt inside each unit. An insulated file cabinet placed at this range was blasted apart. Pieces of it were identified, although none of the contents were recovered.

3.2.5 Ranges of 2750 and 3750 Ft

Two uninsulated file cabinets exposed at the 2750- and 3750-ft ranges, one behind a block wall (Fig. 3.12) and the other with an insulated file (Fig. 3.13), were so badly scorched and damaged as to be rendered unusable (Figs. 3.14 and 3.15). The overpressures, estimated at

(Text continues on page 27.)

Fig. 3.2—Debris of safes in view toward GZ.

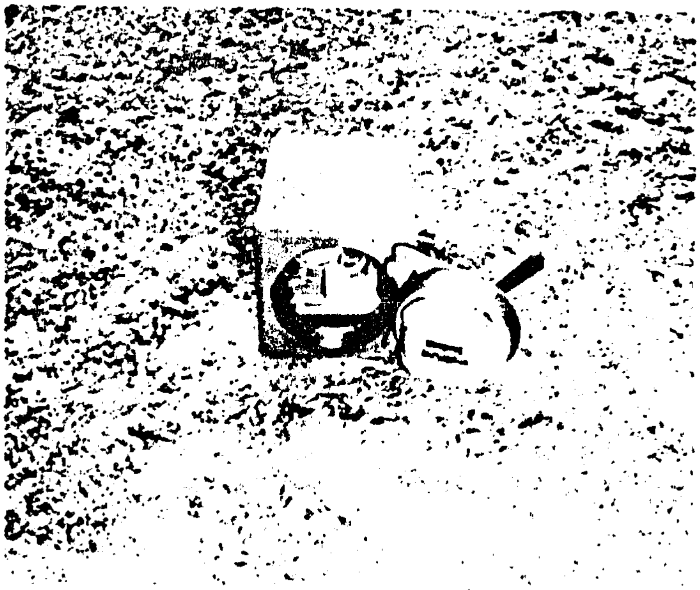


Fig. 3.3—Interior view of money chest 1050 ft from GZ.

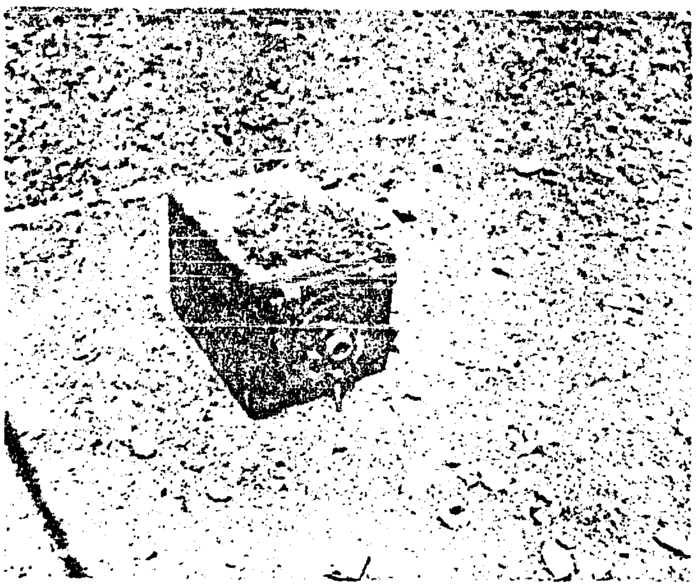


Fig. 3.4—Money chest at 1400 ft from GZ after the blast.

Fig. 3.5—Class C safe 1840 ft from GZ.

Fig. 3.6—Class C safe 560 ft from original placemeir at 1840 ft from GZ.

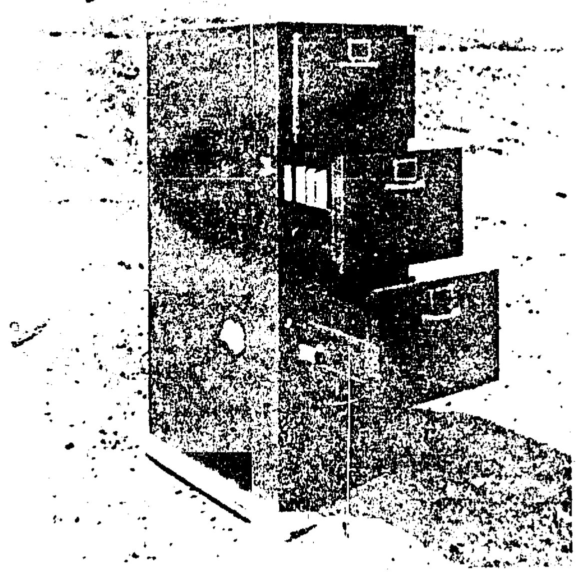


Fig. 3.7—Insulated file and contents 1840 ft from GZ.

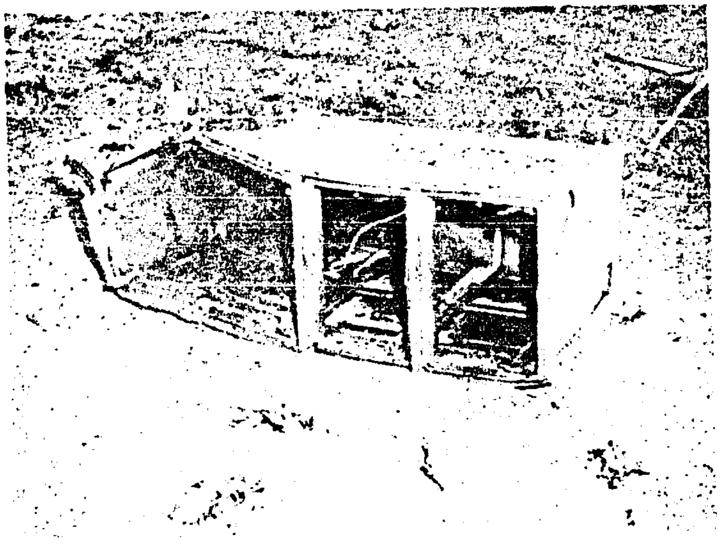


Fig. 3.8—Debris of insulated file.

