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FINAL REPORT

FIELD TEST FY-34

ANNEX D

TEST OPERATIONS (U)

JANUARY 1969

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SYNOPSIS

This annex describes the FT-34 field test in terms of operations conducted during the test.

Background information which led to the requirement for field testing weapon destruction concepts is presented. An inspection concept which outlines the basic phases of inspection in a single facility is shown. Specific test objectives for the FT-34 field test included the determination of classified information revealed during the test, the evaluation of test procedures in convincing inspectors that nuclear weapons were being destroyed, the evaluation of the practicability and effectiveness of the tested procedures, and the identification of field problems.

The overall destruction exercise was conducted at four AEC facilities in a manner which was intended to simulate as closely as practicable the operation of a single facility. The test phases included (1) walkthrough tours, (2) weapon monitoring, (3) burnable material disposal, (4) nonnuclear material disposal, and (5) fissile material recovery and assay. A weight balance of all incoming and destroyed material was maintained by inspection teams throughout the test. The major variables tested were (1) access to weapons and facilities, (2) team size, and (3) evasion in weapons and assay.

Two additional exercises were conducted as a part of FT-34 field operations. Both of these exercises pertained to the assay of uranium. The first exercise was a special assay evasion test for which military inspectors were selected from the inspection force used in the overall destruction exercise. The second exercise was similar to the first except that a single inspection team composed of civilian laboratory scientists from the AEC Oak Ridge complex performed the inspection activities.

Post test exercises pertaining to review of field test derived classification and conviction data are described. Nuclear weapon experts in classification, design, development, and intelligence served as evaluators of information from the post test exercise.

Evasion techniques used during the weapon monitoring and assay phases of the field test are described in detail.

Because of the descriptive nature of the material in this annex, no conclusions or recommendations are presented.

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I. INTRODUCTION

A. BACKGROUND

The United States has proposed before the Eighteen Nation Disarmament Committee that both the United States and the Soviet Union transfer weapons grade uranium to peaceful uses under international safeguards. Ambassador Arthur J. Goldberg, in an address to the United Nations General Assembly on September 23, 1965, stated that the United States would transfer 60,000 kilograms of weapons grade U-235 to non-weapon use if the Soviet Union would transfer 40,000 kilograms. Each nation would destroy nuclear weapons of its own choice to make available such amounts of fissionable material. The United States has also proposed that the transfer include the associated plutonium derived from the destroyed weapons in an agreed upon ratio or quantity.

In view of this proposal, Project CLOUD GAP was directed to field test the concept of monitoring the destruction of nuclear weapons. This test, designated "FT-34, Demonstrated Destruction of Nuclear Weapons," was approved by the Arms Control and Disarmament Agency and the Department of Defense on 25 August 1966. The field phase of the test, which took place from 21 June 1967 to 20 October 1967, took advantage of the current nuclear weapon retirement program. Although Project CLOUD GAP was terminated during the final field stages of this test, the test was completed, and results were analyzed by the Field Operations Division of ACDA/WEC.

B. INSPECTION CONCEPT

The concept of monitoring the demonstrated destruction of nuclear weapons envisions an inspection process which would confirm that real weapons are destroyed and that the fissile material to be placed under safeguards meets the standards for purity and enrichment previously agreed upon. From the point of view of the host nation, the destruction of weapons must be accomplished in such a way that sensitive weapon design information is protected.

The inspection and destruction operations would be conducted at a single facility established for that purpose in each of the participating countries. A possible functional arrangement of such a facility is shown in figure D-1. Prior to the introduction of the weapons for destruction, the inspectors would examine the interior of the facility to determine that no nuclear material had been prepositioned and that the facility could be used to disassemble nuclear weapons. The inspectors would then retire from the interior of the facility, and the weapons for destruction would be presented at the entry point where they would be weighed and examined by the inspectors. The weapons would then be moved into the facility for disassembly and destruction. During the disassembly phase, only host nationals would be permitted in the facility, and the inspectors would remain outside to insure that no further material was introduced or removed. After disassembly, the high explosive and other burnable components would be removed from the facility, weighed, and burned under the observation of inspectors. The recovered fissile material would be weighed and assayed, with the assay either conducted or observed by the inspectors. The remaining nonnuclear components and material would be weighed and disposed of in some mutually agreed upon manner such as ocean burial. Throughout the burning, assay of fissile material, and destruction of nonnuclear components, the material presented for weighing and inspection would be correlated with the original batches of individual weapons. After completion of these processes the inspectors would again examine the interior of the facility to determine that no weapons or components had been withheld.

C. TEST OBJECTIVES

The basic purpose of the field test was to test and evaluate inspection procedures for the demonstrated destruction of nuclear weapons under conditions simulating as closely as practicable the inspection concept previously described.

The specific objectives were:

1. To determine the extent to which the proposed method of demonstrating destruction reveals classified weapon information.

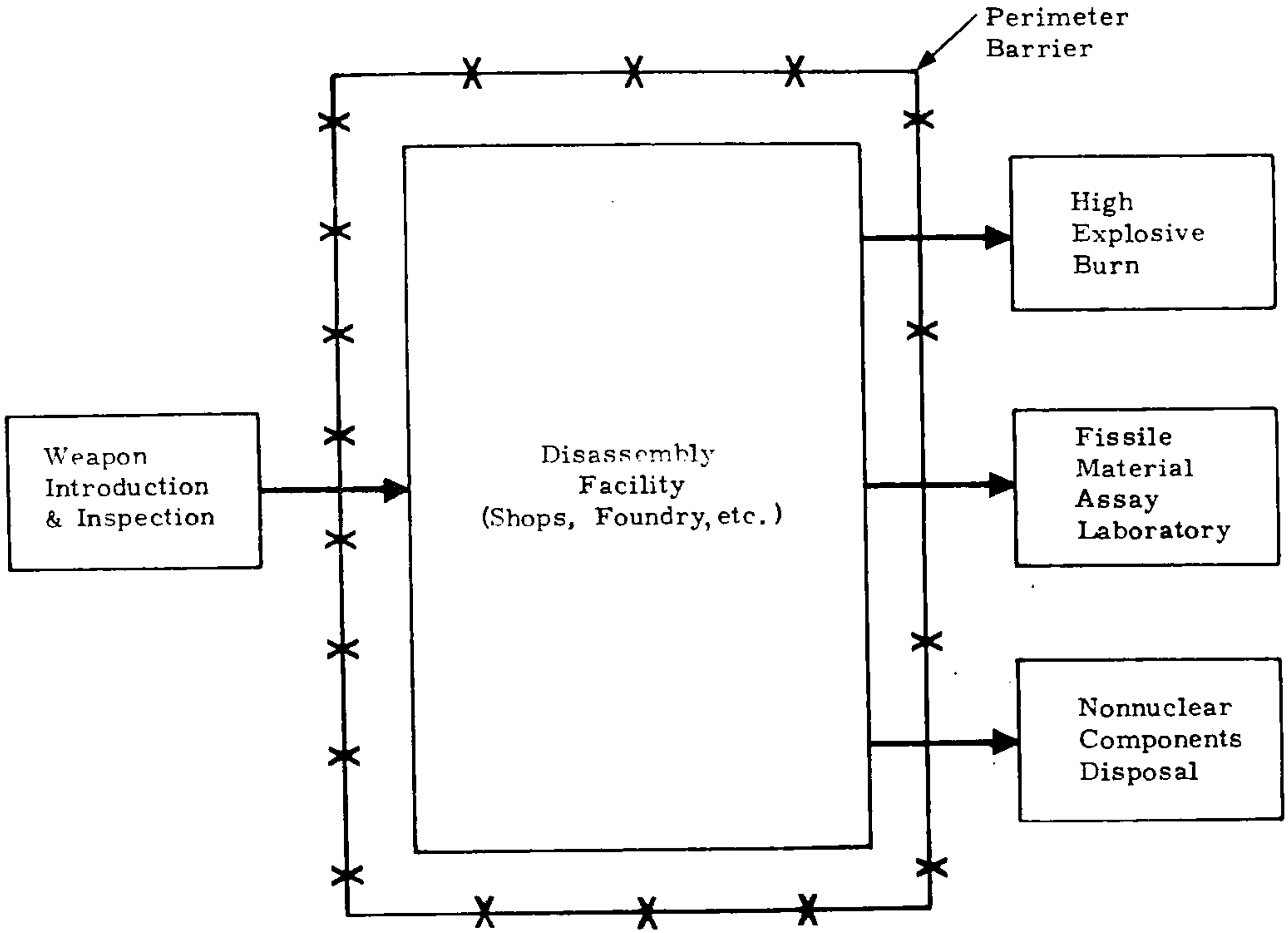

FIGURE D-1. Single Destruction Facility

2. To evaluate the effectiveness of the tested procedures in terms of convincing the Test Inspection Force that nuclear weapons are being destroyed.

3. To evaluate the practicability and effectiveness of the proposed methods and to suggest and implement possible improvements during the test, as necessary.

4. To identify operational, technical, classification, safety, and security problems which arise.

II. FIELD TEST CONDUCT

A. GENERAL

The field operations were conducted as three basic exercises. Although they overlapped to some degree, they will be discussed under separate headings in this report. The first exercise included all phases of the overall destruction demonstration and was conducted in sequence at all test sites. The second concerned only the analysis and assay of samples of uranium and was conducted by selected military inspectors at the Oak Ridge site. The final exercise was similar to the second but was conducted by a team of scientists from the Oak Ridge Gaseous Diffusion Plant and the Oak Ridge National Laboratory.

B. OVERALL DESTRUCTION EXERCISE

1. Description. The overall destruction exercise was designed to simulate as closely as possible the inspection of all phases of the demonstrated destruction of nuclear weapons under inspection concepts previously described. Inspection was performed by teams of officers selected from the military services. The nuclear weapons which were destroyed were selected from those scheduled for normal retirement. The test was performed at several U. S. Atomic Energy Commission facilities on a not-to-interfere basis. Throughout the test, various evasions were practiced on the inspection teams.

2. Test Locations. No single facility for the complete disassembly and destruction of nuclear weapons and the recovery of fissile material exists in the United States. The overall test was, therefore, conducted at four AEC facilities in a manner which was intended to simulate as closely as practicable the operation of a single facility. The use of four different facilities and the requirement not to interfere with normal plant operations introduced some artificiality into the overall test. The four facilities used and their functions for the test were:

a. Pantex Ordnance Plant, Amarillo, Texas (operated by the Mason and Hanger, Silas Mason Company) for the disassembly of weapons and the burning of explosives and other burnable components.

b. Rocky Flats Plant, Golden, Colorado (operated by the Dow Chemical Company) for the recovery and assay of plutonium.

c. Y-12 Plant, Oak Ridge, Tennessee (operated by the Union Carbide Company) for the recovery and assay of uranium.

d. Paducah Plant, Paducah, Kentucky (operated by the Union Carbide Company) for the disposition of the remaining nonnuclear components.

The flow of material for the overall test through these facilities is shown in figure D-2. The weapons to be destroyed were presented for inspection at Pantex. After inspection, initial disassembly and the burning of the high explosives and other burnables took place. Nuclear assemblies containing plutonium were sent to Rocky Flats where the plutonium was recovered and assayed. Nuclear assemblies containing no plutonium were sent from Pantex to Oak Ridge as was the uranium from the assemblies processed at Rocky Flats. At Oak Ridge, the uranium was recovered and assayed. The weapon cases and other nonnuclear components were sent to Paducah for disposal where some metal was smelted, some classified components were buried, and other material was held by the plant for future disposition. Some nonfissile materials were also disposed of at Rocky Flats and Oak Ridge.

3. Tested Variables. The overall exercise investigated the effects of several controlled variables on the inspection process. The variables were the degree of access to the weapon shapes and destruction facilities which inspection teams were permitted, the inspection team size, and the nature of evasions practiced on the inspection teams.

The tested variables are summarized in figure D-3 for each phase of the overall test.

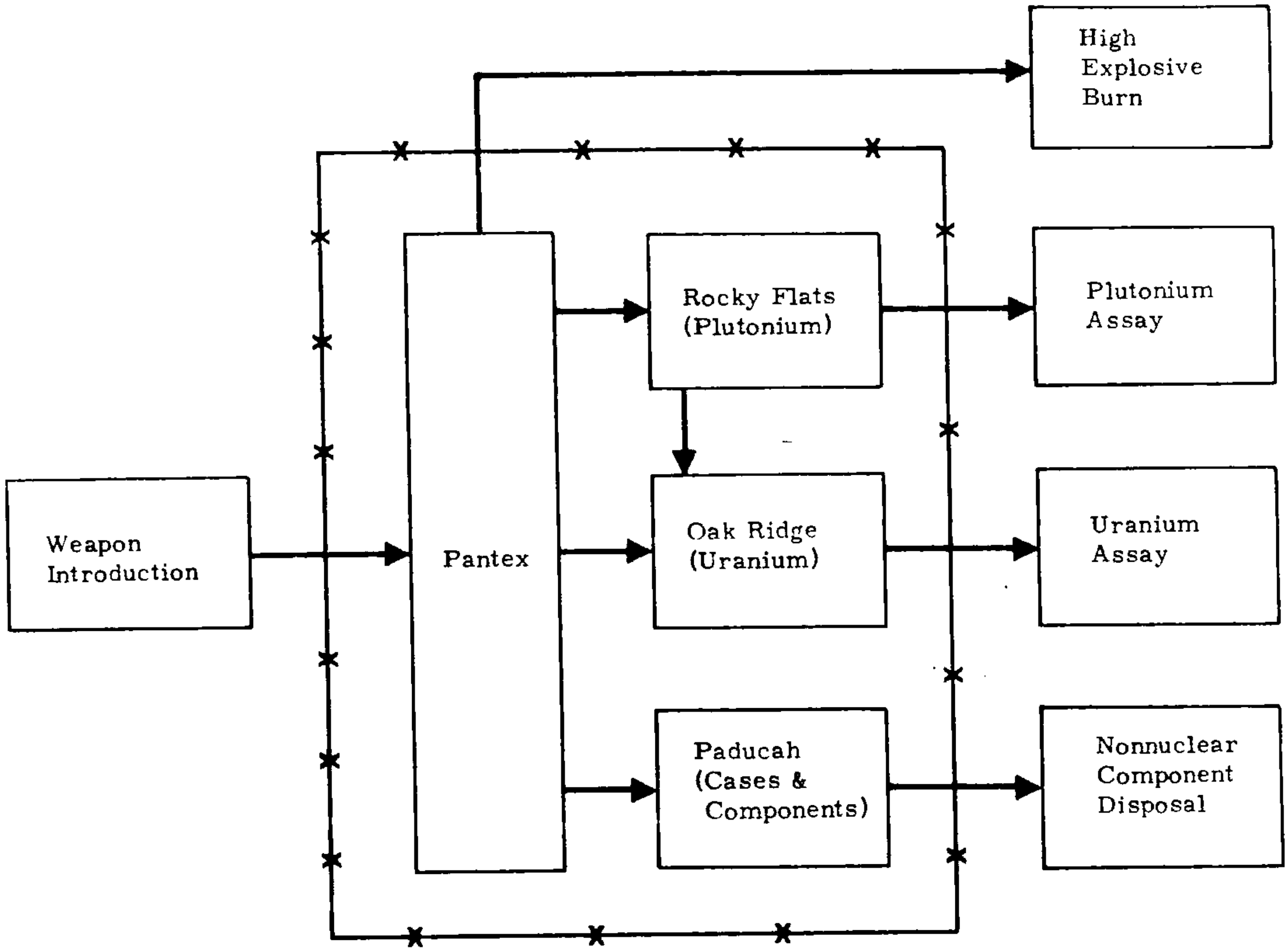

FIGURE D-2. Material Flow For FT-34

FIGURE D-3. FT-34 Tested Variables

Variable	Overall exercise				
	Walkthrough	Shape inspection	Burn	Nonnuclear disposal	Fissile Material Assay
Access to operation	Low, High	A_1, A_2 A_3, A_4	Low, High	A_1, A_2 A_3, A_4	Low, High
Team size	2 Man 4 Man	2 Man 4 Man	2 Man 4 Man	2 Man 4 Man	2 Man 4 Man
Evasion	No	Yes	No[a]	No[a]	Yes

[a]Although no new evasion was attempted during these phases, some components inspected came from fake weapons introduced during the shape inspection phase.

a. Access. The degree of inspector access to the weapon shapes and disassembly facilities during the overall exercise was tested at either two or four levels; the level was determined by the type of operation being performed. As a general rule, each higher level of access to an operation contained all the elements and operations of the preceding lower level.

During the walkthrough phase, the low access inspection teams were allowed only to observe the facilities, fixtures, and tooling and to make notes and sketches. High access teams were additionally allowed to take measurements, photographs, and Geiger counter readings to check for prepositioned fissile material and to detect particles of nuclear material resulting from destruction processing which might, when analyzed, reveal classified information.

During the weapon shape inspection phase, four levels of access were tested. At the first level (A_1), the inspection teams examined the weapon shape exteriors to obtain information regarding weights, locations of some external features, centers of gravity, and dimensions. Heavy tape covered the identification markings and access doors. At the second level (A_2), the teams were additionally allowed to look inside selected opened access doors on several of the weapon shapes and to use Geiger counters at the surfaces of the shapes in order to determine the locations of any radioactive materials. At the third level (A_3), the inspection teams were additionally allowed to take photographs, to use neutron counters to detect indications of the presence of plutonium, and to use a gamma spectrometer to attempt to determine the type of the radioactive materials located previously by the Geiger counters. At the fourth access level (A_4), the teams were additionally allowed to examine X-ray plates of the weapons. Examples of the types of information presented at the A2 and the A4 access levels are shown in figures D-4 and D-5.