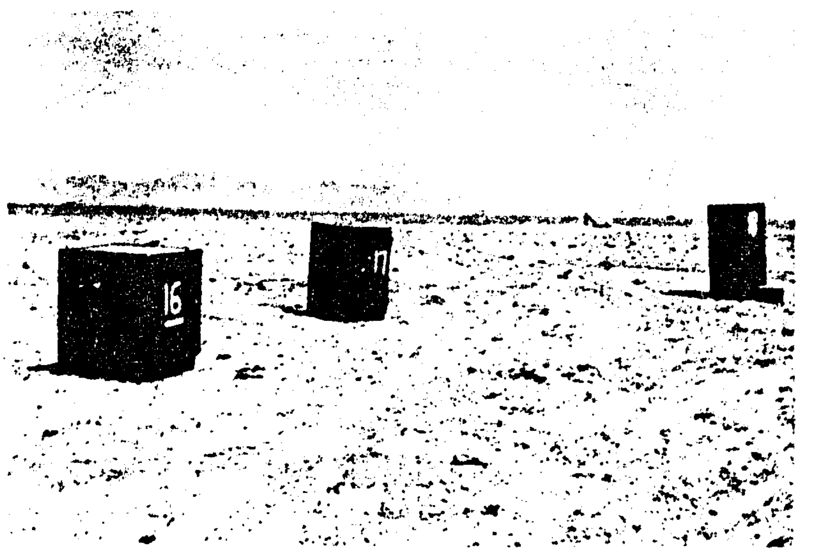


Fig. 3.9—Placement of equipment 2250 ft from GZ.

Fig. 3.10—Class A safe blown from the 2250-ft line to the 2700-ft line.

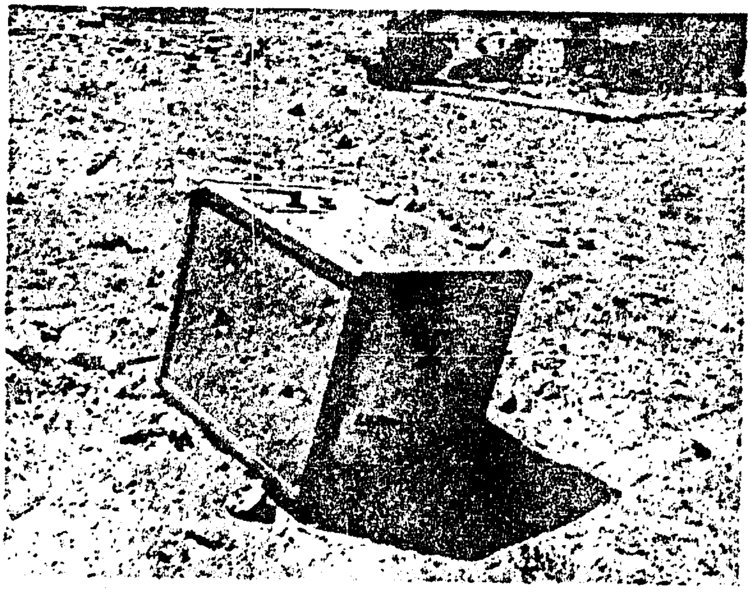


Fig. 3.11—Missile damage to Class A safe found at the 2700-ft line.

10 psi at 2750 ft and 8 psi at 3750 ft, jammed in the doors and wedged them against the frames.

The insulated file exposed at 3750 ft sustained no structural damage, and the contents were unharmed (Fig. 3.15).

3.2.6 Range of 4700 Ft

All units placed at the 4700-ft range were recovered with the records intact and in excellent condition.

An insulated file cabinet placed in the open had a 3-in. dent in the side plate of the door housing. Otherwise the unit and its contents were in excellent condition.

The uninsulated file cabinet placed on the second floor of the brick-veneer structure (Fig. 3.16) and the steel shelving unit holding the document boxes in the basement of the same structure (Fig. 3.17) were damaged by debris. The file cabinet was considered unusable. The top two shelves of the shelving unit were knocked down as the structure collapsed onto it (Figs. 3.18 and 3.19). However, all the records in these units were recovered in good condition.

The uninsulated file in the one-story frame structure was slightly damaged but was considered usable. The records in this unit sustained no damage. It is interesting to note that the wall safe in this structure sustained no damage, although the house collapsed around it. Figures 3.20 and 3.21 show the insulated file before and after the blast.

3.2.7 Ranges of 5500 and 10,500 Ft

Neither the equipment nor the records placed at the 5500- and 10,500-ft ranges sustained damage (Figs. 3.22 and 3.23).

3.3 EVALUATION OF PAPER SAMPLES

Paper samples of known physical and chemical composition were placed at three ranges from GZ (Sec. 2.3.4). All samples were recovered. It was decided to test first those samples exposed at the closest range (4700 ft). If there was extensive degradation or damage from radiation in these samples, it was planned to test those placed at the other two ranges (5500 and 10,500 ft). Since analysis showed minimal damage to the paper samples studied, it was not

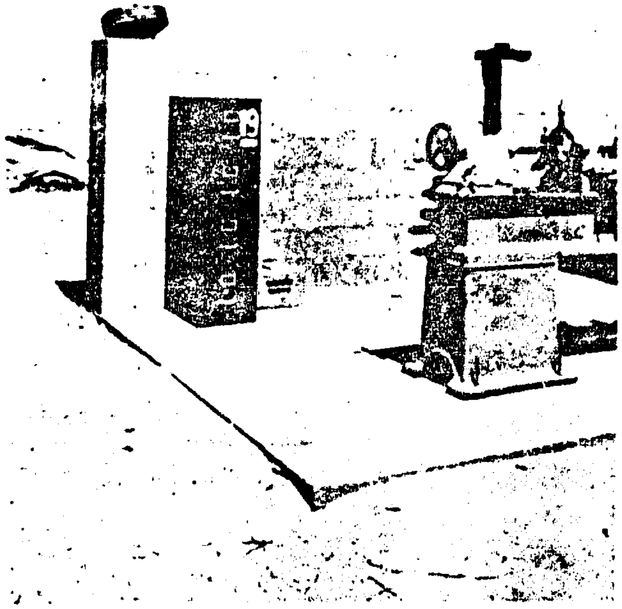


Fig. 3.12—Uninsulated file and cartons of Western Union supplies behind block wall 2750 ft from GZ.

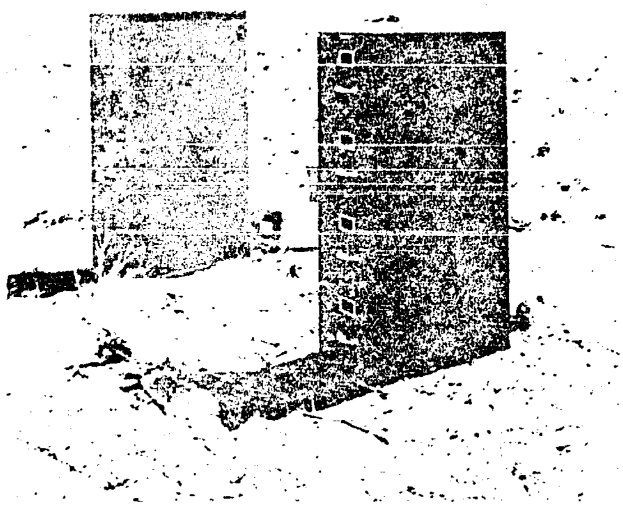


Fig. 3.13—Insulated and uninsulated files 3750 ft from GZ.

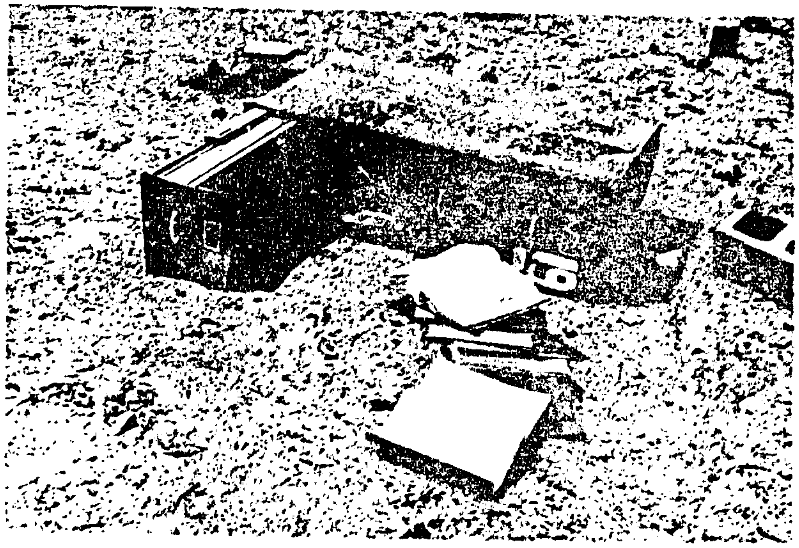


Fig. 3.14—Missile damage from block wall to uninsulated file 2750 ft from GZ.

Fig. 3.15—Scorch and damage to uninsulated file 3750 ft from GZ.

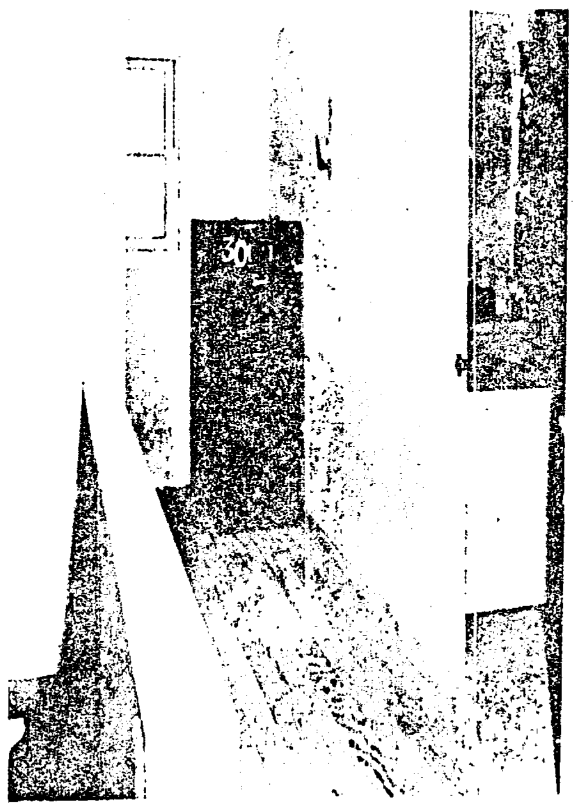


Fig. 3.16—Uninsulated file on second floor of two-story brick building 4700 ft from GZ.

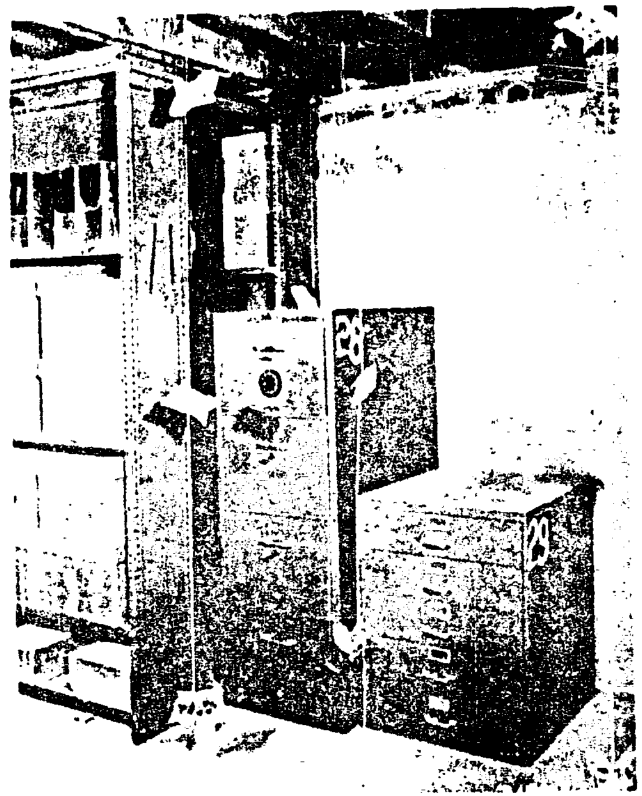


Fig. 3.17—Office and records storage equipment in basement of brick house 4700 ft from GZ.