During the burn phase, low access inspection teams observed the weighing of closed boxes containing the high explosive and other burnables and observed the burn from a safe distance. The high access teams were additionally

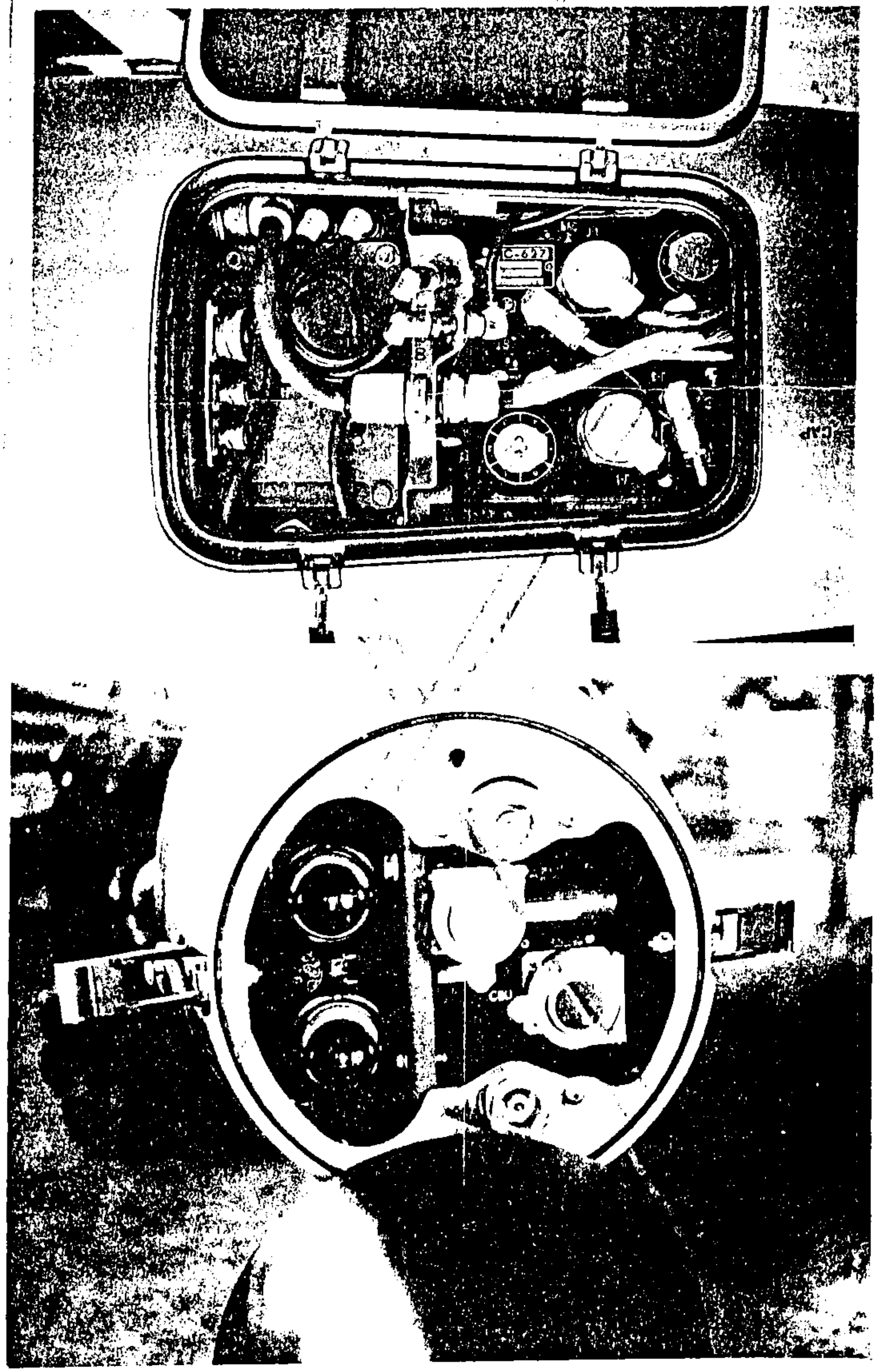

FIGURE D-4. - Open Access Doors on Mk 28

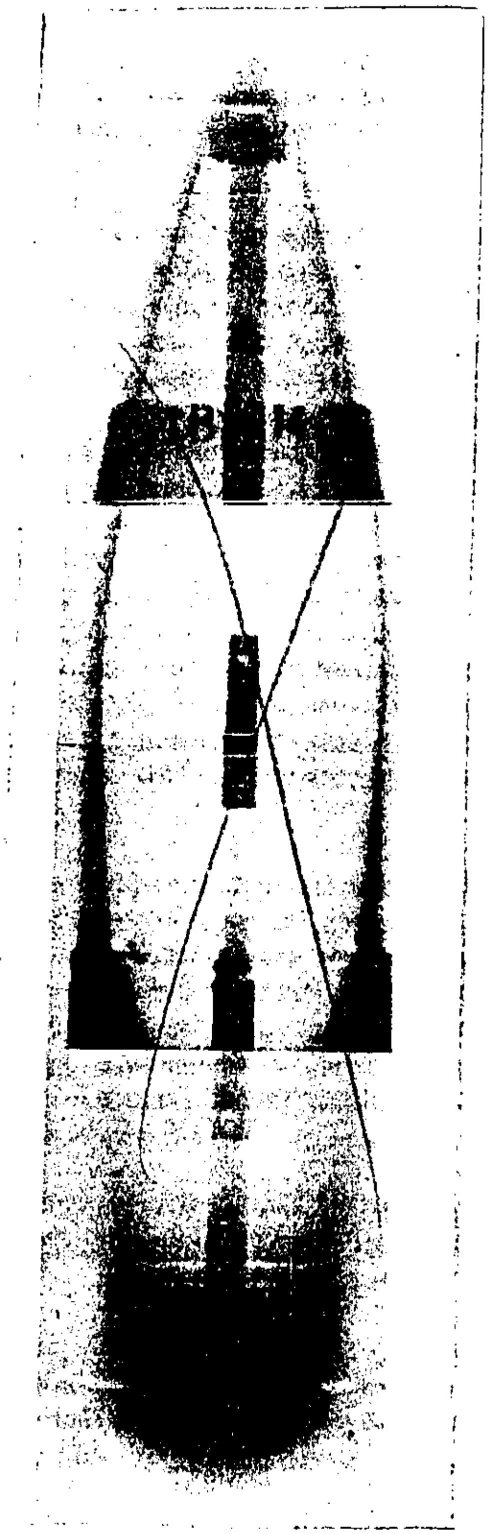

FIGURE D-5. Typical X-ray Information from the 8-Inch Shell, A_4 Access Level allowed to look into and photograph the opened boxes containing the burnables. Both access levels allowed the teams to examine the residue after the burning and to obtain tare weights of the containers used to transfer materials to the burn area.

Four access levels were tested during the disposition of the nonnuclear components. At the first level (A_1), the inspection teams observed metal ingots from the smelter, closed boxes containing various components, and several weapon cases (with ends sealed) which could not be smelted and which were too large for packaging. They checked the weights of some material for disposal and recorded all weights. They also observed the burial of some packaged classified components. At the second level (A_2), the teams were additionally allowed to look, from a distance of about 10 feet, into the opened packing boxes and weapon cases with ends unsealed. At the third level (A_3), the teams were additionally allowed to examine, but not touch, the contents of the packing cases displayed on the floor. At the fourth level (A_4), the teams were additionally allowed to handle, measure, and photograph these components. No further disassembly was permitted.

During the fissile material assay phase, low access inspection teams observed laboratory technicians performing the assay but were not permitted to ask questions. High access level teams performed all operations except those not permitted by safety regulations. At Rocky Flats, high access teams were essentially observer teams since safety regulations permitted only Dow Chemical technicians to perform work in glove boxes (enclosed work areas).

b. Team Size. In each of the five phases of the overall test and at each access level, inspection teams of two men and of four men were tested.

c. Evasion. Various evasions were practiced on the inspection teams during the weapon shape inspection and the fissile material assay phases of the overall exercise. The specific techniques used will be discussed in a later chapter.

5. Inspection Force. The inspectors for the overall test were company or field grade officers selected from the military services on a temporary duty basis. All inspectors had some chemical and/or nuclear experience but had no current familiarity with all of the specific weapons being inspected; however, some of the inspectors had extensive prior knowledge of some of the weapons being inspected. Prior to the field operation, they were given training at Test Headquarters at the Paducah facility which covered a review of nuclear weapon technology, the data gathering and reporting processes, and guides for the detection of classified information. Annex B, "Inspectorate and Training," presents detailed information about the test inspection force.

At Paducah Test Headquarters, during the initial training and orientation sessions, each group of 13 inspectors (LIMA and MIKE) was formed into four inspection teams. These teams consisted of two two-man and two four-man teams. The team designations and size are shown in figure D-6. The thirteenth inspector was designated as chief inspector and was also available as a spare inspector. The chief inspector was never utilized as an inspector during FT-34.

FIGURE D-6. Team Designations and Sizes for Overall Exercise

Team size	Team number	
	Low access	High access
1	L_1 M_1	L_2 M_2
S_2	L_3 M_3	L_4 M_4

where

S_1 = two-man teams
S_2 = four-man teams
L_1, L_2, L_3, L_4 = LIMA teams
M_1, M_2, M_3, M_4 = MIKE teams

Four identical batches of weapon shapes were subjected to inspection, two each by the LIMA and MIKE groups. Since the inspections of weapon shapes at Pantex and of nonnuclear components at Paducah were to be performed in four access levels, the low access teams (figure D-6) performed an A_1 inspection on the first batch of weapons and an A_2 inspection on the second batch while, similarly, the high access teams performed A_1, A_2, and A_3 inspections on the first batch and A_1, A_2, A_3, and A_4 inspections on the second batch. See annex B, "Inspectorate and Training," for further details on the inspection force.

5. Weapon Shapes and Batching of Shapes. Seventy-two weapon shapes were presented to the inspectors in four batches-two batches to each group of inspectors. All batches had 18 weapon shapes and were identical in makeup; however, inspectors were unaware of this. Two each of nine different types of weapons were included in each batch. Five of the types of shapes (10 per batch) were bona fide weapons and four types (eight per batch) were fake weapons. The types of weapon shapes utilized in FT-34 are listed in figure D-7 and are described below. A more detailed description of the fake weapons is given in Chapter IV, "Evasion."

FIGURE D-7. Weapon Types Used in FT-34

Bona Fide Weapons

Mk 25/Genie	Warhead, adaption kit, nose section, AIR-2A configuration
Mk 28/EX	Bomb, shape components, Y2
Mk 30-Mod 1/Talos	Warhead, adaption kit, interbodies
Mk 39/Mod 2	Bomb, Y1
Mk 56/Minuteman	Warhead, reentry vehicle Mk 11

Fake Weapons

BDU-12/B, Bomb Drop Unit
Eight-inch artillery shell
Mk 28/EX bomb
Hawk warhead section

a. Bona Fide Weapons

(1) The Mk 25 Warhead is used in the U.S. Air Force air-to-air missile, AIR-2A, as shown in figure D-8. The warhead is a single-stage, pressurized, fission device 17 inches in diameter and 26 inches long. It weighs approximately 222 pounds and contains both plutonium and uranium. The missile warhead body is 17.4 inches in diameter and 48.1 inches long. It weighs approximately 287 pounds. DOE (b)(3)

(2) The Mk 28 Mod 1 Ex Bomb is a freefall bomb carried externally on tactical aircraft. It is shown in figure D-9. The warhead is a two-stage, pressurized, thermonuclear device which contains both plutonium and uranium. The bomb is 20 inches in diameter and 170 inches long and weighs approximately 2040 pounds.

(3) The Mk 30 Mod 1 Warhead is used in the U.S. Navy ship-to-air missile, Talos, as shown in figure D-10. The warhead is a sealed, single-stage, pressurized, nuclear device 22 inches in diameter and 48.4 inches long. It weighs approximately 460 pounds and contains uranium but no plutonium. The missile warhead body is 22 inches in diameter and 78 inches long. It weighs approximately 619 pounds. DOE (b)(3)

(4) The Mk 39 Mod 2 Bomb is a freefall or parachute-retarded bomb delivered by strategic aircraft. The warhead is a two stage thermonuclear device containing uranium but no plutonium. The bomb, which is shown in figure D-11, is 140 inches long and weighs approximately 7,100 pounds. (The parachute was removed from the units destroyed during the field test leaving a weight of about 6,660 pounds.) The diameter of the main body is 34.5 inches and that of the tail section is 44 inches. The Mk 39 was the largest weapon used in the field test.

(5) The Mk 56 Mod 1 Warhead used in the Minuteman reentry vehicle is a small two-stage, sealed, thermonuclear device containing both plutonium and uranium. It is 18.6 inches in maximum diameter, 47.3 inches long, and it weighs approximately 600 pounds. The Minuteman reentry vehicle, Mk 11 RV, in which the warhead is used, is shown in figure D-12. DOE (b)(3)

FIGURE D-8. Mk 25 Warhead, AIR-2A Nose Section

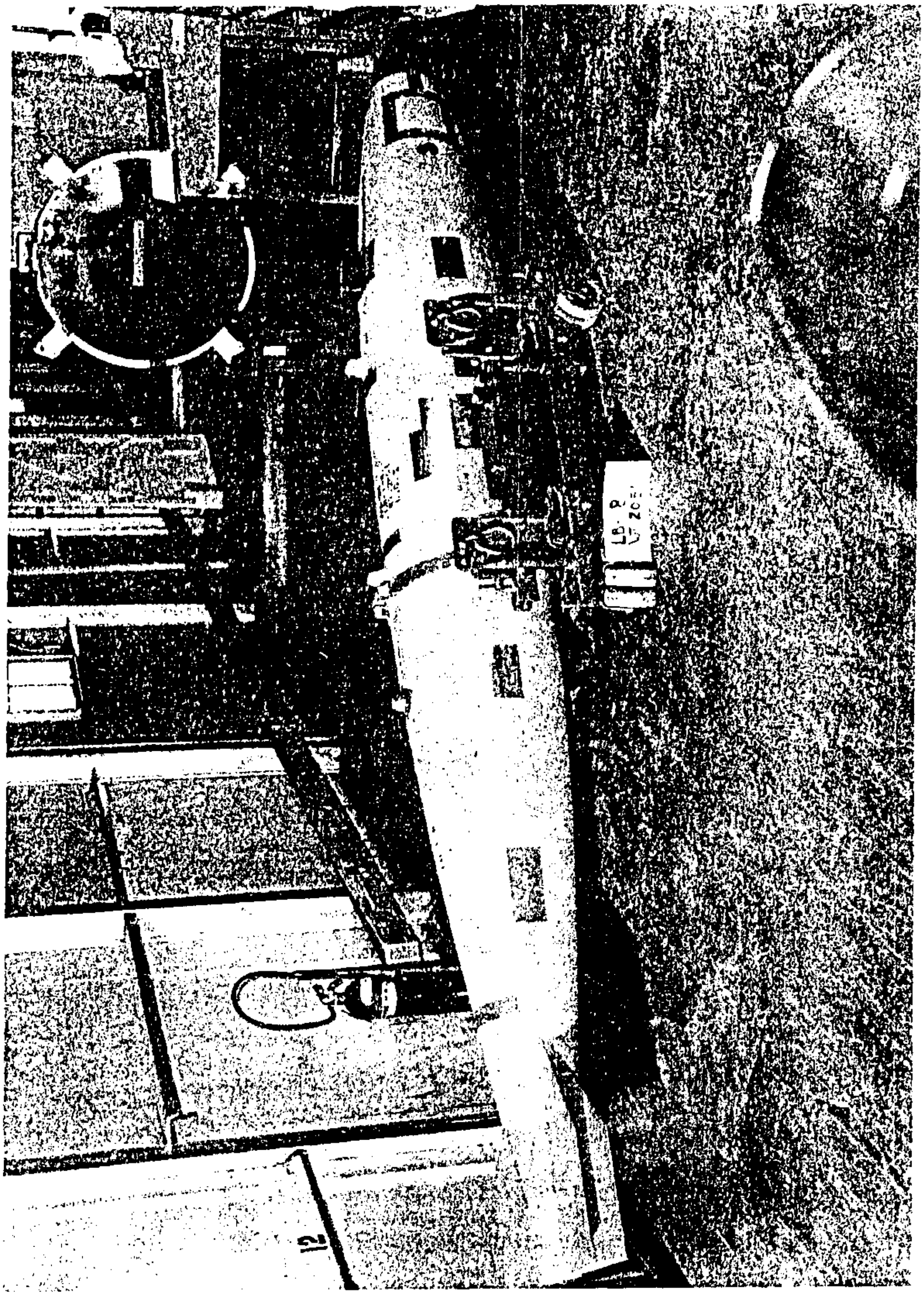

FIGURE D-9. Mk 28/EX Bomb, Real

FIGURE D-10. Mk 30 Warhead, Talos Innerbody

(b)(1)
(b)(3)

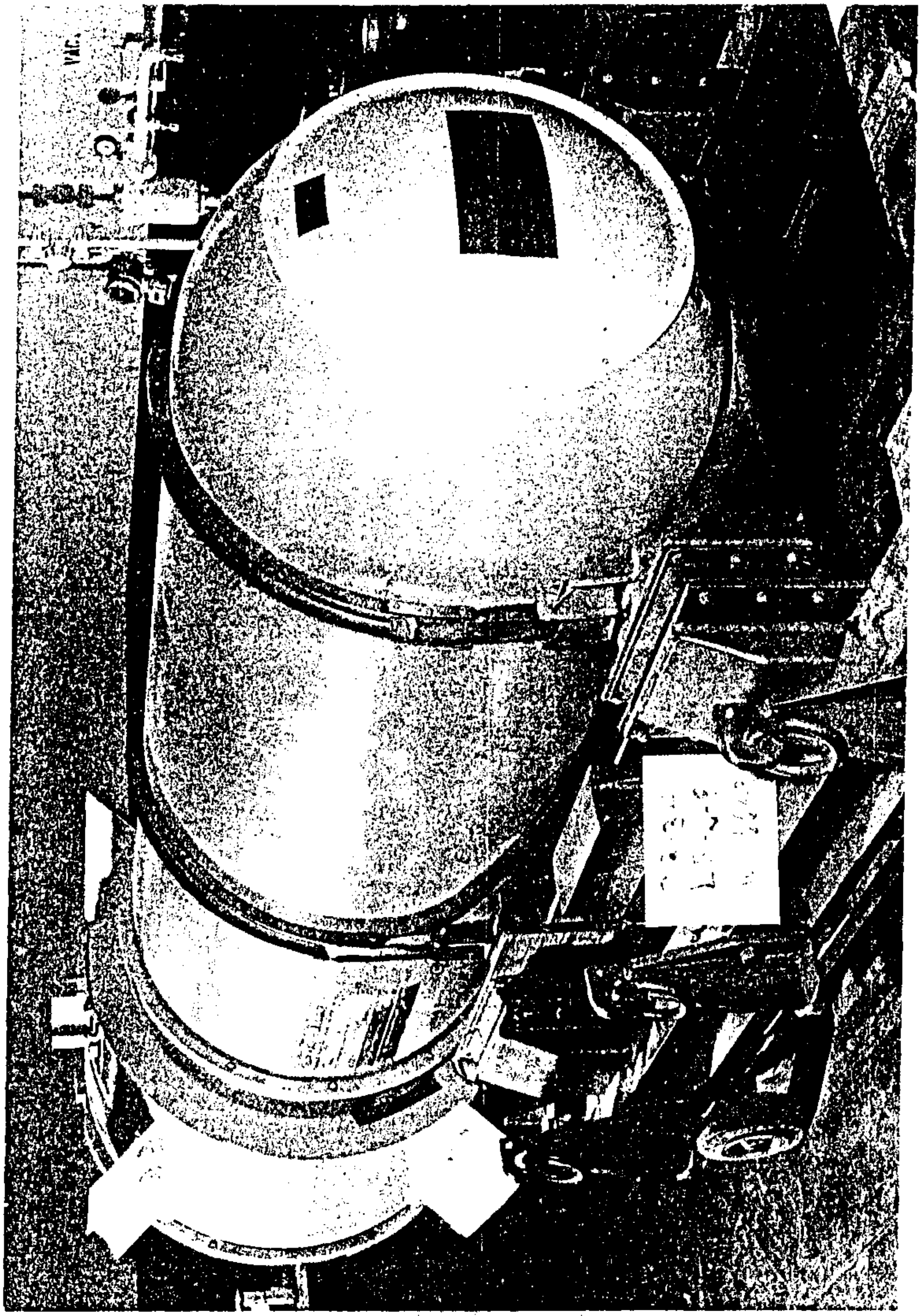

FIGURE D-11. Mk 39 Bomb

DOE
(b)(3)

FIGURE D-12. Mk 56 Warhead, Mk 11 Reentry Vehicle

The MK 11 RV is 32 inches in maximum diameter and 80 inches long. It weighs approximately 775 pounds with the nuclear device installed.

b. Fake Weapons

(1) The BDU-12/B, figure D-13, is a ballistic shape used as a practice bomb. The modified units were 14.75 inches in diameter, 118 inches long, and weighed approximately 500 pounds.

(3) Figure D-15 shows the modified Mk 28 training bomb used in the test. It was 20 inches in diameter and 170 inches long and weighed approximately 2,000 pounds.

(4) The most sophisticated fake weapon used for the field test was a modified warhead from the U.S. Army Hawk missile. The warhead used for the test is shown in figure D-16. [redacted]

6. Test Phases. The inspection operations for the overall exercise were divided into five phases, some of which overlapped in time or location. Throughout each of these phases, inspection teams made extensive records of everything they observed including dimensions and features of tooling, weapon shapes, and destruction products. With these observations, inspectors attempted to detect classified information revealed and determine the credibility of the demonstration.