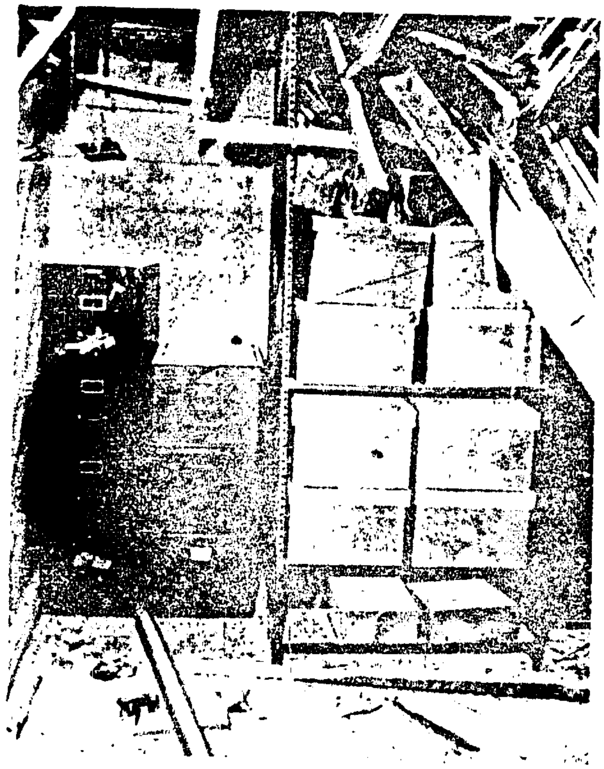


Fig. 3.18—Structure collapse on records storage equipment in basement of brick house 4700 ft from GZ.

necessary to subject all samples to analysis. The purified sulfite paper showed the greatest change, but even this was slight.

Table 3.2 shows the results of the analyses of paper samples immediately after and six months after the test.

3.4 ANALYSIS OF TELEGRAPH MATERIALS

Cartons of telegraph tape and Teledeltos paper were exposed at five ranges: 2250, 2750, 3750, 4700, and 5500 ft. Recovery of tape was made from all ranges but the closest one. Recovery of paper was made from the three most distant ranges.

Some slight radioactivity was indicated within two cartons. In one case the particle causing the radiation was $\frac{1}{16}$ in. in diameter and was spherical; it was radiating 20 mr/hr. In the other case the particle was cylindrical, $\frac{1}{16}$ in., and was radiating 16 mr/hr. Neither particle was magnetic, and both had the appearance of fused black glass. The radiation was 90 per cent beta, and the rest was gamma. The first particle came from a carton exposed at 2750 ft; the second, from a location at 3750 ft.

The recovered telegraph tape was unchanged in appearance and performed satisfactorily in standard apparatus. The Teledeltos paper was also unchanged and performed satisfactorily in machines for which it was designed. These samples were tested under actual operating conditions by the Western Union Telegraph Co.

3.5 MICROFILM AND PHOTOGRAPHIC PAPER

Microfilm was recovered in usable condition from two money chests located 1050 and 1840 ft from GZ. All microfilm and photographic paper placed in equipment as noted in Table

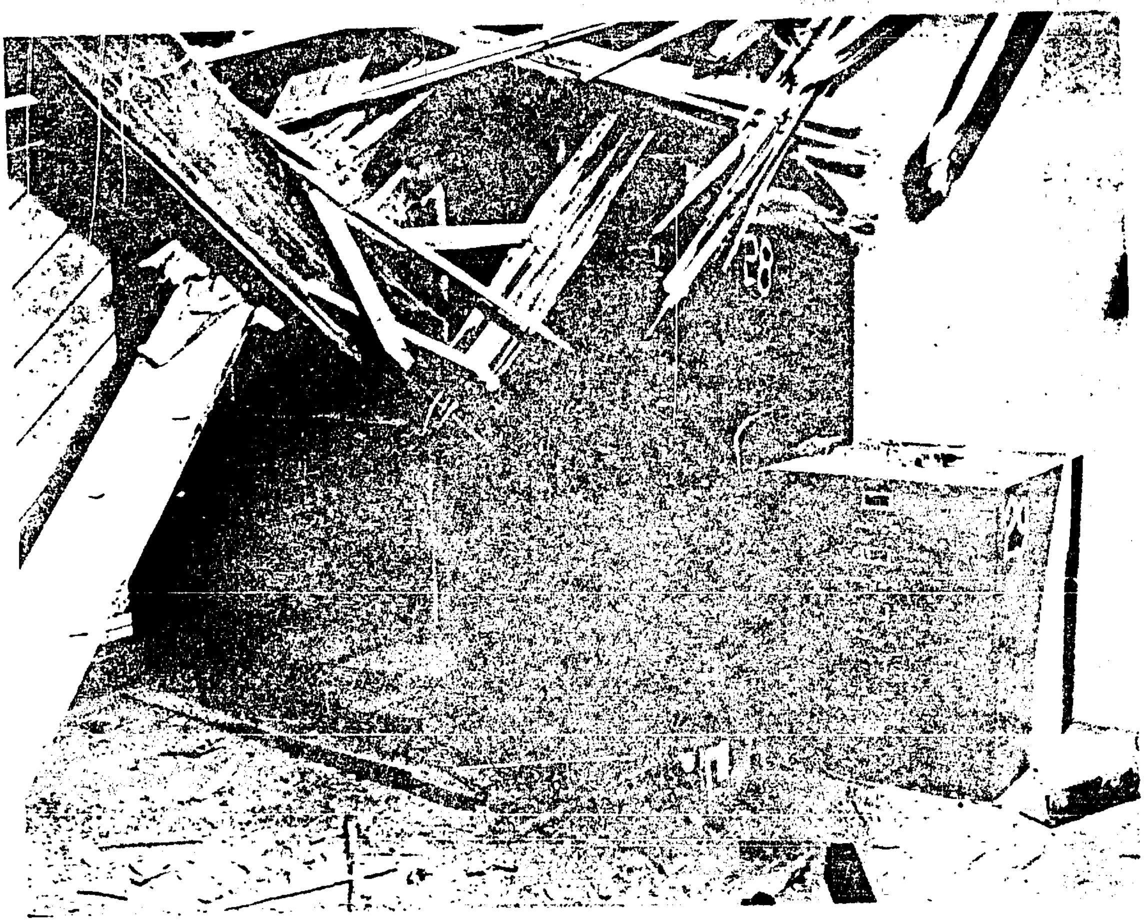


Fig. 3.19—Debris load in basement of brick house 4700 ft from GZ.

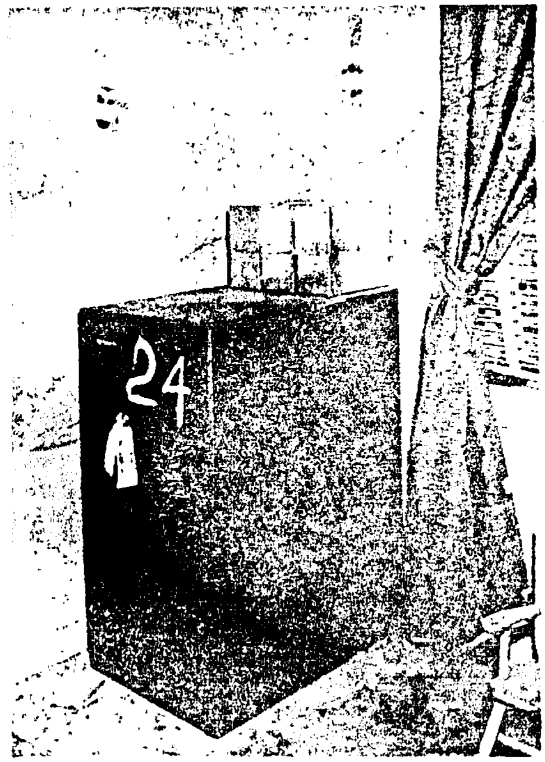
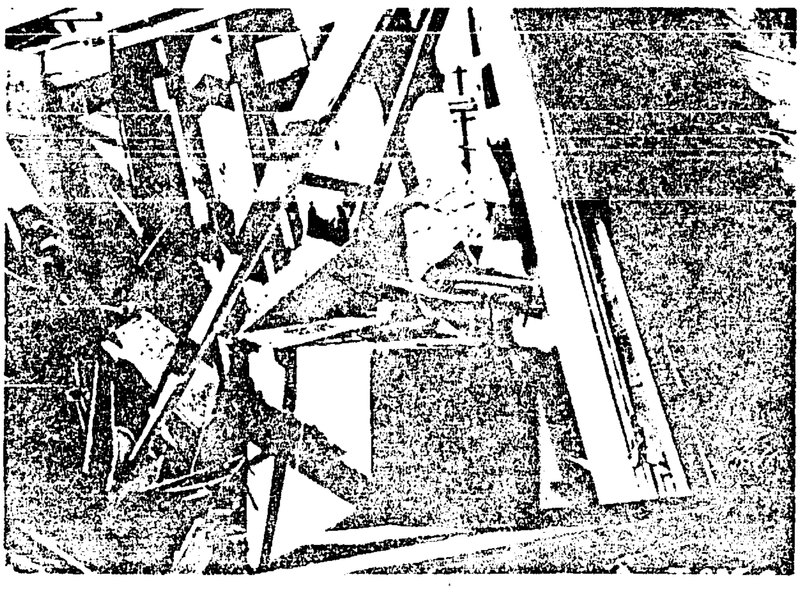


Fig. 3.20—Insulated file in bedroom of frame rambler 4700 ft from GZ.



3.21—Insulated file covered with debris in frame rambler 4700 ft from GZ after the blast.

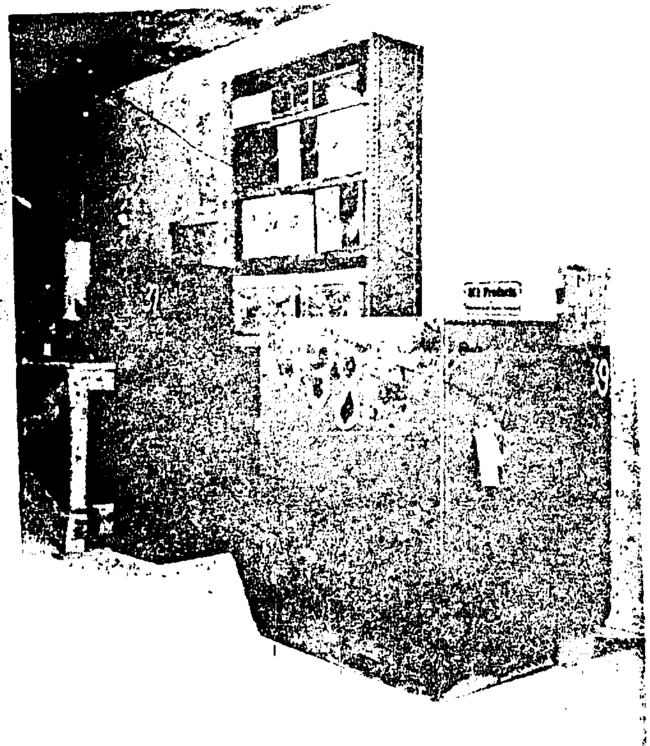


Fig. 3.22—Records storage equipment in garage of precast concrete house 10,500 ft from GZ.