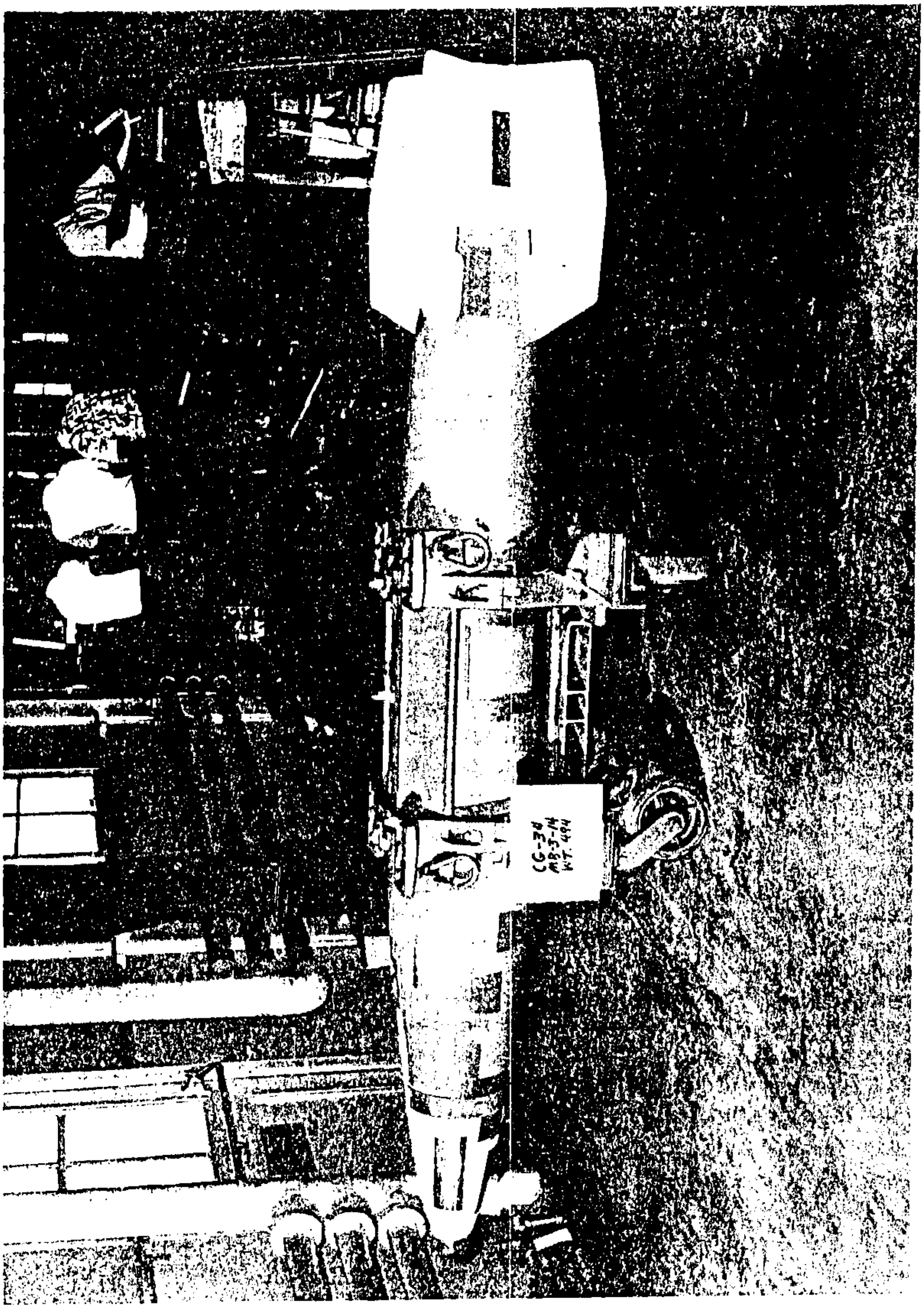

FIGURE D-13. Mk 57 Ballistic Drop Unit Bomb Shape, Fake

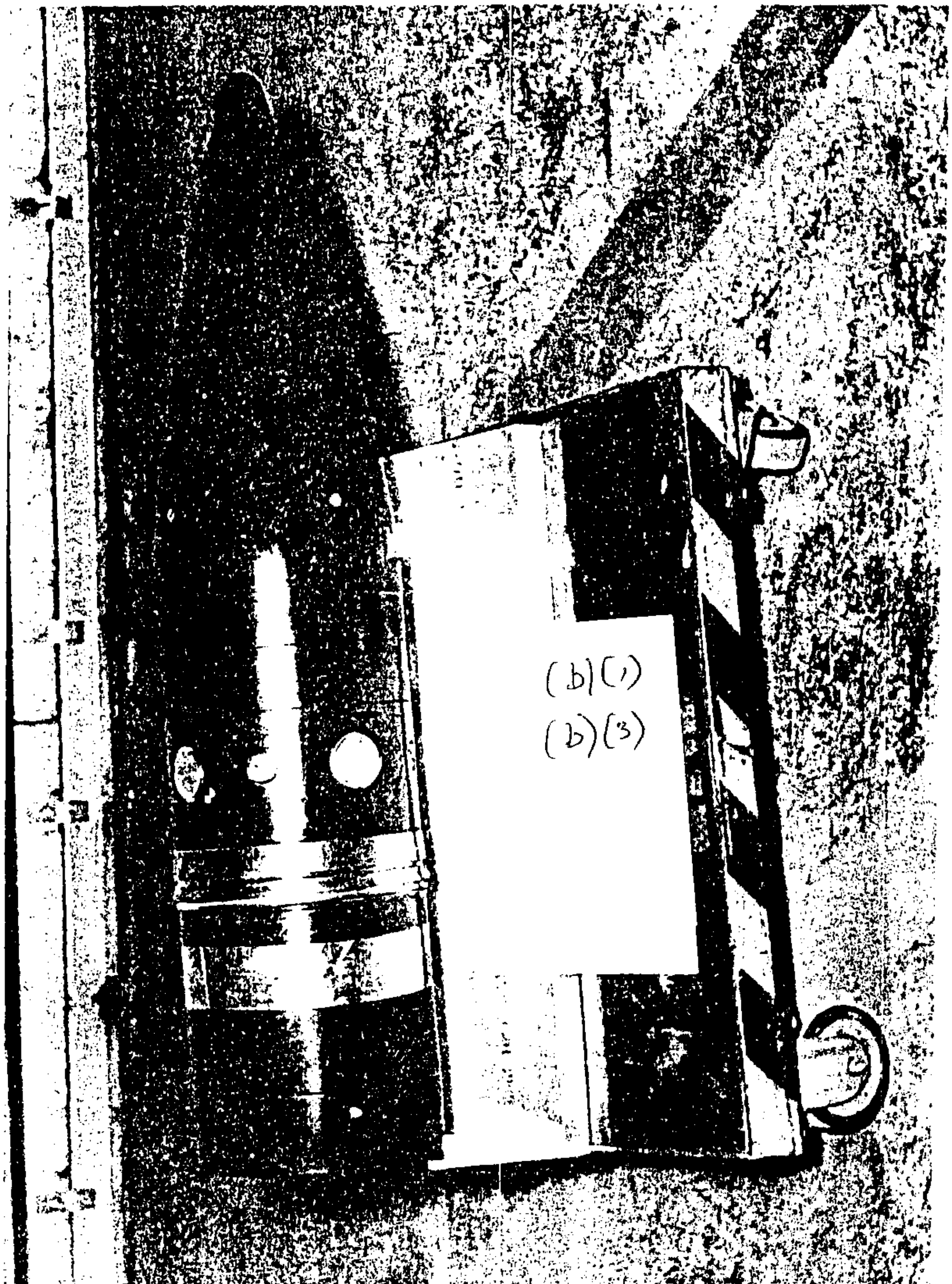

FIGURE D-14. Eight-Inch Artillery Shell (Fake Mk 33 Shell)

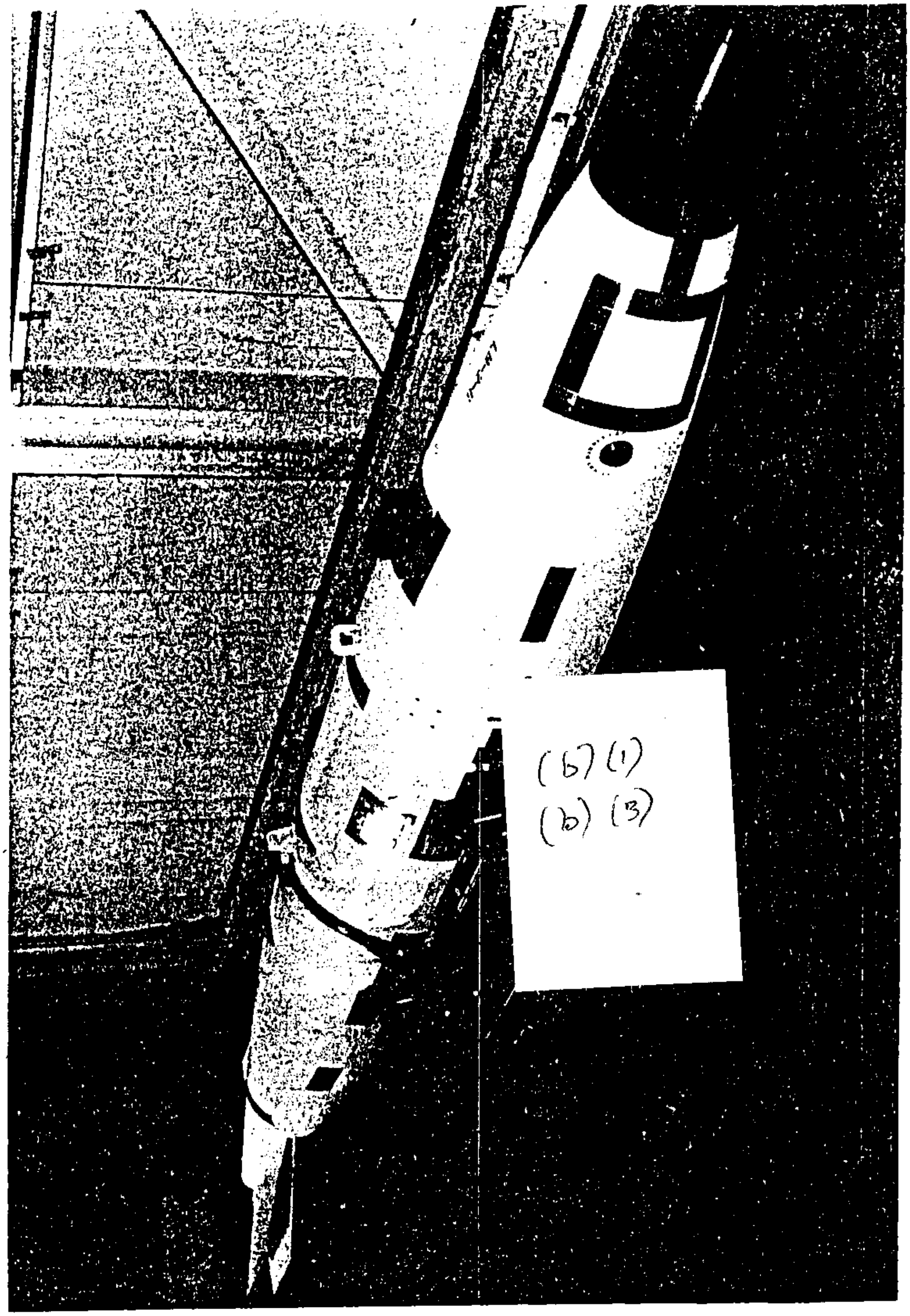

FIGURE D-15 Mk 28/EX Bomb, Fake

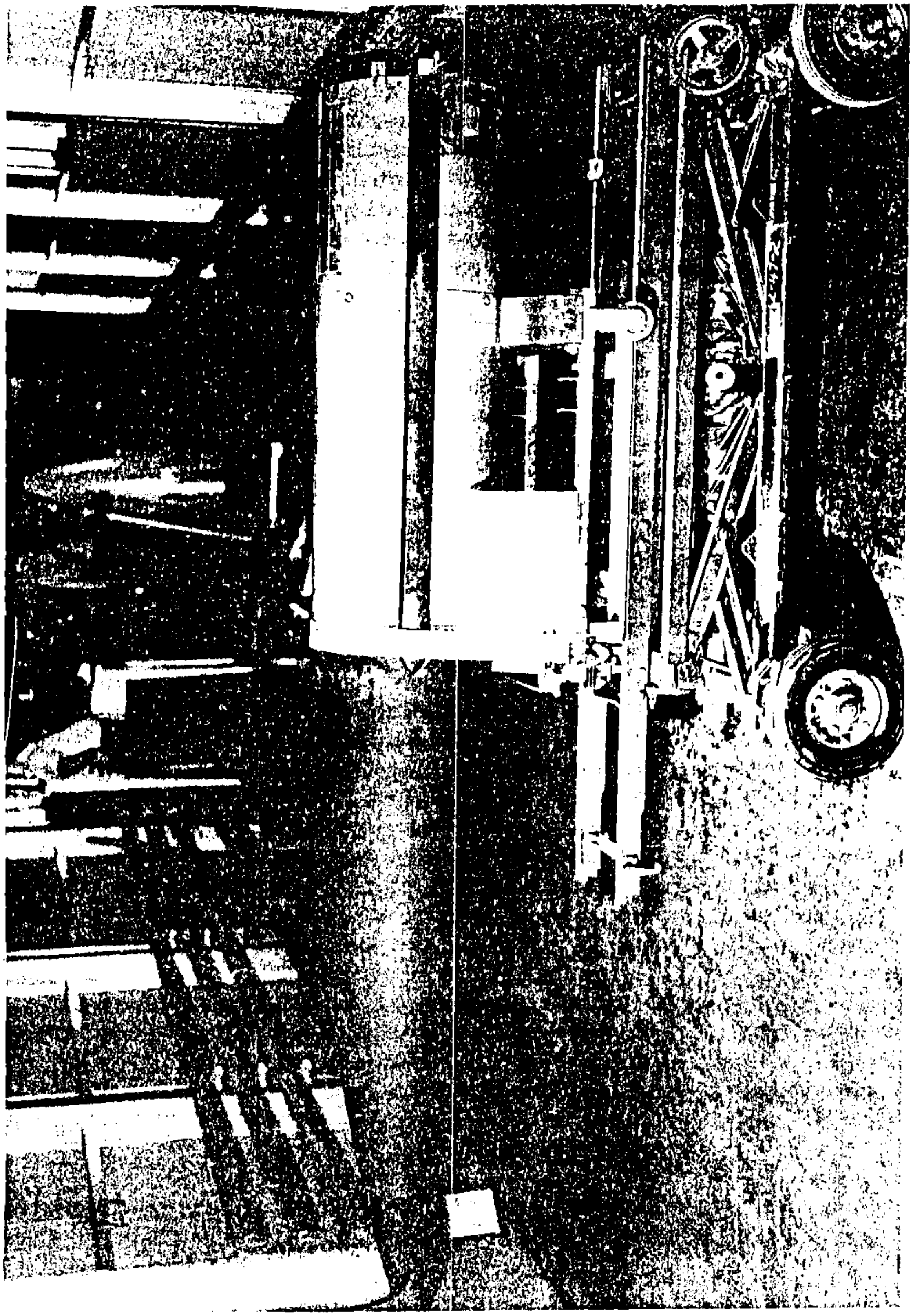

FIGURE D-16. HAWK Warhead Section, Fake

a. General

(1) Orientations. During the first day at each facility, all FT-34 inspectors received orientation lectures which acquainted them with the facility, safety practices, hazards, and security regulations applicable to the facility. These lectures were given by host plant personnel. Other administrative matters such as pay, leave, sickness, and transportation were covered by FT-34 test control personnel.

(2) Common Operations. FT-34 operations common to all AEC facilities incorporated into the overall exercise were three walkthrough tours of the facilities intended (1) to familiarize the inspectorate with the areas where disassembly operations would take place and (2) to permit inspector observations which would contribute to the revelation of classified information or conviction that actual nuclear weapons had been presented for destruction. These walkthrough tours were scheduled so that a tour preceded and followed all disassembly operations on a particular batch of weapons or materials.

Continuity of the inspection process was maintained by use of a weight balance between the weight of weapon shapes introduced at Pantex and material disposed of during disassembly operations. Weights of materials expended or reclaimed were given to the inspectors. (Weighing operations were observed by inspectors when it was practical to permit observation.) No evasion was practiced on shipments of weapon material between or within facilities which would involve weight balance considerations.

When necessary, practical training was conducted at the test sites to familiarize the inspectors with a particular activity (X-ray plate reading, gamma-spectrometer operation, assay procedures, etc.)

b. Walkthrough Tours

(1) General. The first test phase consisted of walkthrough tours of each of the four facilities by the

inspectors who looked for indications that the facility was equipped to process bona fide weapons, searched for indications that nuclear material had been prepositioned, and recorded any data that might reveal classified information. These walkthroughs were conducted before and after the processing of each batch of weapons or material..

(2) Pantex Walkthrough Tours

(a) Initial Walkthrough Tour. All inspector teams were admitted to the inspection area and were permitted to walk briefly through the disassembly areas to become acquainted with both the areas and the materials in the areas presented for inspection. After the initial quick tour, teams were separated into two groups, and each group was assigned to one of the disassembly areas for walkthrough tour inspection. A period of 2 hours was allocated for each group in each inspection area. At the end of the 2 hours, the groups changed areas so that both groups inspected both areas. The initial reaction on the part of inspectors upon viewing the weapon disassembly areas was one of surprise at the quantity of material exhibited, although some indication of the types and quantity of disassembly equipment was provided during training sessions at test headquarters. For the walkthrough tours, no weapons or weapon components were located in the disassembly areas. No attempt was made to shield or hide tools or fixtures which revealed classified information. All fixtures or equipment not associated with FT-34 was either removed or covered and marked as nontest material.

(b) Second Walkthrough Tour. After disposition of the first batch of burnable material, a second walkthrough inspection tour was conducted through the disassembly areas. This tour combined the operations of a final tour for batch one material and an initial tour for batch two materials. Inspectors provided information on differences noted between the first walkthrough tour and the second tour. Inspection data from the first tour were made available to teams for subsequent tours.

(c) Final Walkthrough Tour. A final walkthrough tour was conducted in the disassembly areas after disposal of all batch two materials. This tour was conducted in the same manner as the previous tours. High access teams were given the opportunity to collect small samples of materials in the area for later analysis. LIMA teams collected two scraps of high explosive material and one small particle of rubber of unknown origin. The high explosive materials, which were from weapons used in the test, were not classified. The rubber was uncontaminated; it could have been weapon-derived or could have been from the heel of a safety shoe. No classification was attached to any of the microsample particles found at Pantex.

(3) Rocky Flats Walkthrough Tours

(a) Initial Walkthrough. Inspectors were conducted on an initial walkthrough tour of the disassembly area and the foundry area. No weapon components were present in the areas, and all large equipment not to be used for FT-34 operations was covered. All non-FT-34 areas were blocked from view by the use of opaque plastic sheeting. After this walkthrough tour, components from the first batch of weapons inspected at Pantex were moved into the disassembly area and dismantled by Rocky Flats personnel. Inspectors did not view any disassembly operations.

(b) Second Walkthrough. After the dismantling and the packaging of components of the first batch of material was completed, inspectors were conducted on a second walkthrough of the disassembly area. Inspectors then were conducted on the second walkthrough tour of the foundry. The MIKE team did not elect to take a second walkthrough tour of the foundry area.

(c) Final Walkthrough. After disassembly and packaging of the components from the second batch was completed, inspectors were conducted on a final walkthrough of the disassembly area. During this walkthrough, the inspectors observed the nonplutonium and nonuranium components packaged for disposal. These components were not exposed to the inspectors. The LIMA inspectors were then conducted on a final walkthrough of the foundry. The MIKE teams did not elect to make a final walkthrough of the foundry area.

(4) Paducah Walkthrough Tours

(a) Initial Walkthrough Tours. Before weapon components shipped from Pantex were displayed, inspectors were conducted on an initial walkthrough of the disassembly and furnace area. These areas were cleared of any weapon components or equipment not used for FT-34 operations. Inspectors observed the weighing of empty containers (tare weights) in which some of the components prepared for disposition would be packaged. Storage areas containing non-FT-34 material and some FT-34 material not ready for display were obscured by the use of opaque plastic sheeting.

(b) Second Walkthrough. Inspectors were conducted on a second walkthrough of the disassembly and furnace areas after components of the first batch had been disposed of and before the second batch was processed.

(c) Final Walkthrough. A final walkthrough of the disassembly and furnace areas was conducted after components of the second batch of materials had been processed and disposed of.

(5) Oak Ridge Walkthrough Tours

(a) Initial Walkthrough. Before the first batch of uranium assemblies from Pantex and the uranium parts from Rocky Flats were disassembled and processed, inspectors were conducted on an initial walkthrough of the disassembly area and the enriched uranium foundry. All fixtures or equipment not to be used during the FT-34 field test were removed or covered. Non-FT-34 areas were obscured by the use of drop cloths. Access levels were the same as those used during walkthrough tours at all other test sites.