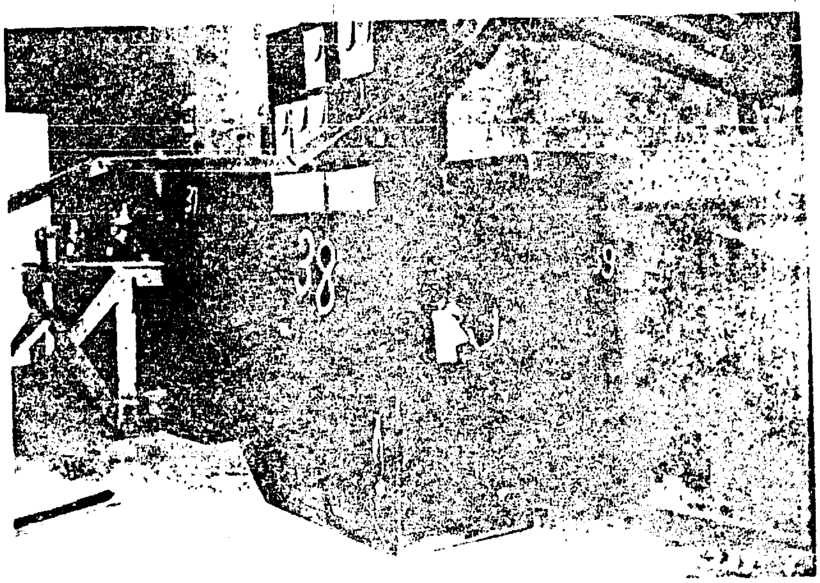


Fig. 3.23—Records storage equipment in garage of concrete building 10,500 ft from GZ after the explosion.

2.1 and later recovered was determined to be in usable condition. This included exposed and unexposed film and exposed and unexposed photographic paper. All microfilm and photographic paper which was recovered showed no indication of the effects of radiation. All samples of film and photographic paper recovered and returned for laboratory tests to the Remington Rand Division of the Sperry Rand Corporation were found to be in usable condition.

TABLE 3.2—EFFECT OF IRRADIATION ON THE DEGREE OF POLYMERIZATION OF PAPER

Type of paper	Sample No.*	Filler	Viscosity† Absolute	Viscosity† Relative	Fluidity reciprocal poises	Degree of polymerization‡
New rag	991-C		6.30	4.49	15.9	1020
	991-I		6.10	4.34	16.4	995
	991-II		5.79	4.12	17.27	956
Soda sulfite	1143-C		3.36	2.39	29.8	570
	1143-I		3.28	2.34	30.05	553
	1143-II		3.13	2.23	31.95	522
Purified sulfite	1164-C	12.1§	4.48	3.19	22.3	767
	1164-I	12.1§	3.82	2.73	26.2	657
	1164-II	12.1§	3.08	2.20	32.47	513
Old rag	1214-C		3.58	2.55	27.9	612
	1214-I		3.40	2.42	29.4	577
	1214-II		3.46	2.47	28.9	590

*C, control samples; I, irradiated samples two weeks after exposure; II, irradiated samples six months after exposure.

†Concentration of 0.05 g of cellulose per 100 ml of solution (weight of cellulose corrected for moisture and, in the case of sample No. 1164, for filler).

‡The so-called "degree of polymerization" represents an average volume for the number of anhydroglucose units in the molecule. A decrease in the degree of polymerization represents the degree of degradation or deterioration of paper.

§Clay filler, 12.1 per cent.

Chapter 4

DISCUSSION AND CONCLUSIONS

4.1 DESTROYED UNSHIELDED EQUIPMENT

Pieces of metal from records storage equipment recovered at the test site were twisted and telescoped, with ruptures along the welded bead lines. Examination of these remnants led to the conclusion that the units had burst from internal pressure. It is believed that this was due primarily to the forces on the inside panels, resulting from the difference between atmospheric pressure inside the units and subatmospheric pressure outside the units which occurred during the negative phase, following passage of the shock front.

At the locations closest to GZ, intense heat may also have caused accumulation of gases from the equipment insulation, with resultant explosive bursting of the units.

This indicates the desirability of considering internal as well as external pressures in the structural design of protective records storage equipment.

4.2 SHIELDED EQUIPMENT

The test results show that structures 4700 ft from GZ and beyond (but still within the zone of severe damage) give records and records storage equipment considerable protection from the primary effects of a nuclear explosion. It was also demonstrated that the greater portion of damage in this zone will be caused by falling debris.

4.3 EVALUATION AND ESTIMATE OF BLAST DAMAGE

The extent of damage resulting from a blast can be minimized by adequate planning for protection. Such plans must assume:

1. Proximity of target area
2. Size of device detonated
3. Altitude from which device is detonated

The device detonated during Apple II shot had a yield approximately 50 per cent greater than nominal and was detonated from a 500-ft tower. Because of the height from which the test device was detonated, there was no crater effect at GZ. Lower altitudes for detonation would cause a crater in the immediate vicinity of GZ. Despite the possibility of cratering, the mass protective effect of the earth itself is a major defense against the results of a nuclear blast.

There are limits to the destructive power of a nuclear device, and these limits can be estimated. From Fig. 4.1, estimates can be made of blast-damage radii for nuclear weapons of different sizes. The horizontal scale indicates bomb size in terms of megatons and the Hiroshima bomb, which had a yield of 20 kt. A bomb burst height of 2000 ft is assumed. Limits of blast damage for zones A, B, C, and D are shown. The zones are arbitrary categories set according to the degree of damage that can be expected within each. For example, with A-damage, typical urban buildings are virtually destroyed; with B-damage, they must be de-

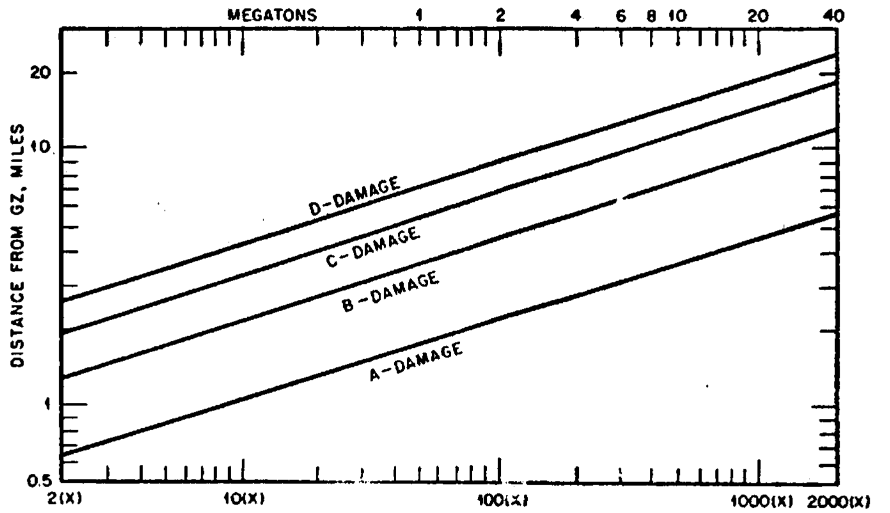


Fig. 4.1---Blast damage for nuclear weapons. Bomb sizes are in terms of the Hiroshima bomb and in megatons (Hiroshima bomb = 1(X) = 20,000 tons of TNT; 1 megaton = one million tons of TNT).

molished; with C-damage, they must be vacated for repairs; and, with D-damage, the repairs can be made while the buildings are in use. Figure 4.1, moreover, refers only to blast damage and does not include effects of thermal or of nuclear radiation. It also disregards the effect of radioactive fall-out.

As explained in Chap. 2, equipment and materials were placed at various ranges from GZ. In terms of the preceding definitions:

1. The first six ranges were in Zone A (500-, 1050-, 1270-, 1840-, 2250-, and 2750-ft lines).
2. The next two ranges were in Zone B (3750- and 4700-ft lines).
3. The next range (5500-ft line) was near the division between Zone B and Zone C.
4. The last range (10,500-ft line) was in Zone D.

Table 4.1 sets forth the types of damage to be expected in buildings of different types of construction in different zones. For civil defense purposes a forecast is made, in terms of Project 35.5 results, of the physical effects of a nuclear explosion on records materials and equipment located in such structures.

TABLE 4.1—FORECAST OF PHYSICAL DAMAGE FROM BOMB EFFECTS

Structures and equipment	Zones of damage A	B	C	D
1. Reinforced-concrete or steel-frame building	Building standing but most masonry-panel walls and non-load-bearing panels and partitions probably destroyed or displaced	Buildings standing but many masonry-panel walls and non-load-bearing partitions probably destroyed or displaced	Interiors moderately damaged	Interiors slightly damaged
a. Records equipment above ground		Exterior damage to most Class A, B, and C safes; records recoverable, subject to debris, fire, and water damage	Class A, B, and C safes and insulated and uninsulated files recoverable and reusable, subject to debris, fire, and water damage	All classes of safes, files, storage boxes, transfiles, and document boxes recoverable and reusable
b. Records equipment below ground (basement)		Most Class A, B, and C safes, insulated and uninsulated files, microfilm cabinets, records storage boxes, and document boxes recoverable and reusable, subject to heavy debris load	No damage	No damage
2. Ordinary buildings of typical urban type (frame house)	Virtually completely destroyed	Severely damaged or destroyed; buildings must be torn down	Moderately or severely damaged; buildings must be vacated for repairs	Partially damaged; buildings need not be vacated during repairs
a. Records equipment above ground		Very heavy debris load; exterior damage to most Class A, B, and C safes; records contained in units recoverable	Class A, B, and C safes and insulated files recoverable and reusable; records recoverable	All equipment recoverable and reusable
b. Records equipment below ground		Equipment subject to heavy debris load; most Class A, B, and C safes, insulated and uninsulated files, transfiles, microfilm cabinets, records storage boxes, and document boxes recoverable and reusable	No damage	No damage

*This table is based on the results of Project 35.5 and on Report TB-8-1, Civil Defense Technical Bulletin, February 1955, Fig. 2.

Chapter 5

COMPREHENSIVE PROTECTION PROGRAM

5.1 RECORDS PROTECTION AS MANAGEMENT RESPONSIBILITY

The authors believe that responsible management will want to plan protection programs that will safeguard vital records not only against the effects of a nuclear explosion but also against natural disasters that each year drain enormous sums from the business economy. In 1955, for example, floods caused over one billion dollars worth of property damage. Losses due to fire were close to another billion dollars. It would be both unrealistic and uneconomical to program safeguards against nuclear perils and ignore real and present dangers.

Moreover, protection against the everyday hazards of fire and flood will provide an excellent safeguard against those effects of a nuclear device most likely to concern establishments that survive the immediate explosion. The experience in Japan shows that fire will cause extensive damage or complete destruction.[1] Broken water mains, destruction of dams and reservoirs, and even the water used to extinguish fires present grave hazards. The importance of protective measures against fire and water damage was emphasized in a study of European experience during World War II. An on-the-scene survey indicated that fire and water resulted in more extensive damage than did bomb blasts.[2]

5.2 PROTECTION OF INFORMATION

A program for the protection of vital records should be rooted first in the principle that what must be safeguarded is information, not pieces of paper. A business document is valuable because of the data it records. When the recorded information is absolutely essential to protect the interests of stockholders, employees, and the public, the record is vital.

Therefore the second point to be emphasized is the essentiality of information. Some data are desirable but not essential. Attempts to safeguard too much material may be unnecessarily expensive. Ordinarily, only 1 or 2 per cent of an organization's records are truly vital, and it is this small portion that should be protected.

Vital records protected against disaster should contain up-to-date information. As data become obsolete or useless, the records containing such information should be destroyed and replaced by new records containing current information. Otherwise, a cumulative growth of pieces of paper occurs and makes the reconstruction process assume Herculean proportions. This must be avoided by creating an orderly and manageable flow of most current information through the vital records protection point.

5.3 DETERMINATION OF VITAL RECORDS

The authors recommend a functional approach to determining which records are vital. The first step is analysis of the organization's essential operations and the functions of each of these operations.

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Example. A manufacturing organization might list its essential operations as:

1. Treasury
2. Sales and distribution
3. Engineering
4. Production
5. Administration

The functional breakdown of operations might result in the following functions under the treasury operation: receiving, paying, bookkeeping, and costing.

The second step in the functional approach is the determination of what information is required to carry out an essential function. The third step is to find out which records contain this information. Only these records should be termed "vital" and be safeguarded against disaster.

5.4 BASIC PROTECTION METHODS

The two basic methods of vital records protection are evacuation and duplication. Four variations of these basic methods may be utilized:

1. Built-in dispersal
2. Designed dispersal
3. Evacuation or vaulting of the original
4. Duplication of the original record

The selection of the proper protection method depends on the physical form of the record, the volume of vital records, present location of each record, number of copies in existence, and current use of the record.

Table 5.1 illustrates the use of the four protection methods.