(b) Second Walkthrough. Before inspectors observed the weighing of the residue from the first batch of weapon shapes, they were conducted on a second walkthrough of the disassembly and foundry areas. The second walkthroughs of the disassembly and foundry areas were conducted on different days. Inspection consisted primarily of noting differences found between the walkthrough tours. This included location of tools, fixtures, and equipment.

(c) Final Walkthrough. A final walkthrough tour was conducted after all materials from the second batch had been processed. The final tour covered the foundry and the disassembly areas. As part of the final walkthrough tour, high access inspection teams were allowed to acquire microsamples for later analysis of material content. Several materials were intentionally planted by Y-12 personnel, but inspection team samples taken did not include any of the planted items. One of the other inspection microsamples revealed classified information.

c. Weapon Shape Inspection

(1) General. The second test phase was the inspection of the weapon shapes[1] presented for destruction. The inspectors recorded weapon information revealed by this examination and attempted to distinguish real shapes from fake shapes at each access level. This phase was conducted primarily at the Pantex facility. The credibility of the components was considered when they were inspected at Paducah. Monitoring was done at four levels of access. All other phases were done at two levels; low and high.

(2) Pantex Monitoring

(a) Weapon Shape Monitoring: First Batch Shapes. For the first batch of weapon shapes, the monitoring activities of all teams were performed at the A_1 access level. Upon completion of A_1 monitoring, low level teams were excluded from the inspection area, while high level teams remained to perform monitoring operations at the A_2 and the A_3 access levels. Space and safety limitations within the inspection area precluded the introduction of a full batch of weapon shapes at one time. Therefore, the weapon shapes were presented for

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[1]The term "weapon shape" is used to indicate that a batch might contain both real and fake weapons.

inspection in half-batches consisting of nine weapon shapes. Half-batches of weapon shapes were not composed of the same types of weapons. That is a half-batch did not consist of one of each of the nine types of weapons used in the test but rather was a mixture of shapes. One requirement for weapon shape presentation was that the Mk 39 bombs be in the first half-batch of shapes presented. Disassembly time was critical for the Mk 39, not only because of its size but also because of the method of HE disassembly required. The Mk 39 high explosive system was bonded at assembly and required cold-soaking at dry ice temperatures for a period of 24 hours or more to facilitate cracking and disassembly. This process has not always been successful on the first attempt; therefore, it was necessary to disassemble Mk 39 bombs early to allow for contingency time and schedule adjustment. The half-batch method of weapon shape presentation afforded the inspectors the opportunity to select several shapes from the first half-batch for verification of the premarked weight values and center-of-gravity (c.g.) locations. Because the first half-batch of shapes was being disassembled while the second half-batch was being inspected, weight and c.g. verification could not be permitted for second half-batch shapes. The scales used for verification of weights were located in the disassembly area where inspectors were not permitted during disassembly operations.

Before the introduction of weapon shapes, high access level teams were permitted to acquire background level readings on the Geiger counter and the portable neutron counter in the inspection area.

During weapon monitoring, each inspection team was required to list any classified information which it believed was revealed during inspection. Also required were team calls of real or fake for each weapon shape inspected at each access level of inspection. Specific instructions given to inspection personnel were to assume that a weapon shape was real (and to call it real) unless some significant reason appeared to indicate that a shape was fake. Information presented during training at test headquarters and additional guidelines presented in the inspection manual were the criteria used for both classification revelation and validity calls for weapon shapes. Weapon shape calls were by team consensus. Team leaders were authorized to break ties and to present team calls in the event that disagreement arose among team members. Team leaders were required to note minority opinions in their data packages.

During monitoring at the A_3 access level, Pantex personnel were available to help operate and calibrate the gamma-spectrometer used in the test. Initially, only one gamma-spectrometer was available for use, but a second was obtained and used for LIMA batch two and subsequent batches.

(b) Weapon Shape Monitoring: Second Batch of Weapon Shapes. Inspection monitoring for the second batch of weapon shapes was similar to that for the first batch except that low access teams performed A_1, and A_2 access level monitoring, and high access teams performed A_1, A_2, A_3, and A_4 monitoring. Weapon shapes were presented in a different order for batch two compared with the order of presentation used for batch one. Mk 39 bombs were still among the shapes presented in the first half-batch. X-ray training for high access teams was presented (see annex B), and X-ray plate reading tables were used for the A_4 access level. To add realism to the exercise, high level team members were allowed to observe the positioning of a weapon shape in the X-ray facility and to see how the X-ray technique was applied to FT-34 weapon shapes.

(3) Paducah Monitoring

(a) General. Weapon cases from which nuclear systems had been removed and other nonuclear components were sent from Pantex to Paducah for monitoring and final disposition. Monitoring of this residue was performed by batches at four access levels, as was weapon monitoring at Pantex. Inspectors were required to identify materials, to list classified information, and were permitted to make evasion calls.

(b) Case and Component Monitoring: Batch One. For batch one monitoring, low access teams inspected at the A_1 level. High access teams inspected at access levels A_1, A_2, and A_3.

(c) Case and Component Monitoring: Batch Two. The second batch of material was monitored in the same manner as the first, except that low access teams monitored at A_1 and A_2 levels, and high access teams monitored at all four access levels. Access level A_4 permitted handling of components and photography.

Based on observations at Paducah, inspectors were allowed to modify their conviction calls made at Pantex; a call of "fake" had to be justified.

d. Burnable Material Disposal

(1) General. The third phase of the overall destruction exercise was the burning of the high explosive and other burnable components from the weapons presented and disassembled at Pantex. This phase was also conducted at the Pantex facility.

(2) Disposal

(a) Batch One. After the first full batch of weapon shapes had been completely disassembled and the burnable materials positioned in tote boxes, inspectors were admitted to the disassembly area for monitoring. High access teams were permitted to see and photograph the burnable materials in the tote boxes. Low access teams were permitted to observe only the closed boxes. All tote boxes were marked with tare (empty) weights before burnables were placed in the boxes. All full boxes were weighed in the presence of all inspection teams so that the total weight of all burnables could be ascertained by subtracting all tare weights from all full weights. The tare boxes were loaded on trucks, and the inspectors accompanied the trucks to the burning ground area. Inspectors were conducted on a tour of the empty burn pads and were then directed to the remote bunker while the tote boxes were emptied and the contents prepared for burning. Burning was observable only from the bunker (control point) through a periscope and a mirror system provided by Pantex. After burning and after the appropriate safe waiting period, inspectors were permitted to inspect the residue on the burn pads. Low access teams sketched residue locations while high access teams used photography for recording data.

(b) Batch Two. The disposal of burnables for batch two materials was conducted in the same manner as for batch one materials. One difference did occur, however, in ascertaining tote box tare weights after material had been disposed of. Empty tote boxes were returned from the burn area to the scales in building 12-53 and weighed. Disposal weights were obtained by subtracting verified tare weights from full weights of all tote boxes.

e. Nonnuclear Material Disposal

(1) General. The fourth phase was the destruction of the remaining nonnuclear components by smelting and/or burial under the observation of the inspectors or by packaging and simulated disposal. This phase was conducted primarily at the Paducah facility. However, nonnuclear components associated with the nuclear assemblies were disposed of at Rocky Flats and Oak Ridge.

(2) Rocky Flats Disposal. Three types of weapon-derived materials were involved in Rocky Flats operations: plutonium for recovery and assay; uranium for shipment to Oak Ridge, and residue material such as beryllium, depleted uranium, and aluminum. Weights of incoming materials from Pantex were recorded by inspectors. The weight of recovered plutonium was determined in the foundry before sampling. Residue materials were packaged and considered disposed of under international agreements. Weights of residue packages were made available to inspection teams. The weight of uranium for shipment to Oak Ridge could then be determined.

(3) Paducah Disposal

(a) General. Material disposal at Paducah was accomplished by declaration and by burial.

(b) Monitoring Disposal. After all applicable components from the first batch of weapons had been processed by plant personnel, inspectors entered the disassembly and furnace areas and viewed the material at the appropriate access levels. Included in this display of materials were weapon cases and nonnuclear components, the lead and aluminum ingots recovered from case smelting, and slag associated with these materials. All materials were weighed in the presence of inspectors. Inspectors observed the burial of selected components which are normally disposed of by burial at Paducah. Other material was assumed to be properly disposed of. Materials in the declared disposal category were actually reclaimed for salvage and reuse after completion of the FT-34 inspection.

(4) Oak Ridge Disposal

(a) General. Disposal at Oak Ridge was by declaration. Two types of materials were involved in Oak Ridge operations: (1) recoverable enriched uranium, and (2) residue materials. Residue materials consisted of depleted uranium, lithium compounds, aluminum, stainless steel, beryllium, and other materials from nuclear assemblies of the weapons displayed at Pantex.

(b) First Batch Residue. After the plant had processed all components of the first batch of weapon shapes, all residue except the enriched uranium was packaged for simulated disposal. Inspectors observed the weighing of these closed packages and recorded the weights. Tare weights of containers were obtained during the initial walkthrough tour. At this point, the residue was assumed to be disposed of.

(c) Second Batch Residue. Inspection of residue for second batch materials was the same as for the first batch materials. Inspectors observed the weighing of residue packages and the residue materials were declared to be disposed of under safeguard conditions. There was no burial for material disposal at Oak Ridge.

f. Fissile Material Recovery and Assay

(1) General. The fifth phase was the assay of plutonium and enriched uranium recovered at Rocky Flats and Oak Ridge from the weapon shapes monitored and disassembled at Pantex. After disassembly of nuclear components at the appropriate test site, the fissile materials were smelted and cast into ingots or buttons for sampling, and the samples were evaluated in assay laboratories. Inspectors were required to list classified information revealed and to determine the purity and isotopic content of fissile material placed under assumed safeguard conditions.

(2) Fissile Material Recovery and Sampling

(a) Rocky Flats Weighing and Sampling. After completing the third walkthrough tour, inspectors observed the weighing and sampling of all plutonium ingots from both batches of weapon components. All inspection teams had identical access to the collection of samples for assay purposes and observed the sampling activity which was performed by Rocky Flats personnel. Because of the hazardous nature of plutonium, this operation was performed by experienced Rocky Flats personnel rather than by the inspectors. Sufficient sample material was taken from each ingot to permit assay by each team of all cast plutonium ingots. Spare material was taken from each ingot to permit standard assay by the Rocky Flats laboratory for control purposes. No evasion was practiced in the sample collection.

There were four ingots of plutonium in each batch of weapon shapes. During the LIMA group weighing and sampling operations, the high access teams, 2 and 4, observed the weighing and sampling of two ingots. The low access teams, 1 and 3, observed the weighing and sampling of two other ingots.

During the MIKE group operation, one inspector was selected from each team to observe the weighing and sampling of all ingots. Congestion in the sampling area during the LIMA exercise suggested this change in procedure.

(b) Oak Ridge Weighing and Sampling. Inspectors observed the weighing of all billets on the scales in the foundry area. At this point, ingots were assumed to be placed under the safeguards of an international control agency. Sixteen billets, [redacted], were obtained from each batch of weapon material. DOE (b)(3)

Inspectors of teams 1 and 3 observed the drilling of ingots and the degreasing of samples in preparation for assay. Inspectors of teams 2 and 4 performed these operations themselves.

Time was not available for assaying samples from all ingots obtained from the weapon material processed. It was necessary, therefore, to limit the number of samples assayed. While samples (up to three samples per ingot) could be taken from every ingot, the time limitation required each team to select only four samples from each batch to be assayed. These four samples were selected at random by the inspectors from all the ingots available from a specific pour. At least one sample from a pour was required. No evasion was practiced during sample collection phases of the test. The samples from each ingot were positively identified by the test controllers at the time the sample was taken. This identification was necessary to keep records for comparing results with control samples from each ingot used by Union Carbide personnel. [redacted] DOE (b)(3)

Inspectors retained control of the samples once they were taken and personally took them to the assay laboratory.

(3) Assay Operations

(a) General. The assay of the recovered fissile material was conducted at Oak Ridge for uranium and at Rocky Flats for plutonium after samples were taken. At both locations, the process was similar although different equipment and techniques were utilized. The purity of the sample in grams of uranium or plutonium per gram of sample was determined by chemical analysis, impurities were analyzed by emission spectroscopy, and the isotopic content of the recovered material was determined by mass spectroscopy.

(b) Rocky Flats Assay

1 Assay Training. While Rocky Flats personnel were disassembling components, inspectors were given onsite training in laboratory procedures as preparation for the assay portion of the exercise. As a result of experience gained from LIMA operations the MIKE group was given an orientation tour of the FT-34 laboratory area.

2 Assay Operations. Assay of samples from the first batch was performed first. Teams 1 and 3 observed all operations being performed by plant technicians. Inspectors on these teams were not allowed to question operators except to confirm what operation was being performed. Teams 2 and 4 performed all assay operations except those which were carried out within glove boxes. Inspectors from these teams questioned plant technicians about operations in the glove boxes with the limitation that no questions concerning evasion be asked.

Evasion was practiced in each area of the plutonium assay. Because all fissile material obtained in the test was scheduled for reuse in the weapons program, no dilution or conversion was permissible either in the smelting/casting operation or in the samples taken. Evasion was, therefore, limited to assay techniques themselves (see chapter IV).

During all phases of assay inspection, inspectors were asked to state whether or not they believed evasion had been practiced. A call of evasion had to be justified.

(c) Oak Ridge Assay

1 Assay Training. While Oak Ridge personnel were processing components of the first batch of weapons (disassembling, smelting, and casting), inspectors were trained in assay techniques and the use of assay equipment. Inspectors previously had classroom training in assay procedures at test headquarters. Assay procedures and the operation of equipment was described to all inspectors. Inspectors having the higher access were trained to operate the equipment and to perform all assay operations themselves. Low access level tours were permitted only to observe assay procedures being performed by Y-12 laboratory personnel.

2 Assay Operations. Assay operations involved chemical titration to determine the weight of uranium in the sample; emission spectroscopy, to determine the impurities in the sample; and mass spectroscopy, to determine the isotopic content of the uranium. Inspectors of teams 1 and 3 observed assay operations performed by plant technicians. Inspectors of teams 2 and 4 performed assay operations using plant equipment.

Evasion was practiced on all teams during the assay. Inspectors were asked to judge (call) after each assay operation whether or not evasion was practiced. If an inspector stated that evasion had been practiced, he had to give a valid reason for his call. A listing of classified information revealed was also an inspection requirement.

f. Weight Balance. Throughout all test phases and at all test sites, inspectors maintained records of the weights of materials being processed. The incoming weights were determined at Pantex by weighing the weapons presented for destruction. At each of the four facilities, the outgoing weight of burnables, nonnuclear material, and fissile material was determined and recorded. The total outgoing weight was compared with the incoming weight to determine the net weight balance for the process. Because of time and equipment limitations, inspectors did not perform the actual weighing but spot checked the weights determined by plant personnel. Weight balance information was retained by each inspection team as it moved from one test site to the next. Several operational problems occurred, particularly at Paducah, which negated some of the test reference data needed for analysis.

C. MILITARY INSPECTOR SPECIAL ASSAY

When each of the LIMA and MIKE groups of inspectors finished the overall exercise, selected members of each group were rearranged into four teams of two men each in order to investigate further some of the problems associated with inspection of the assay of uranium. These teams inspected the assay of eight specially prepared uranium samples. The effect of access on inspection performance was tested by allowing two of the teams high access (i.e., they performed most of the assay operations themselves) and the other two low access (i.e., they could only observe the assay as performed by the host laboratory technicians). The effect of team composition was tested by having two of the teams composed of men relatively experienced in laboratory procedures while the remaining teams were relatively inexperienced. The arrangement and denotation of these teams is shown below. All of the teams were subject to extensive evasion practices during the assay of most of the samples.

Team Structure - Military Special Assay

Team composition	Access	
	Low	High
Experienced	L_a, M_a	L_b, M_b
Inexperienced	L_c, M_c	L_d, M_d

L = LIMA Group
M = MIKE Group

D. LABORATORY SCIENTIST SPECIAL ASSAY

After the special assay exercise by the military inspectors, three skilled laboratory scientists supplied by the operating contractor at Oak Ridge performed the same assay operations. They worked only as a high access team (i.e., performing the work themselves) assaying the same set of eight specially prepared samples and being subjected to the same evasion schemes as the military special assay inspectors. The three team members were experts respectively in the chemical analysis, emission spectroscopy, and mass spectroscopy phases of uranium assay.

E. TEST ORGANIZATION AND SUPPORT

The test headquarters was located at the AEC facility at Paducah, Kentucky. The test headquarters staff consisted of the Test Director, Technical Director, Operations Officer, and several Support Officers. A data section was established at the test headquarters to serve as a central collection point for all test data resulting from field operations. Initial data analysis was performed by this group.

The staff maintained at each of the operating sites included a Test Site Commander, a representative of the analytical contractor, two AEC classification specialists, a support officer, and four Test Control Officers. The latter accompanied the inspection teams during their operations to insure that the test plans were followed and completed. The AEC classification specialists monitored all operations to assure that all classified information exposed was identified.

At each of the four test sites, the AEC operating contractor performed the disassembly and destruction operations and provided certain basic support operations.

Annex A, "Test Control and Support," describes in detail the test organization and functions used for FT-34.

The schedule for field operations is shown in figure D-17. In general, the planned test schedule was adhered to at the various test sites. The overall schedule deviated from plans by 1 week because of the delay in availability of contractor assay personnel.

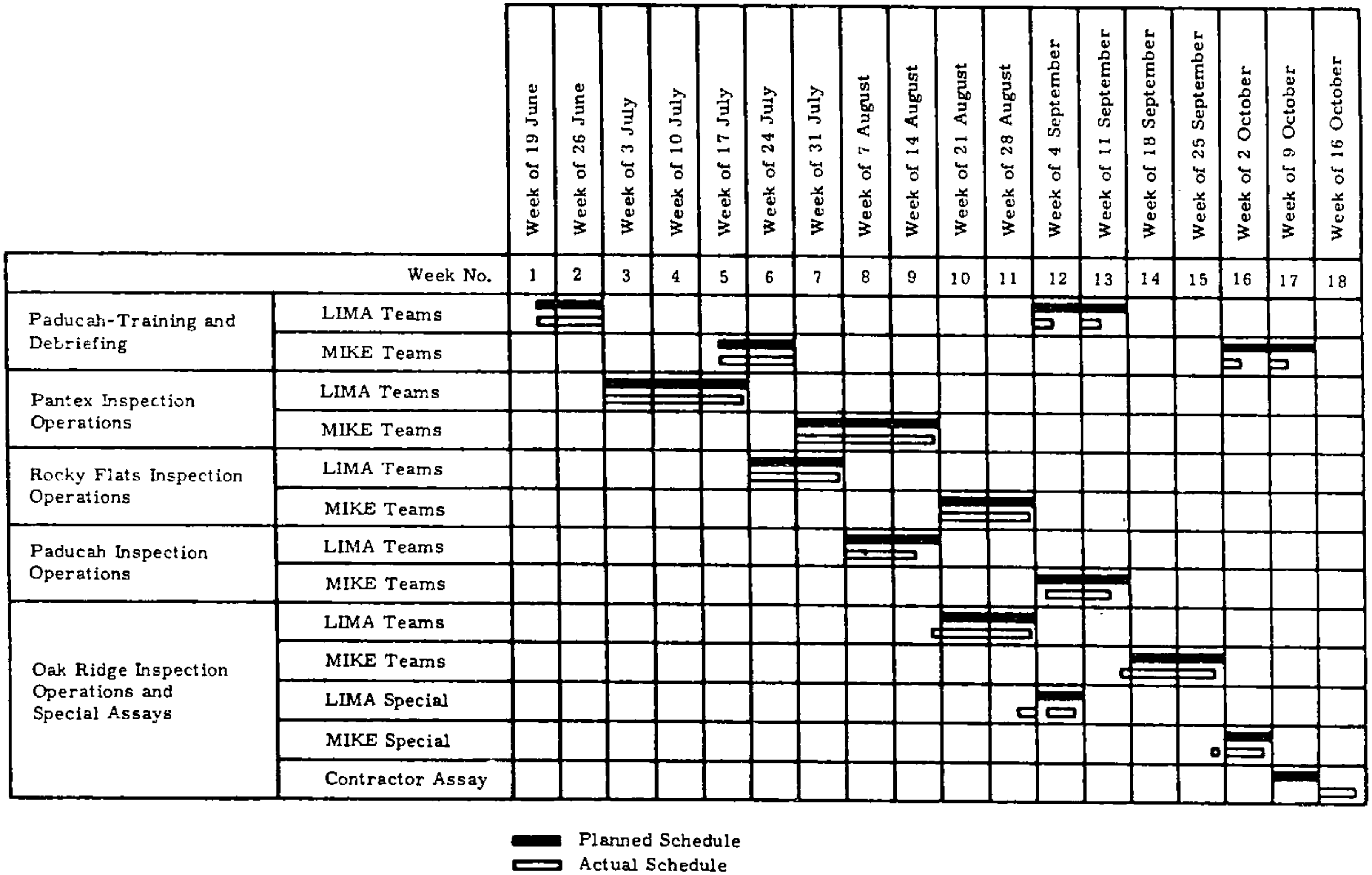

FIGURE D-17. Field Operation Schedule, FT-34

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III. POST-TEST EXERCISES

A. GENERAL

After the completion of FT-34 test operations in October 1967, two post-test exercises were planned and conducted to expand the data base for analysis and to acquire information expected to be of value in interpreting test data. These exercises also involved review of the field test data by knowledgeable experts. The post-test exercises were directed toward acquiring information relative to two major test objectives: classification and conviction.