5.4.1 Built-in Dispersal

This method makes use of the maintenance of duplicate copies of records in two or more geographically separated locations. In a multiplant company, for example, a distant plant may keep an original record and send a copy to the home office. Duplicates or originals of company records may also be maintained by a bank, insurance company, or title company. A government agency may maintain an original or a duplicate. However, government agency protection

TABLE 5.1 — EXAMPLES OF PROTECTION METHODS

Operation:	Sales	Treasury	Administrative	Manufacturing
Function:	Pricing	Bookkeeping	Personnel administration	Producing
Information needed to:	Reconstruct basic sales prices of products	Reconstruct assets and liabilities of the corporation	Reconstruct annuity contributions of the individual employee and the corporation	Reestablish present plant-area layouts
Vital record:	Price lists	General ledger	Annuity ledger sheet	Plant layout drawings
Method of protection:*	BID: district sales office copies provide sufficient protection through wide dispersal	EO: original ledgers sent to Vital Records Center when two years old; retained permanently	DO: sheets microfilmed annually and film sent to Vital Records Center; retained one year	DD: existing copy of all layout drawings sent to Vital Records Center; retained until superseded

*Code: BID, built-in dispersal; EO, evacuation of original; DO, duplication of original; DD, designed dispersal.

should be relied upon only when management has definite knowledge that the record is kept at a geographic location apart from the company, that it is retained for a sufficient length of time, and that adequate protection is provided.

5.4.2 Designed Dispersal

This method involves modification of existing procedures to make use of an existing copy of a vital record already in the paper-work stream. This existing copy is designated as the vital records copy and is forwarded to the Vital Records Center.

5.4.3 Evacuation or Vaulting of the Original

If a vital record is referred to infrequently, the most economical and effective protection is provided by evacuating the original to a Vital Records Center, to a specially protected area, or to special equipment such as a vault, safe, or insulated file cabinet. Costly duplication of the records and duplicate maintenance are eliminated.

5.4.4 Duplication of Original Record

Under this method an extra copy of the original record—a carbon copy, a photostatic copy, or a microfilm copy—is created when the original is made or at a later date. This method is the most expensive and should be used only for records that cannot be protected by the other three methods. When this method is used, cost analyses should be made of various duplicating processes to determine the one that is most economical.

5.5 VITAL RECORDS CENTER

A Vital Records Center is a storage area in a location where a company can provide a suitable structure and proper equipment to protect against natural or nuclear disaster. The location should take the following into account:

1. Proximity to a target area
2. Vulnerability to natural disaster such as flood, tornadoes, and fire
3. Distance from headquarters of the company
4. Communication and transportation facilities

Great care must be exercised in selecting the site for a Vital Records Center. Although a location out of specific target areas or locations known to be vulnerable to natural disasters is advisable, there is no reason for a Vital Records Center to be all but inaccessible.

Records may be safe even when located within a storage center proximate to a target area (Table 4.1).

A Vital Records Center may be established as a separate storage unit or may be combined with the organization's regular records center. Since vital records normally constitute well under 5 per cent of the total records volume, this combination is frequently both feasible and practical (Fig. 5.1). It also reduces operational costs.

A number of small companies may consider the possibility of pooling their resources and sharing the facilities of one Vital Records Center to serve all of them. This likewise minimizes expenses for individual organizations. Each organization must make its own decision as to the exact location of its Vital Records Center. The general pattern of protective measures can be set forth, but there can be no substitute for individual evaluation of organizational needs.

5.5.1 Construction of Vital Records Center

Other test results show that a reinforced-concrete structure is the most resistant type of (normal) construction in withstanding blast damage. It is therefore suggested that a building planned as a Vital Records Center be of this type construction.

Construction on high ground supplies protection against damage by floods. Removal from heavy concentrations of buildings will lower the possibility of fire incidence and damage from debris. Internal fire-fighting arrangements independent of public systems, which may be unable to respond to alarms, and of public water mains, which may be damaged or inoperative, are essential.[1]

5.5.2 Selection of Equipment

The test results (based on aboveground-level detonation) show that, even at ranges within Zones B and C, safes and insulated files provide some protection against nuclear explosion. Therefore it is recommended that careful consideration be given to the utilization of safe files and insulated equipment. Great selectivity should be exercised in choosing the equipment, and its use should be restricted to the most essential records required at hand and not otherwise protected. Even an organization that believes that its size and volume of records do not warrant or justify an elaborate protection program would be well advised to review the possible use of such protective equipment.

Fig. 5.1—Records storage center

5.6 SUMMARY

In World War II the United States relied heavily on the evacuation of original or duplicate records or on microfilming to protect essential information. Against this background the general pattern of records protection developed around the following three concepts:

1. Dispersal of records to remote and almost inaccessible locations
2. Wholesale microfilming of records
3. Use of special protective equipment such as safes and insulated files

Each concept has its uses in contributing to records protection programs, but three essential factors have often been omitted from planning:

1. The determination, according to objective standards, of precisely which records are vital to an organization

2. A scientific basis for utilizing to the best advantage the techniques available for records protection

3. A comprehensive program for protection planned to fit individual organizational needs

Project 35.5 was conducted in order to provide the scientific data essential to planning vital records protection. The information resulting from Project 35.5 presented in Chaps. 1 to 4, plus data on identification of vital records and protective measures developed in independent research, provided the basis for the recommendations presented in this chapter.

The solution to the problem of vital records protection lies in a comprehensive program rather than solely in such techniques as the evacuation of documents, duplication of records, or utilization of equipment. The essentials of a program are the following:

1. Analysis of organizational requirements so that vital records may be identified and segregated
2. Design of a balanced protection program to meet organizational needs
3. Selective use of equipment
4. Selective utilization of methods of protection

The authors hope that this report will serve to provide management with a factual basis for planning a sound program of protection for vital records against nuclear and natural disasters. The information now at hand demonstrates that such protection is both possible and practicable. It is our hope that responsible management will utilize these data to program protection and to ensure the continuity of business enterprise.

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2. Robert A. Shiff and Emmett J. Leahy, Bombs Do Not Respect Vital Business Records, *The Controller*, March 1951, p. 109.

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