B. CLASSIFICATION REVIEW

The first post-test exercise was a review and an evaluation of the relative values of classified information items associated with the FT-34 field test. For this review, a document containing evaluation information and instructions was prepared and circulated to selected evaluators. The document contained two parts. Part I consisted of a listing of 110 information items separated into information categories of (1) fission systems, (2) thermonuclear systems, (3) nuclear materials, (4) external weapon information, and (5) nonnuclear components. The 110 information items were derived from weapon and materials design information exposed during field test operations. The list contained not only classified information from the field test but also other design features which were judged to be important if revealed to foreign nationals in the process of a treaty demonstration of nuclear weapon destruction. Not all items listed were classified by current AEC classification guidelines. The list of Part I items is shown in annex F. Part II consisted of a listing of weapon monitoring information for all FT-34 access levels and extrapolated information associated with an untested access level which was defined as access to weapon disassembly operations with measurement and sampling privileges for nuclear system components only. This level is referred to as A_5. Access level information for Part II was furnished for six of the nine weapon types used in FT-34: all real weapons, plus the fake Hawk warhead section, were used; others contained either no classified information or information duplicated by one of the six shapes used.

Evaluators were instructed to complete Part I before starting Part II. For each part of the classification review booklet, evaluators were asked to provide a score based upon a preselected item arbitrarily assigned 100 units or points; these scores reflected the evaluators' opinions of the value to foreign nationals of each item. Two groups of foreign nationals were considered: one group from a current nuclear power (U.S.S.R.) and the second group representing an Nth (nonnuclear) country.[1] Evaluators were instructed to score each item for each group in the Part I section. For Part II, evaluators were instructed to score information presented for each weapon for access levels A_1 through A_4 before scoring the information content for the untested A_5 access level. Excluding the preselected base scores, each evaluator provided 218 scores of information items listed in Part I and 48 scores for the access level-weapon matrix of Part II. No limit was placed upon the evaluators in scoring, although zero was considered to be the lowest score possible (negative scores were not permitted), and the arbitrary base score provided was not to be construed as a maximum score possible. Fractional scores were permitted.

Evaluators were told that items presented were not necessarily classified by current classification guidance but that some items, regardless of classification, were believed to convey nuclear weapon design information which would possibly be of value to other nations if revealed during inspection. The level of classification of an item presented for scoring was to be considered secondary to the evaluator's opinion of the actual worth of the item. This condition was delineated so that scores would not reflect classification guide information directly. Data from this exercise were analyzed and the results are shown in annex F.

[1]An Nth country was defined as one which has the technological base necessary to embark upon a nuclear weapons program. Sweden was cited as an example of an Nth country.

Fourteen evaluators were selected to score the classification review booklet. The major qualification for evaluator selection was that the individuals selected have an extensive background in some phase of nuclear weaponry or in classification related to nuclear weapons. Evaluators were all properly cleared personnel selected from several government agencies directly associated with nuclear weapons.

C. CONVICTION TEST

The second post-test exercise was a conviction test directed toward accumulating additional data regarding the credibility of weapons used in the FT-34 field test. Inspection personnel used for this test phase were obtained from AEC contractor laboratories and were experienced in nuclear weapon design and development. Five three-man inspection teams were used for the conviction test. Each team was composed of a physicist, a mechanical engineer, and an electrical engineer. The conviction test was performed in two stages. The first stage, conducted at Sandia Corporation Sandia Laboratory during the week of 8 December 1967, used three inspection teams composed of six engineers from Sandia Corporation Sandia Laboratory and three physicists from the Los Alamos Scientific Laboratory. The second stage, conducted during the week of 5 January 1968, used two teams composed of four engineers from Sandia Corporation Livermore Laboratory and two physicists from the Lawrence Radiation Laboratory. All teams were presented with the same information for the conviction test.

An instruction booklet for the conviction test was prepared and distributed to all inspectors. The booklet described the FT-34 field test and its objectives, provided background information concerning FT-34, and presented general instructions pertaining to the conduct of the conviction test. The conviction test was described as a proxy field test utilizing data and information derived from FT-34 inspection and test reference data. The purpose of the conviction test was to determine how well inspectors could distinguish between real and fake weapon shapes at several access levels of inspection. Only nine weapon shapes were used for the conviction test, one each of the nine types used in FT-34. The test was conducted as though inspection were performed at a single destruction facility. All walkthrough tour information was presented as part of the A_1 access level, as was information on weight balance of materials, assay results, total quantities of fissile materials, and burn pad residue data. At access levels A_1 through A_4, Pantex and Paducah monitoring information was combined. No test data were available for the A_5 access level. Inspectors were instructed to make calls of real or fake on each weapon shape at each access level. Calls of fake were to be supported by reasons why the weapon shape was suspect. Two sets of calls were required from each inspection team. One set of calls was required on the basis that shape "could be real;" the other set of calls was required on the basis that the shape "is real." The first set of calls dealt with limited information based only on test data; the second set dealt with unlimited information and other factors such as prior knowledge, poor design, etc. which varied with the individual inspector. Real or fake calls were recorded by inspection teams. In addition to the team calls, each inspector was required to indicate his conviction, on a scale of 0 to 100 percent, that the shape was real for both "limited" and "unlimited" conditions. Each inspector initialed his set of percentage conviction calls so that trends among the skills represented could be ascertained. Data from the conviction test exercise were analyzed, and results were compared to those of field test inspectors. Results of the analyses are shown in annex F.

The use of only nine shapes for the conviction test, the presentation of test information in single facility format, the use of all access levels by all teams, and the constant team size and composition were factors which precluded any replication for FT-34 and conviction test inspection procedures. No replication was intended between the two groups, nor was replication used.

IV. EVASION

A. PURPOSE

Evasion methods practiced against inspection teams was a controlled test variable in FT-34. The purpose of evasion was to permit a determination of the effects of evasion on test results and to assess the ability of the test inspection force to detect and record evasion practices used in the test. One of the major test objectives, conviction, was dependent upon the results of inspector discrimination between bona fide and fake weapons presented for destruction. Evasion weapon shapes, therefore, became a major item of interest for the test. The ability to detect evasion during assay of fissile materials was indirectly a part of the conviction objective and was also directly related to another test objective, the effectiveness of inspection procedures. A description of the evasions used in FT-34, in both weapons and assay, is presented in this section.

B. WEAPON INSPECTION EVASION

The weapon shapes used in FT-34 were described in chapter II. Figures D-23 through D-26 show cross sections of the fake weapons used during the test.

The BDU-12/B, figure D-18, is used as a practice bomb. It has the appearance and ballistic characteristics of the MK 57 bomb but is merely an empty shape which can be dropped and recovered for reuse. For the FT-34 test, the units were modified by the addition of a lead ballast in the rear case section and of a ½-kg. plutonium ball suspended in foam plastic in the nose section as far forward as possible. External appearance was enhanced by machining grooves around the circumference of the shape to resemble the clamp bands used in the real weapon. Flooding ports, pullout plugs and connectors were also added to provide a simulation of the real weapon. Total weight of the unit was approximately

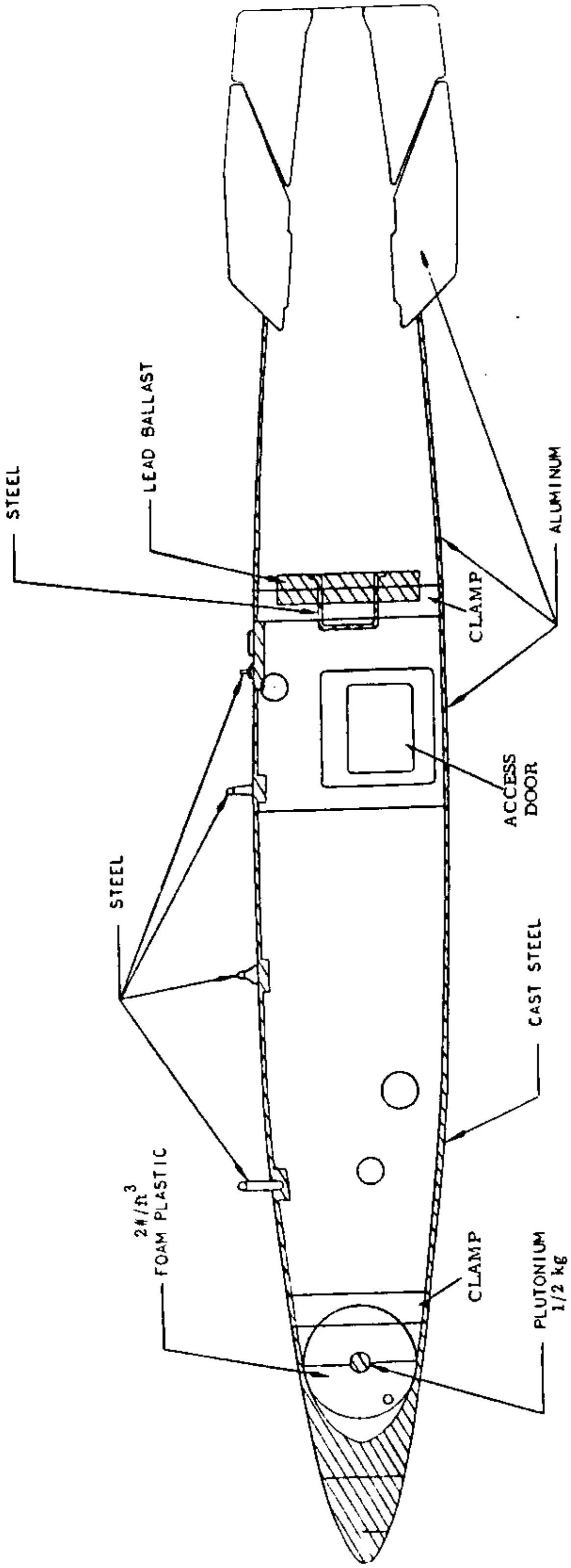


FIGURE D-18. Mk 57 BDU (Bomb Dummy Unit)

FIGURE D-19. 8-Inch Artillery Shell (Mk 33 Mockup)

(b)(1)
(b)(3)

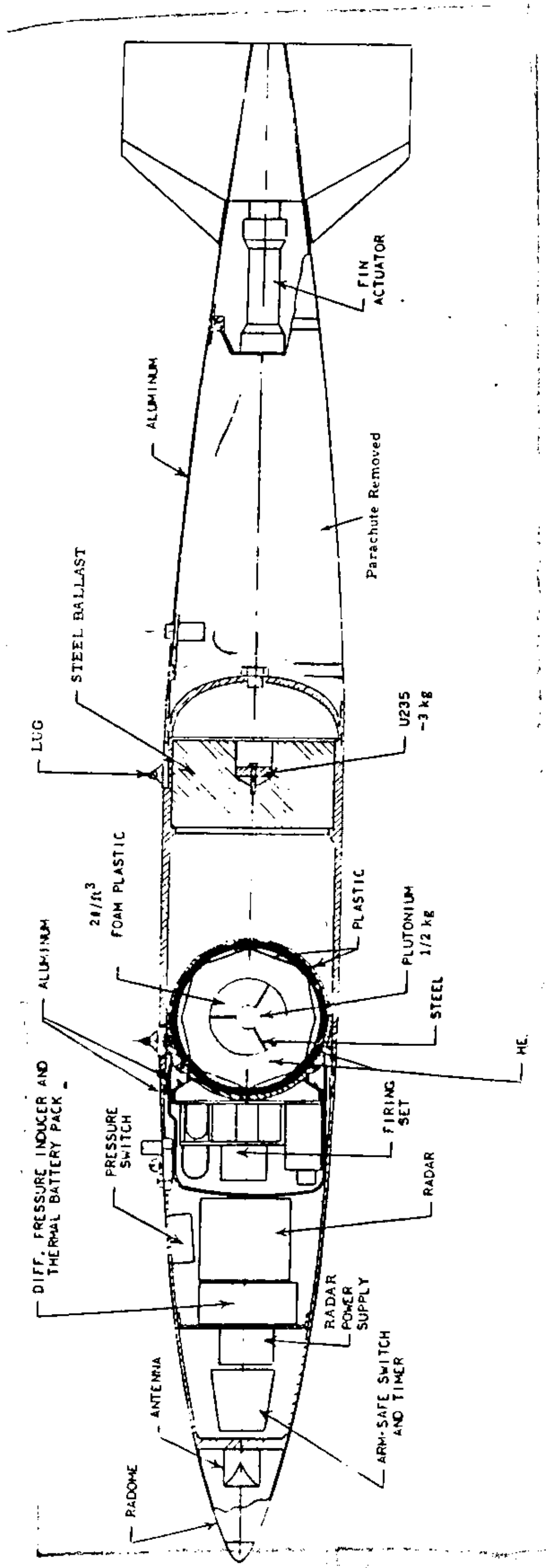


FIGURE D-20. Mk 28/EX Bomb, Y-1 Mockup

FIGURE D-21. HAWK with Fake Nuclear Warhead

(b) (1) DOD
(b) (3)

500 pounds, which approached the true weapon weight. The lead ballast (74 pounds) was used to increase the BDU weight to the proper value and to help position the center-of-gravity at an appropriate location. This unit was intended to be exposed as a fake weapon at access level A_2 because of the unusual and invalid location of radioactive material (Geiger counter survey) and because of the bare interior exposed through the opened access door which on the real weapon houses preflight monitor and fuze setting components.

Figure D-19 shows the mockup fabricated to resemble the 8-inch nuclear artillery shell, Mk 33. For this mockup, conventional inert 8-inch artillery shells were obtained and modified. Additional length was added to the rear of the shell to provide an overall length equal to that of the Mk 33. The windshield was changed to accept a threaded 1-inch bar which ran the length of the shell. The bar was interrupted at [redacted] Externally, machining was done to simulate openings in the case for detents and dashpots. The additional length caused the rotating band to appear forward of normal locations. The 8-inch shell was expected to be exposed as fake at access level A_3 by means of the gamma-spectrometer traces which should have indicated the [redacted] While external appearance was somewhat questionable, the shell was expected to pass undetected at the A_1 and A_2 access levels. Geiger counter readings at A_2 access level were expected to indicate [redacted] radioactive material.

Figure D-20 shows the Mk 28 fake weapon used in the test. This shape was derived from the Y1 yield Mk 28/EX bomb, which is the fission nuclear system version. The Y1 version uses a steel ballast to provide weight and adjust the center-of-gravity location so that all yield versions of the Mk 28 will have approximately the same drop characteristics. For the test, the fission portion was disassembled, and the normal pit was removed and replaced by a foam-covered plutonium ball of the same type used in the Mk 57 BDU and the Hawk. Then the system was reassembled. [redacted]. Nose and tail sections were the same as those found on the bona fide Mk 28 bomb. The fake Mk 28 bomb was expected to be exposed at the A_4 access level (X-ray). The lack of a definitive pit in the primary region [redacted] should have revealed the system as a fake. A_1 level, both real and fake Mk 28 bombs were externally similar, although the fake weapons weighed, on the average, about 40 pounds less than the real weapon. Also, rivet patterns present on the real weapon in the nuclear system region were not present on the fake weapon, although this is a situation which exists because of normal differences in the two different yield versions of the weapon. [redacted]

DOE (b)(1)

DOE (b)(3)

DOE (b)(3)

Figure D-21 shows the Hawk warhead section used for the test. The Hawk system was an inert trainer which was modified for FT-34 use. The inert conventional warhead was removed from the trainer and replaced with a mockup nuclear warhead. The mockup nuclear warhead was configured to resemble a [redacted] The simulated high explosive material consisted of a wax in which magnesium chips were suspended. This material was fabricated to burn during disposal operations. A self-destructed capacitor discharge unit, MC621, from another weapon was used as a firing system. The fake warhead was held in place within the

DOE (b)(3)

warhead case section by foam pieces. The Hawk warhead section was expected to remain unexposed as a fake throughout all access levels. Appearance at A_1 access level should not have provided information necessary to determine that the shape was fake. Geiger counter scanning at A_2 should have shown the presence of radioactivity, and gamma-spectrographs at A_3 should have shown the presence of plutonium, U-235, and U-238. Confirmation of plutonium should have been made at A_3 by neutron counter readings. X-ray plates of the fake warhead were expected to appear credible at the A_4 access level.

In addition to the physical changes made on the fake weapons, all weapons used in the test (except the Mk 11 reentry vehicle) were spray painted various colors on a random basis. The purpose of the painting was twofold: to conceal machining and handling marks which might reveal real or fake shape information and to present to the inspectors weapons which were slightly altered from the way they appeared in the field. This slight alteration in appearance, which was intended as a mild confusion factor, was used in lieu of major modifications and repackaging which would have completely masked weapon identities and relegated inspector prior knowledge to a very minor consideration. Such modification would have been costly and timeconsuming and was therefore ruled out early in the test planning stages.

C. ASSAY EVASION

1. General. The assay or analysis of purity of fissile materials as practiced at Rocky Flats and at Oak Ridge laboratories consists of three separate processes which serve to reinforce and cross-check each other.

a. Chemical Analysis. Chemical analysis by titration is used to determine the percentage of plutonium or uranium in a test sample. Characteristically, values found are generally greater than 99 percent. Careful sample preparation and titration yields results accurate to a fraction of a percent. Results of chemical analysis are generally stated in terms of the number of grams of plutonium or uranium per gram of sample material. To obtain these results, precise weighing of gram quantities of sample material on an analytical balance is required.

b. Emission Spectroscopy. Once the percentage of plutonium or uranium in a sample is determined, the remaining portion of the sample is considered as impurity and is subject to further investigation. Emission spectroscopy is used to determine the types of impurity materials in the sample and their relative abundance, generally determined in parts per million (ppm). The addition of quantities of impurity materials serves as a rough check on the total impurity content found by chemical analysis. Emission spectroscopy utilizes a dried, powdered sample, mixed with appropriate carrier material which is vaporized by an electric arc. This vaporization causes the material under test to emit characteristic spectral lines which vary in intensity according to the quantity of the element present in the sample. The spectrum is recorded in either of two ways. The most precise method used is to record the entire spectrum on a flexible glass sheet coated with a photographic emulsion. Development of the plate, after exposure, produces images of the spectral lines which may be optically compared to a standard set of lines to obtain abundance values. A second method of emission spectroscopy is that of direct readout. The equipment used for direct readout, often called a "quantometer," utilizes phototubes to record spectral line intensity as the sample is arced. Direct reading spectrographs have the advantage of rapid results but suffer from the limitation that only selected (usually 20) elements can be scanned rather than an entire spectrum. If known and predetermined elements are present in a test sample, the direct reading spectrograph can be a very useful analysis tool. If unknowns are expected, it is necessary to use the glass plate method to obtain an entire spectrum. Because comparison methods are used for spectrographic analysis, accuracy may in some instances be no better than 50 percent. The electronics used in direct reading spectrographs make this method of analysis subject to many evasion techniques.

c. Mass Spectroscopy (Isotopic Analysis). The percentage of plutonium or uranium in a sample is determined by chemical analysis and the impurities are determined by emission spectroscopy; the last step in assay is the determination of the abundance of the appropriate isotopes in the sample under test. The mass spectrograph provides this information. The thermal mass spectrograph uses a single (or dual) filament, coated with a solution of sample material. The filament is placed in the instrument and heated by electrical current passed through the filament so that ions of sample material are "boiled off" the filament. The ions are accelerated by an electric field, and their paths are caused to curve by a magnetic field situated perpendicular to the accelerating electric field. Ion path curvature is proportional to the mass of the ion; therefore, the spectrograph "sorts" ions according to mass and collects information by means of detectors of ion currents. Intensity of the ionic current is a measure of the abundance of the particular ions in the sample; therefore, relative mass abundance of isotopes can be found. The relative abundance values are apportioned according to the amount of material of all isotopes found by chemical analysis. This method yields the specific quantity of a particular isotope in a sample. The electronics used in a mass spectrograph make the instrument susceptible to several forms of evasion.

A description of the equipment and procedures used for assay analysis in FT-34 may be found in Technical and Operation Plan, Annex E, "Equipment."

2. Overall Destruction Exercise Evasion

a. General. Assay evasion was practiced at both Rocky Flats and Oak Ridge (Y-12) laboratories during the overall destruction exercise of FT-34. Because of the special assay exercises which were to emphasize evasion, limited evasion practices were used in main test assay phases of inspection.

b. Rocky Flats Evasion. During the assay of plutonium at Rocky Flats, evasion was practiced against all inspection teams. One-half the sample operations were subjected to evasion. Logically, the purpose of evasion would be to make the purity or content of the fissile material appear to be higher than that actually provided. This type of evasion would enable the evader to submit a lesser quantity of material to safeguards, while he apparently met stipulated quantity agreements. The difference between evaded and true values would provide for the withholding of fissile material for weapons use. The plutonium used in FT-34 was high purity, weapons grade material which was to be reclaimed for weapons use. Dilution or blending of the material was economically infeasible. Therefore, evasion practices used in plutonium assay were forced in the direction of making the purity appear lower than it really was. The same techniques could be used to make a low purity appear higher. Evasion was practiced in all phases of assay at Rocky Flats.

(1) Chemical Analysis Evasion. The evasion used during chemical analysis consisted of introducing a more concentrated indicator solution (ferroin end-point indicator) into the titration flask of the blank used for standardization of the ceric sulfate titrant. This solution changed the normality calculations of the titrant and affected the calculations of all samples using the calculated normality. The higher concentration indicator was introduced by the use of an evasion maneuver which used a double storage bottle for the indicator (see figure D-22). The small inner bottle contained the higher concentration indicator solution. With the large bottle full, the opacity of the solution caused the inner bottle to be obscured from view, except from direct top viewing which was not available for inspectors. The laboratory technician transferred the indicator from the inner bottle, rather than from the large bottle, to the titration flask.

(2) Mass Spectroscopy Evasion. Mass spectroscopy evasion was accomplished at Rocky Flats by the use of precoated filaments which were used by the inspectors. The precoating was done with a material high in Pu-240 content which altered the ratio of plutonium isotopes obtained. Since the isotopic ratios must total 100 percent, increased Pu-240 made the Pu-239 abundance appear lower than it actually

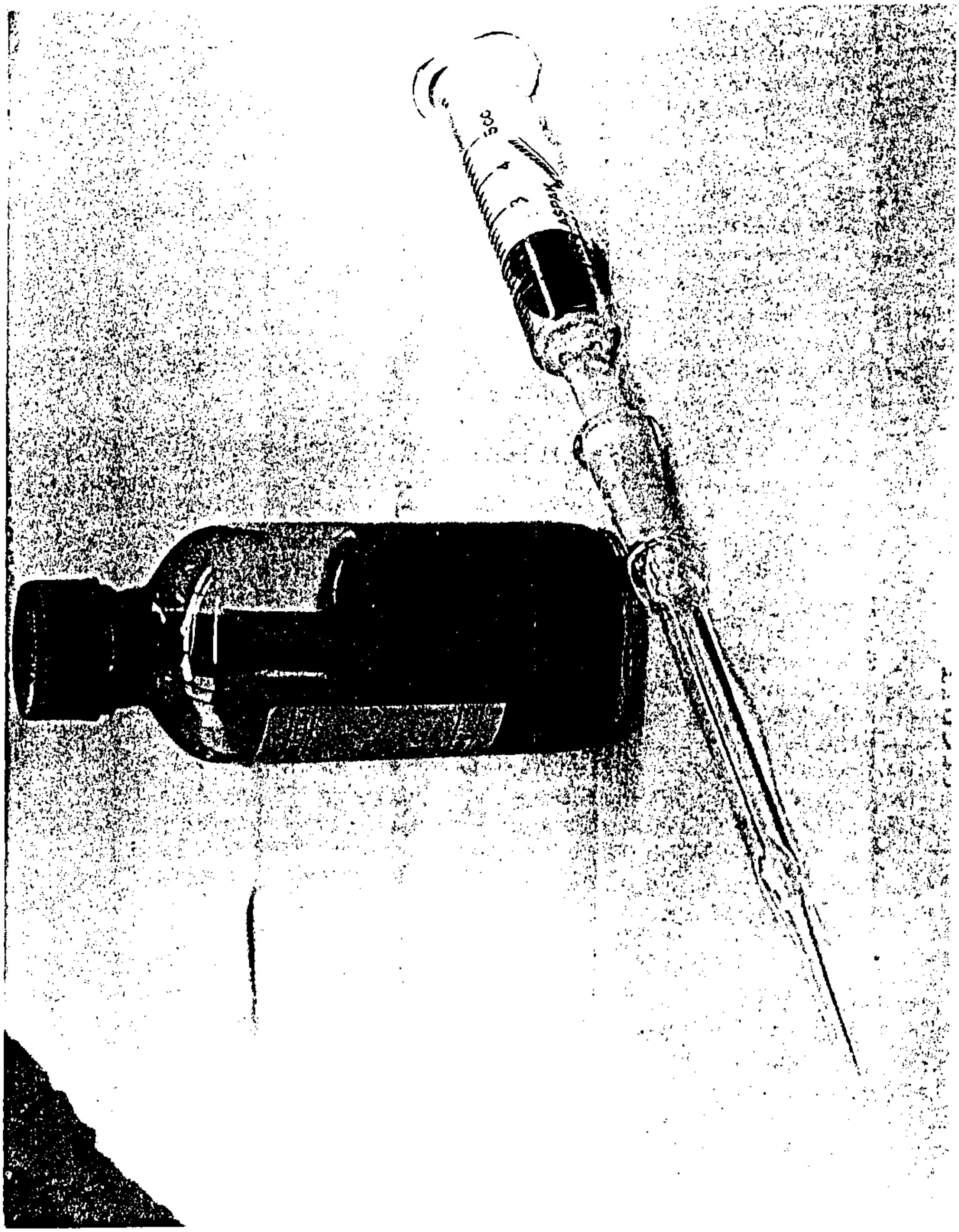


FIGURE D-22 Ferroin Indicator Solution Bottles and Transfer Pipette was. The precoated filaments had a tarnished appearance which could have been detected by alert inspectors. Newly coated filaments are clean and shiny in appearance. Figure D-23 shows the filaments as they appeared before insertion into the mass spectrograph.

(3) Emission Spectroscopy Evasion. Evasion was practiced during emission spectroscopy by the addition of three elements, aluminum, calcium, and zinc, to the sodium fluoride carrier normally used. This contamination made the normal amounts of these elements in the sample appear high and balanced the impurity level found in chemical analysis where plutonium content was made to appear lower than actual. After it was weighed, the contaminated carrier mixture was placed in plastic vials, and the vials were attached to masking tape to facilitate handling within glove boxes. Figure D-24 shows the vials of contaminated carrier mixture. Figure D-25 shows where the contaminated vials of carrier material were transferred. The noncontaminated carrier vials were filled in the presence of inspectors or by high access inspectors, and a sleight-of-hand switch was made by the laboratory technician as the uncontaminated vials passed through an airlock to a conveyor belt behind protective glass. Figure D-26 shows where the switch was made and the method of switching.

(4) Evasion Opportunities. Each inspection team observed the assay of two samples of plutonium from each batch of material derived from weapons inspected at Pantex. Each inspection team observed four samples run through each of the three phases of assay for a total of 12 sample operations. For all eight teams, a total of 96 sample operations were used at Rocky Flats. One-half of the sample operations used evasion tactics. All of the batch two (LIMA) and batch three (MIKE) sample operations were evaded in all areas or phases of assay. Chemical analysis evasion was designed to produce a plutonium content approximately 1 percent lower than actual. Emission spectroscopy evasion produced results approximately 3 percent low.

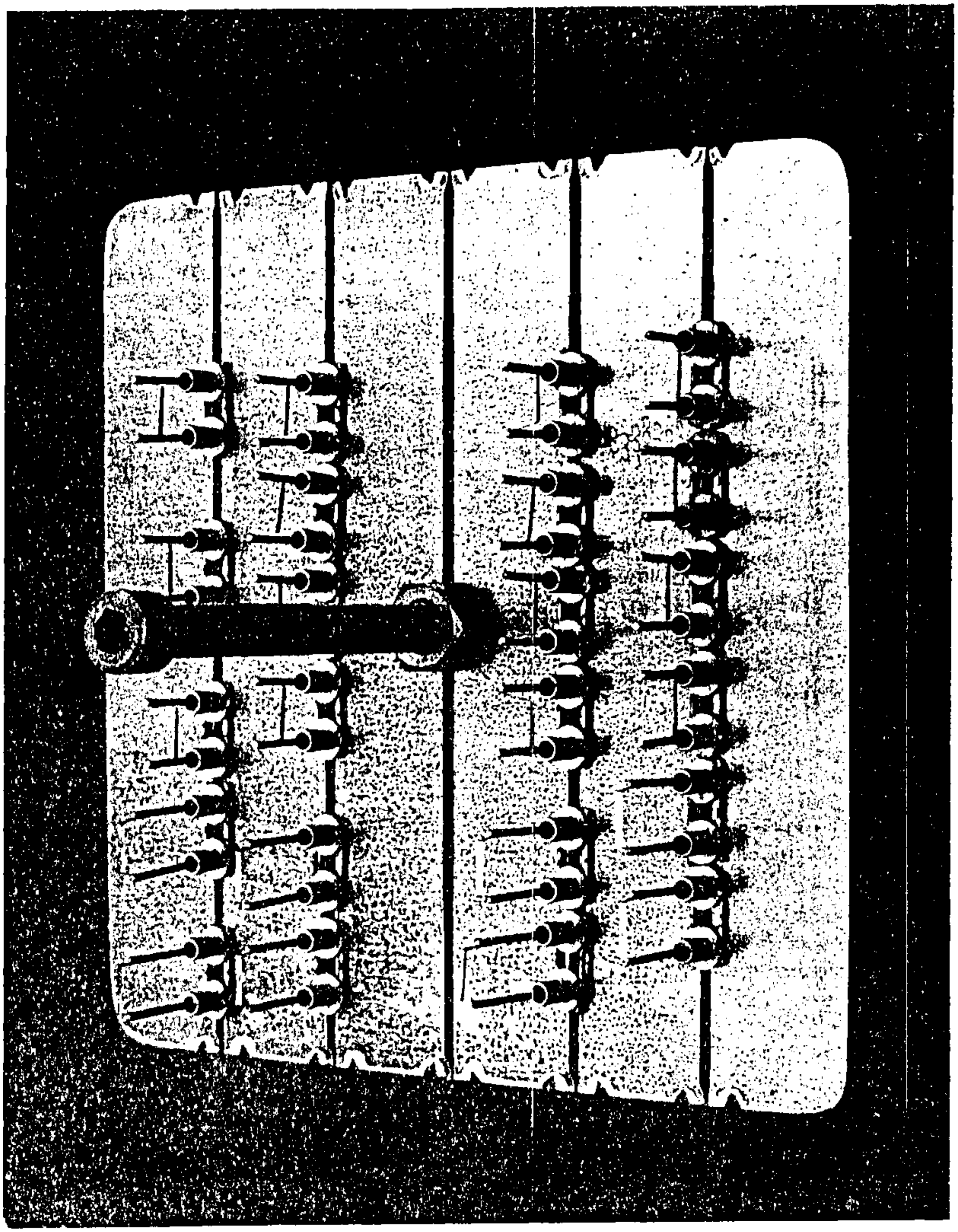


FIGURE D-23. Mass Spectrographic Filaments

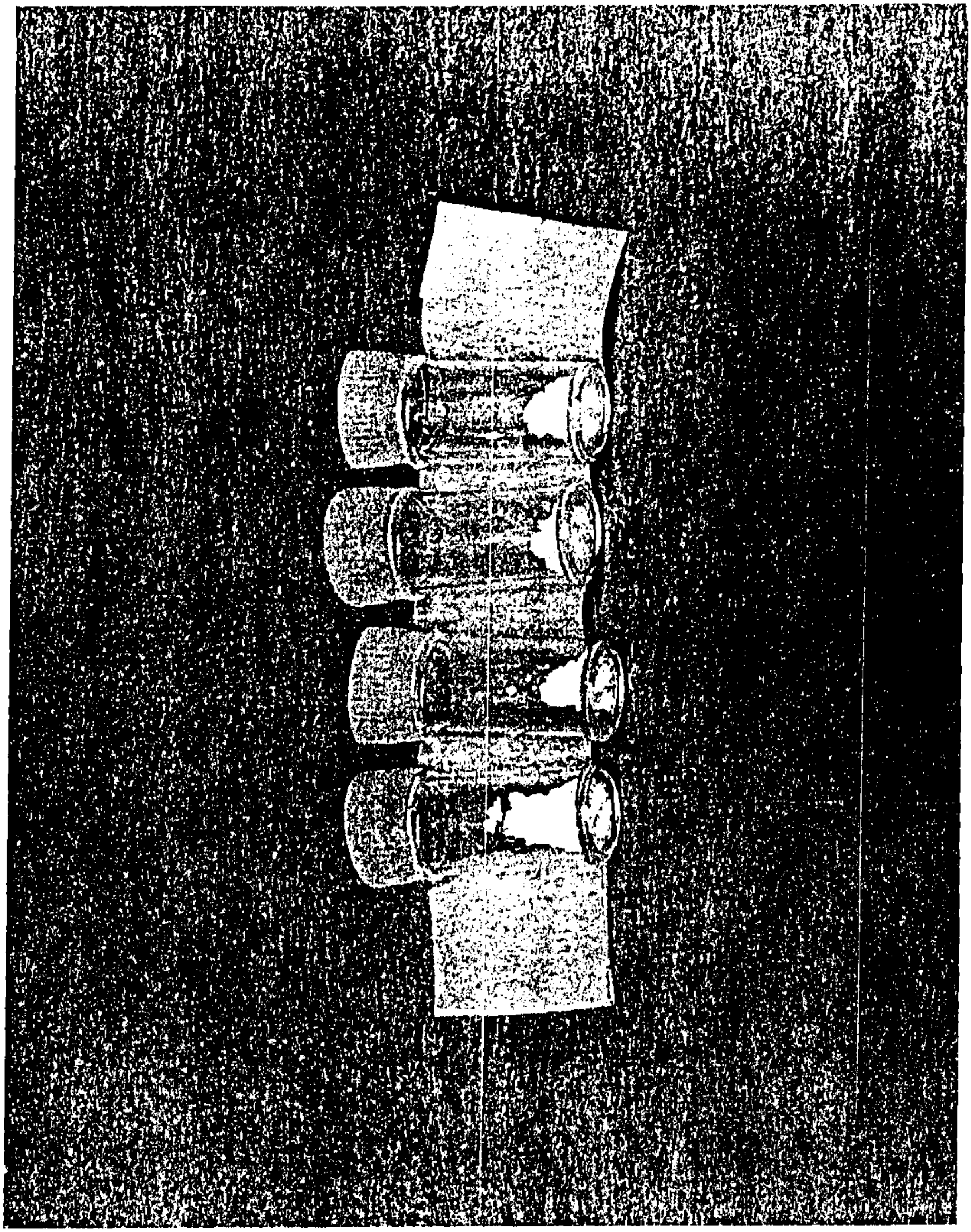


FIGURE D-24. Vials of Carrier

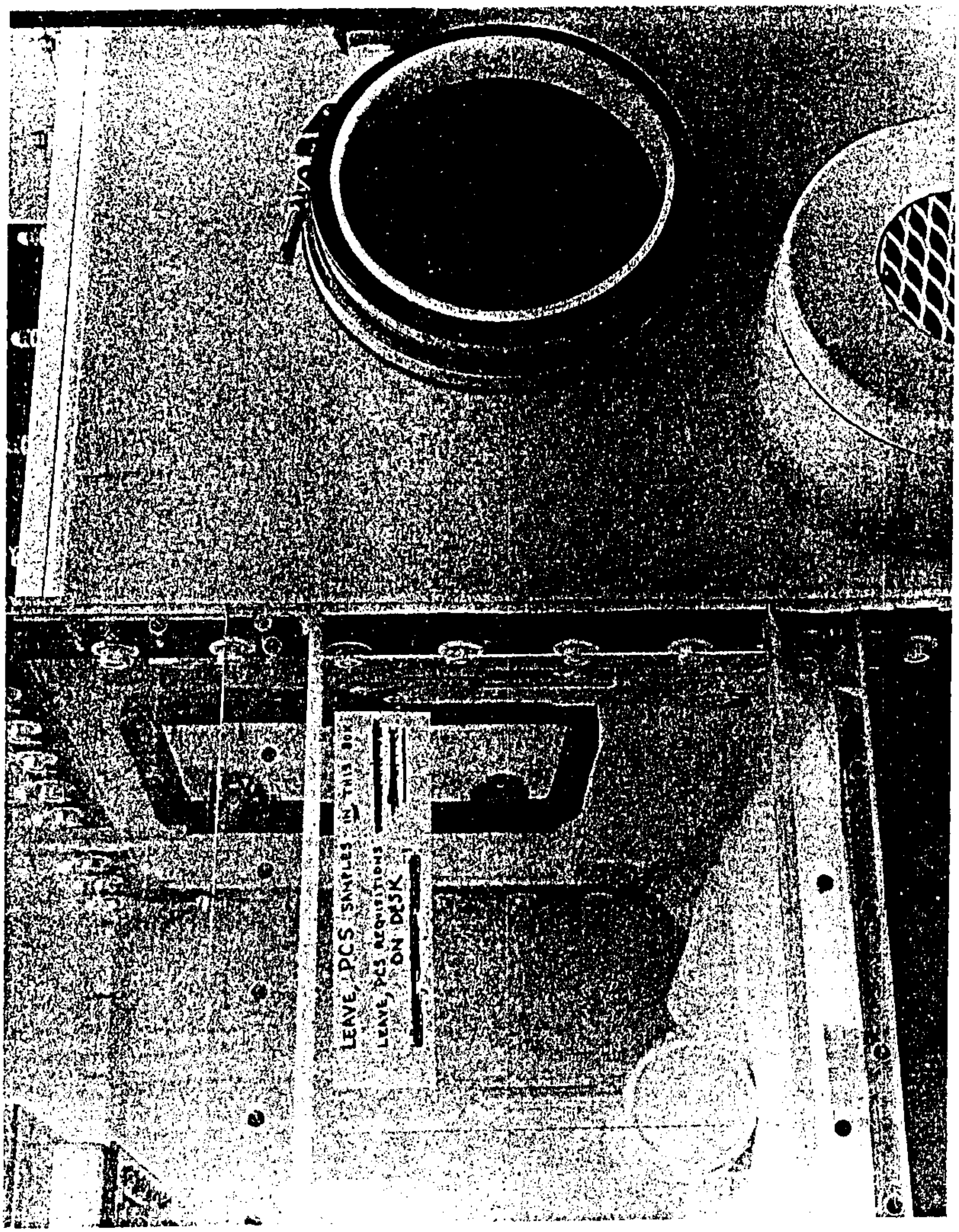


FIGURE D-25. Airlock-Conveyor Carrier Transfer Area

FIGURE D-26. Carrier Vial Switching Operation

c. Oak Ridge Evasion

(1) Isotopic Analysis Evasion. Evasion was practiced against all inspection teams during the main test assay of enriched uranium. The percentage enrichment of the uranium recovered from weapons disassembled at Pantex was such that evasion techniques could be used to make the U-235 content appear higher than actual values used. Only one type of evasion was used during main test assay at Oak Ridge: mass spectroscopic evasion in isotopic analysis. The specific type of evasion used, which was designated the "ratio method," consisted of remote observation and control of the isotopic ratio peaks which appeared as an output of the mass spectrograph on the strip recorder chart paper. This output was different from that used at the Rocky Flats mass spectrograph. At Rocky Flats, output information was presented by means of a digitized system, which printed results rather than by means of graphic display of isotopic peaks used at Oak Ridge. The ratio method of evasion was used on only those samples which contained normal product level (nominal 93-1/2 percent) U-235.

The ratio method of evasion used at Oak Ridge was developed to alter the readout peak of the U-238 isotope so that ratio measurements of the other isotopes, particularly U-235, would appear larger than actual values. Ratio alteration was accomplished by the insertion of a larger-than normal impedance between the vibrating reed electrometer and the strip recorder pen circuit. The insertion of this impedance was done by electrical relays which were actuated by remote means. A manual remote switch and a radio-controlled switch were used to actuate the impedance insertion relay. Automatic switching was also used, and the remote switches were used to back up the automatic switching, if necessary. The automatic switching involved the use of a solid-state device as a flux level detector positioned between the poles of the mass spectrometer electromagnet. When a flux level corresponding to the midpoint level between graphical readouts for isotopes U-237 and U-238 was reached, a voltage crossover detector actuated a switching relay to insert impedance into the recorder for U-238 isotope presentation. This reduced the signal output and display of U-238 while other isotopic displays remained normal and thereby altered the U-235/U-238 ratio in the direction of increased content of U-235. A remote recorder was used in conjunction with the remote relay control switches to monitor spectrograph recorder values and to enable operators to override automatic switching. Figure D-27 shows a block diagram of the ratio evasion method. Figure D-28 shows the automatic switching electronics package developed at the Y-12 laboratory.

(2) Evasion Opportunities. Each inspection team participated (either by observing or performing) in the assay of eight samples during the main test assay at Oak Ridge. Each team, then was involved in 24 sample operations of which four sample operations were evaded by the ratio method. The total number of sample operations for all teams was 192, and the total number of evaded sample operations was 48. The extent of evasion used at Oak Ridge was approximately 2 percent.

3. Special Assay Exercise Evasion

a. General. For the special assay exercise conducted by military inspectors at Oak Ridge, evasion was used in all phases of assay against all inspection teams. Specially prepared sample materials were used for the special assay test. These materials were not derived from the weapons used in FT-34, but they did contain enriched uranium at either a high (93-½ percent) or a low (37-½ percent) enrichment. The samples were alloyed with aluminum and iron. The ternary alloy used constituted part of the evasion, but further evasion was designed to either mask the presence of one or more of the constituents or to provide false information regarding the extent of the constituent in the sample. Samples were provided to inspectors in a precleaned and degreased condition so that no time would be lost for these preparatory operations.

Evasion used during the contractor assay exercise was the same as for the special assay test for

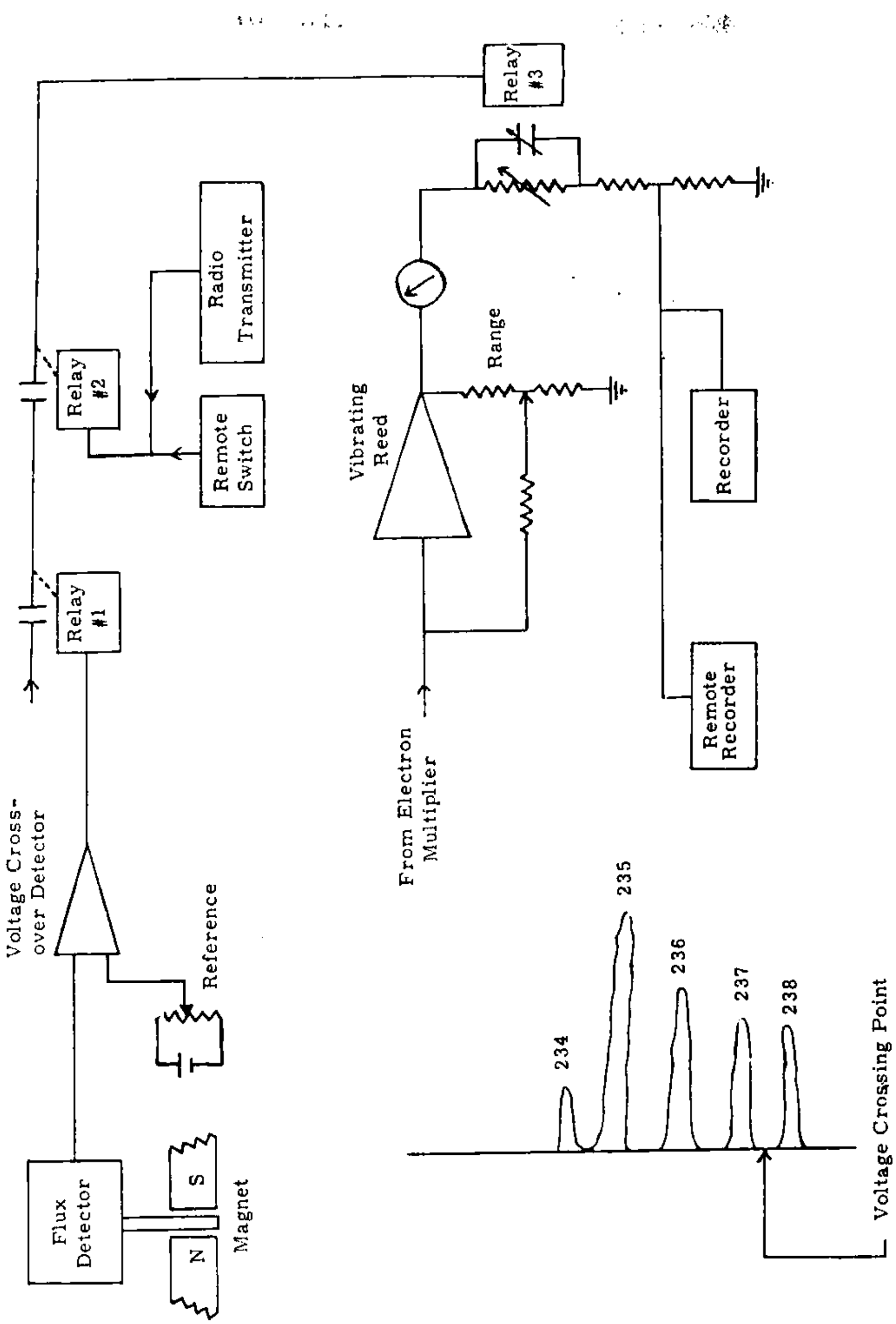


FIGURE D-27 Mass Spectroscopic Evasion, Ratio Method

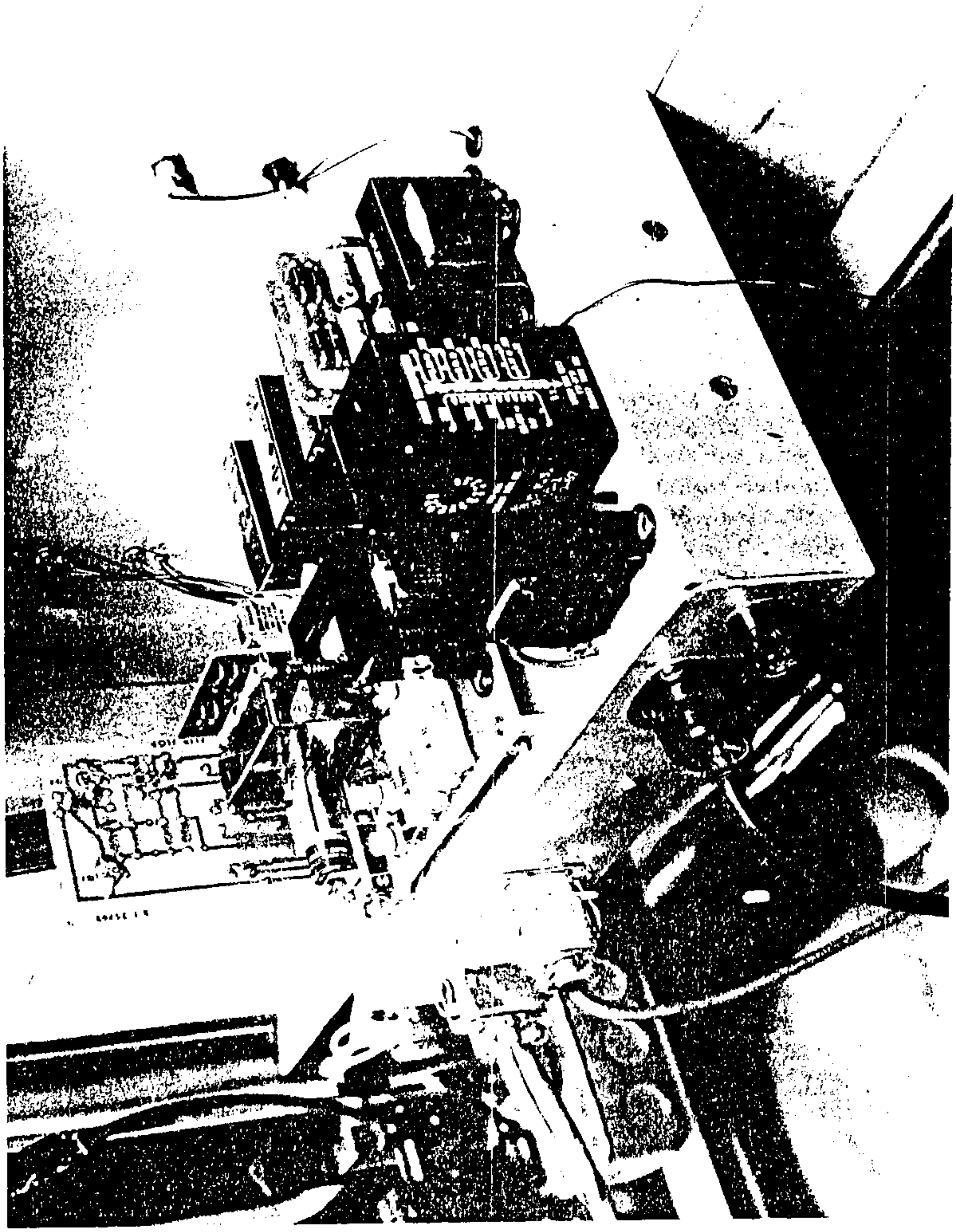
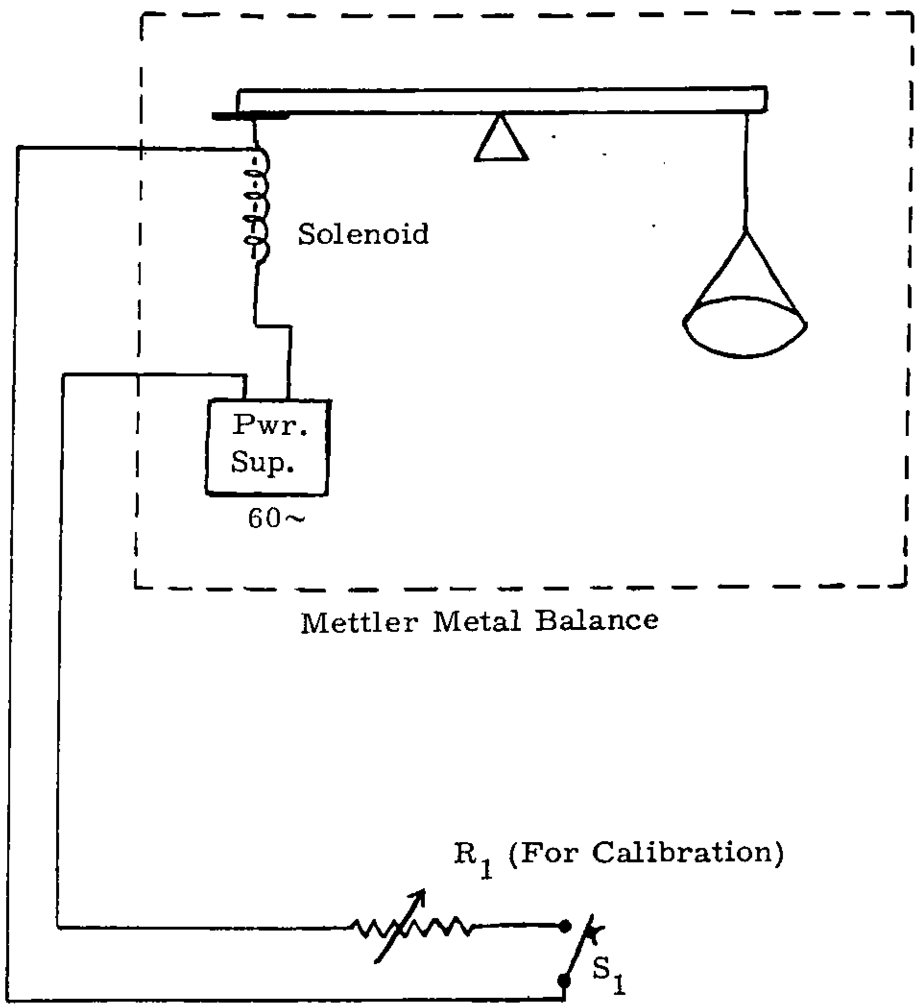


FIGURE D-31. Electronics Package Used for Ratio Evasion military inspectors. The MIKE special assay test evasion schedule was used for the contractor assay test. The single contractor inspection team used eight unknown samples and performed all phases of assay analysis. For the contractor assay test there were 24 sample operations and 12 of these were evaded sample operations.

b. Chemical Analysis Evasion. Two methods of evasion were used during chemical analysis phases of the special assay test. These are discussed below as (1) the use of ternary alloys and (2) use of a modified analytical balance.

(1) Use of Ternary Alloys. Five of the samples used in the special assay test were made up of specially prepared uranium samples. Three of these were alloyed with 0.9 percent iron and 1.1 percent aluminum and two of them with 1.6 percent aluminum by weight. Because iron titrates similarly to uranium, the values obtained during titration for grams of uranium per gram of sample appeared high by about 2 percent. The aluminum in the alloy did not titrate as uranium. It was simply an inert ballast to supply the necessary weight to the sample.

(2) Use of a Modified Analytical Balance. In order to obtain acceptable results in determining grams of uranium per grams of sample, sample weights must be made with an accuracy of a few parts in ten thousand for gram quantities of material. A Mettler analytical balance was used at the Oak Ridge Y-12 laboratory to provide accurate sample weights. A specific balance was designated for FT-34 use, and this balance was arranged so that a remotely controlled switch could cause the balance to weigh low by about 1.5 percent. The balance was modified by the addition of a small electromagnet located within the balance housing. The magnet was remotely energized when a false weighing was desired; at all other times the balance weighed correctly. A block diagram of the evasion scheme is shown in figure D-29. The remote switch was located in a drawer of the balance table adjacent to the FT-34-designated balance (figure D-30). When an inspector brought a sample to the



Note: R_1 and S_1 located at a remote control station

FIGURE D-29. Block Diagram - Analytical Balance Evasion Technique

FIGURE D-30. Remote Switch for Mettler Balance Evasion

FT-34 balance, the balance operator at the adjacent table observed the sample bottle color code and, from prearranged instructions, activated the balance electromagnet when the proper samples were being weighed. Laboratory technicians were scheduled to perform normal plant operations at the adjacent balance bench during all FT-34 sample weighings. Constant alertness was required on the part of the operators so that false weighings were produced on only the correctly designated samples. In figure D-31, the Mettler balance is shown without its case. In figure D-32, the Mettler balance is shown with the electromagnet installed. Wiring from the adjacent balance to the FT-34 balance was located in the floor power receptacles and ran under the floor between benches. The ground wire and terminal in the grounded (3-wire) power line was used to carry energizing current for the electromagnet.

c. Emission Spectroscopy Evasion. Both types of emission spectrographs were used in the special assay test: the full spectrum photographic plate type and the direct-reading type. Evasion was used for both instruments.

(1) Jarrell-Ash Full Spectrum Analyzer. Four of the eight samples per team were analyzed on the full spectrum analyzer. Since an excess of aluminum was deliberately added to two of the uranium samples, it was desirable to mask the presence of aluminum so that impurities found by emission spectroscopy would not indicate a deviation from total impurities found by chemical analysis. For the full spectrum analyzer, a carrier containing aluminum was used. When arced, the aluminum in the carrier effectively masked the aluminum in the sample so that quantities could not be ascertained.

(2) Direct Reading Spectrograph (Quantometer). Four of the eight samples per team were analyzed on the quantometer which recorded the presence and quantities of 18 different elements. Evasion for the quantometer was used to hide the quantity of iron in the ternary alloy samples. Originally, iron was to be shown as zero (or just a few parts per million). However, it was found during sample preparation

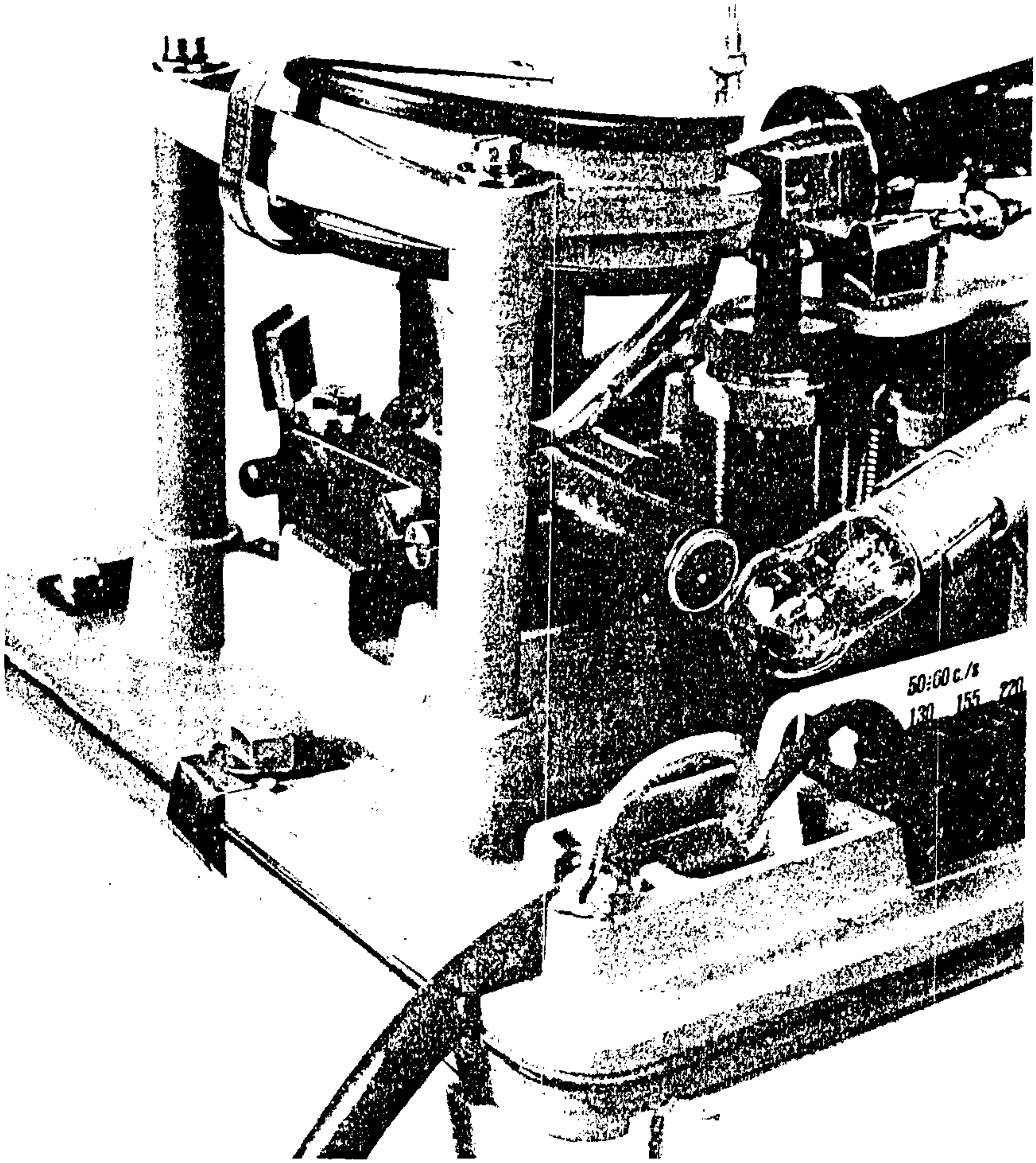


FIGURE D-31. Mettler Balance Without Case

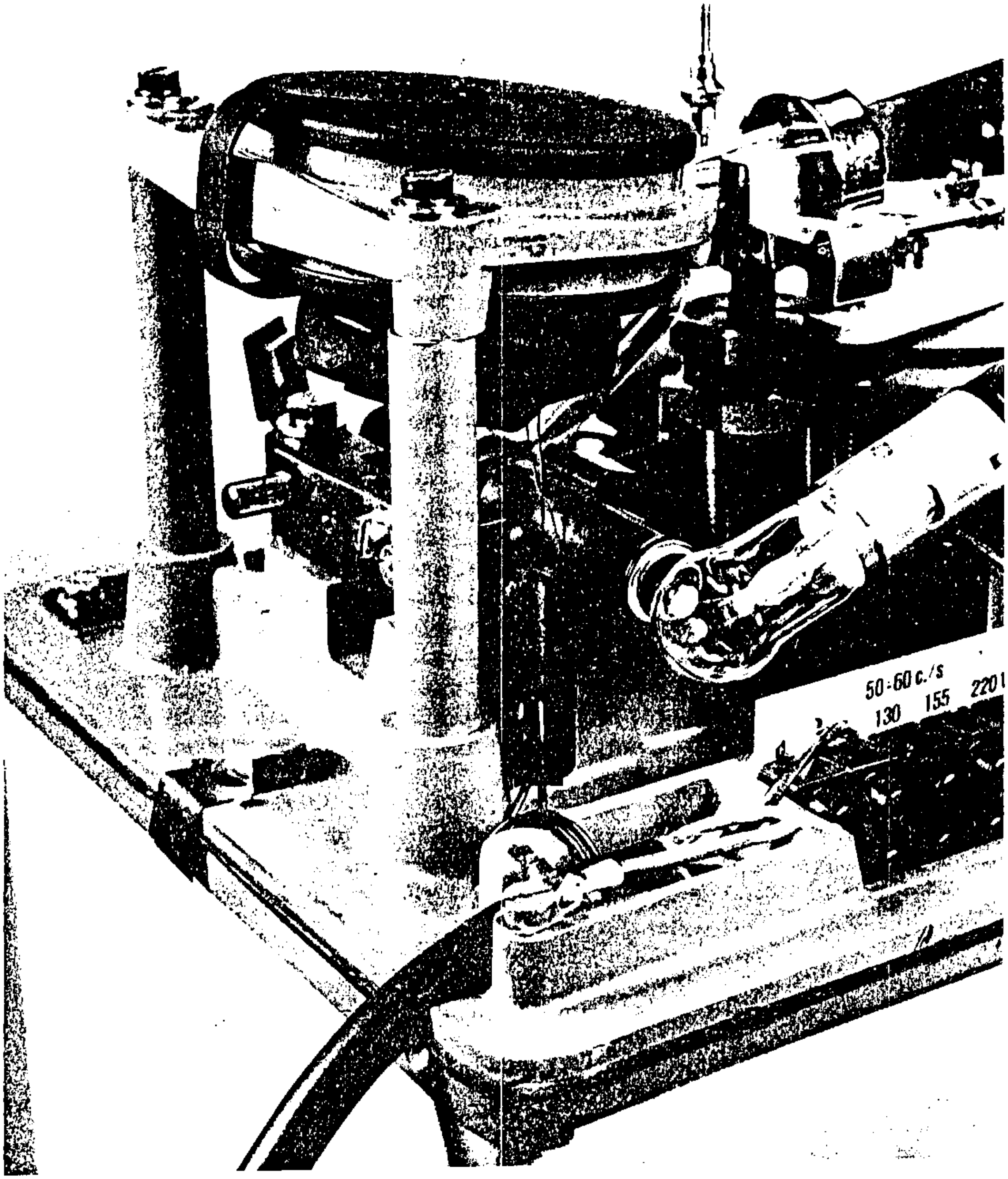


FIGURE D-32. Electromagnet Installed in Mettler Balance that iron in the sample appeared as a noticeable and easily identified "rusty" precipitate and, subsequently, had to be revealed in emission spectroscopy. The actual quantity in the samples was approximately 8000 parts per million; this quantity would have revealed evasion used in chemical analysis. Therefore, it was decided to show the presence of iron in the sample but only to the extent of 700 to 900 parts per million. The method used for reducing the apparent quantity of iron in the sample is shown in figure D-33. Each sample which contained iron was also "spiked" with a small quantity of germanium. When the sample was arced, the presence of germanium was detected, and this detection triggered a tape programmer which opened a relay. The relay controlled an evasion resistor which was in line with the recorder output trace for the iron line in the sample. Thus, the evasion scheme was self-actuating when the proper sample was arced and evasion was desired. A manual switch was also used to control the evasion relay. This switch had to be used early in the LIMA special assay. Figures D-34 and D-35 show the iron trace obtained from the quantometer when evasion was not used and also with the use of the evasion relay. Without evasion, an off-scale reading occurs and indicates the presence of iron as several thousand parts per million. With evasion, the same sample indicates 700 to 800 parts per million for iron. Figures D-36 and D-37 show the electronic racks of the quantometer and the evasion circuitry location.

d. Mass Spectrographic Evasion. Two methods of mass spectrographic evasion were used during the special assay test to make the quantity of U-235 appear larger than it actually was.

(1) Ratio Method. The ratio method of evasison described above, was used during main test assay and in the special assay test.

(2) Hidden Filament Evasion. A second method of mass spectrographic evasion, similar to the method used at Rocky Flats, was used for the special assay test. A filament, coated with a preselected isotopic ratio material, was inserted into the ion source of the mass spectrograph in such a manner that the source appeared normal for cursory visual

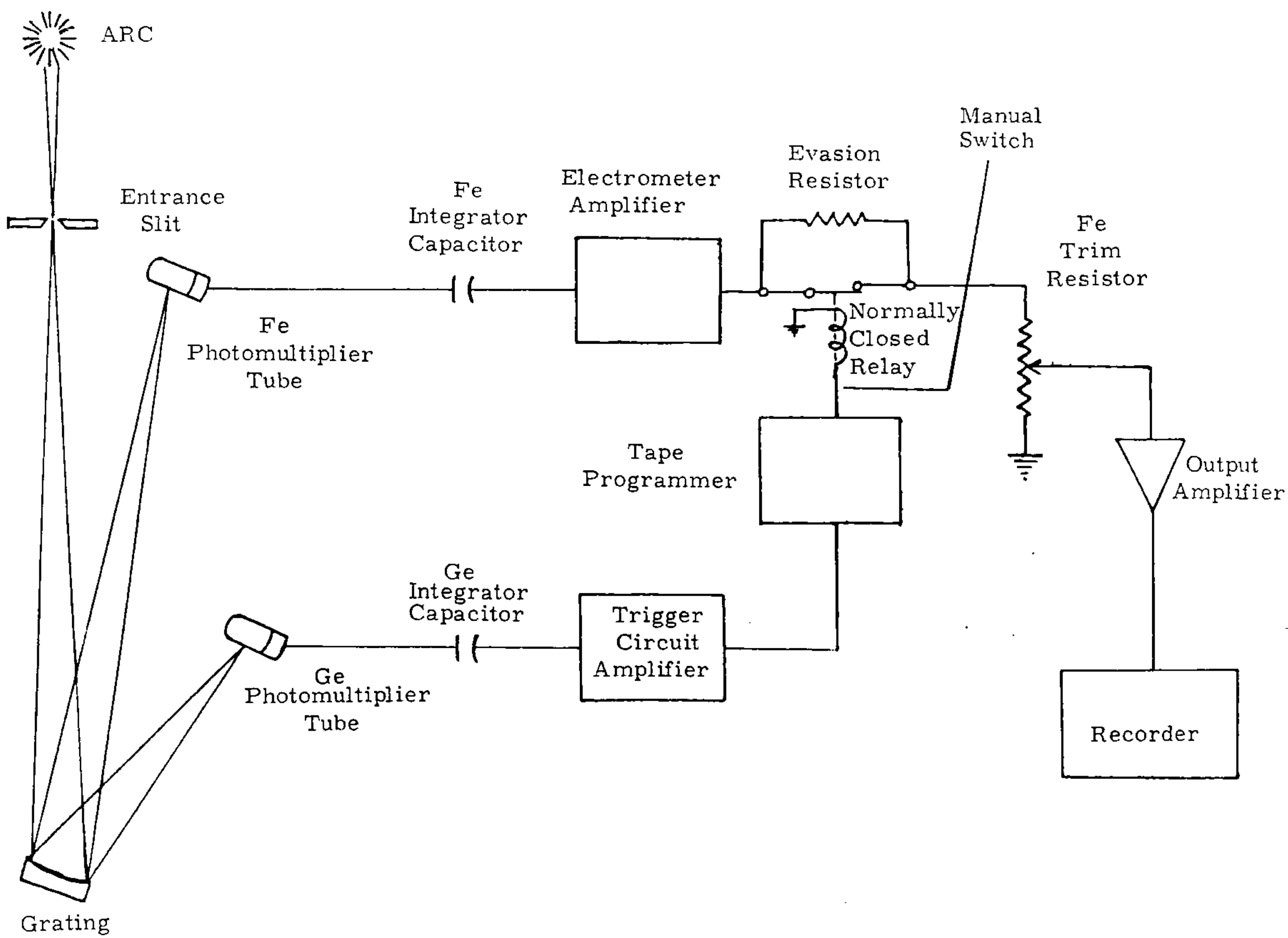


FIGURE D-33. Block Diagram - Direct Reading Spectrograph Evasion Technique

SPECTROGRAPHIC REGULAR URANIUM PYRO READ OUT SHEET

FIGURE D-34 Quantometer Output Without Evasion

SPECTROGRAPHIC REGULAR URANIUM PYRO READ OUT SHEET

FIGURE D-35 Quantometer Output With Evasion

DOE
(b)(3)

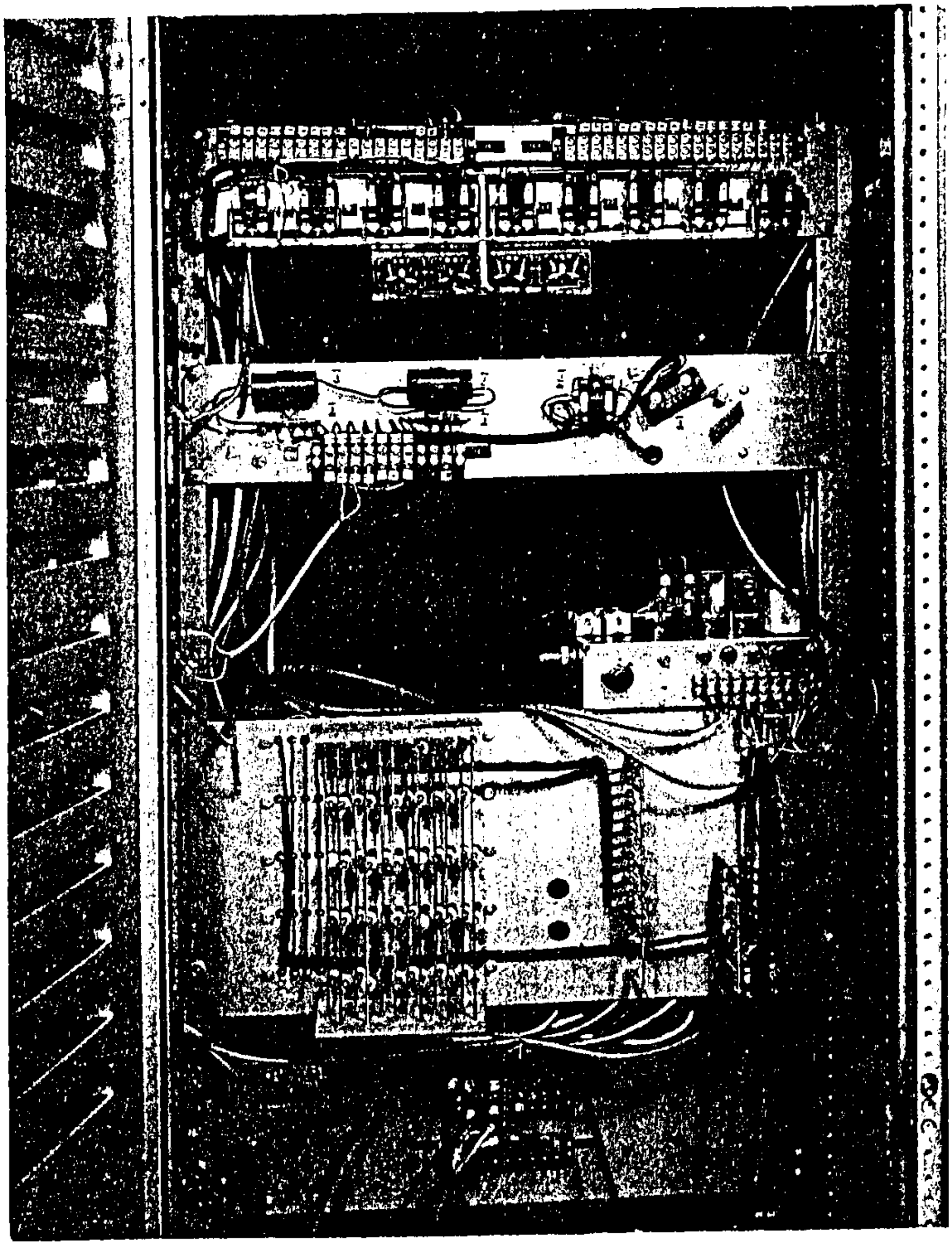


FIGURE D-36. Quantometer Electronics

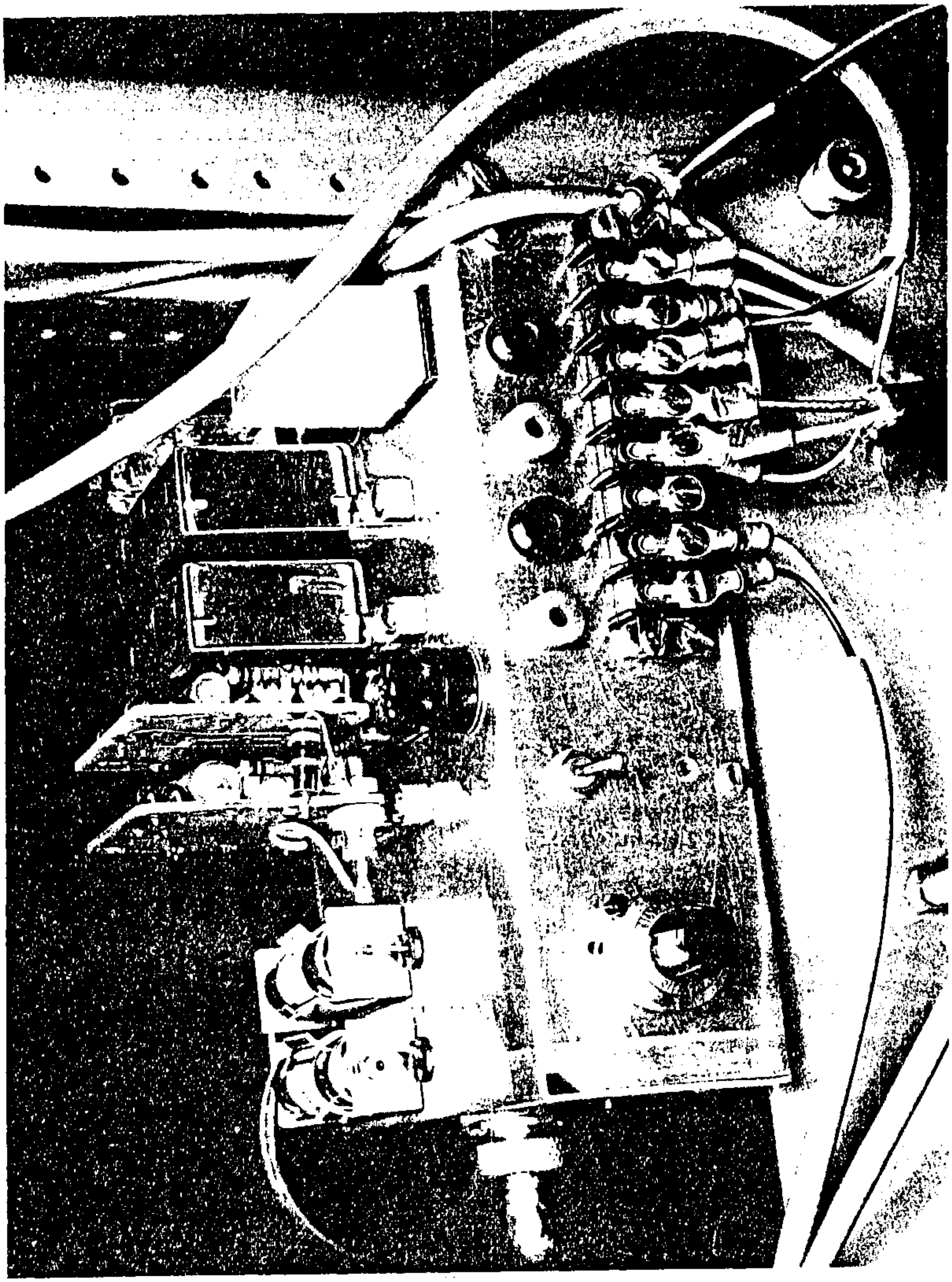


FIGURE D-37. Quantometer Evasion Circuitry observation. By means of a remotely controlled relay, the internal (hidden) filament was heated and its sample material analyzed instead of the inspector's sample material on the "V-block" filament. Figure D-38 shows schematically how this was accomplished. The relay was controlled by a remote switch through wiring brought out of the mass spectrograph through unused gas lines. Color codes used on inspector's sample bottles provided information necessary to determine when to use this method of evasion. Figures D-39, D-40, and D-41 show the ion source and its hidden filament and the location of the ion source in the mass spectrograph. Each method of evasion was used on one of the eight special assay samples.

e. Special Assay Test Evasion Schedule. The evasion schedule for the special assay test is shown in figure D-42. Each of the eight inspection teams observed or performed analyses on eight samples through three assay operations. The total number of sample operations conducted was 192. Half of the sample operations were scheduled for evasion. One evaded sample operation for a LIMA team was not conducted because of operational difficulties with equipment; therefore, the total number of evaded sample operations was 95 for the entire special assay test.

5. Summary of Assay Evasion. Assay evasion throughout the entire FT-34 operation incorporated fairly crude methods (sleight-of-hand subsitution) as well as highly sophisticated methods using remotely and/or automatically controlled electronic techniques. Evasion in the special assay exercise required considerable effort in cross coupling among the various assay analysis methods used so that an evasion in one phase of assay would not be inadvertently discovered by analysis in another phase. The methods used in assay analysis have been adopted to provide checks among the several phases of analysis. Therefore, planning for evasion methods must be sufficiently thorough to avoid the pitfalls of disclosure by either carelessness or cross-checks among the analysis methods used. This was the case for FT-34, particularly for the comprehensive evasion used in the special assay tests.

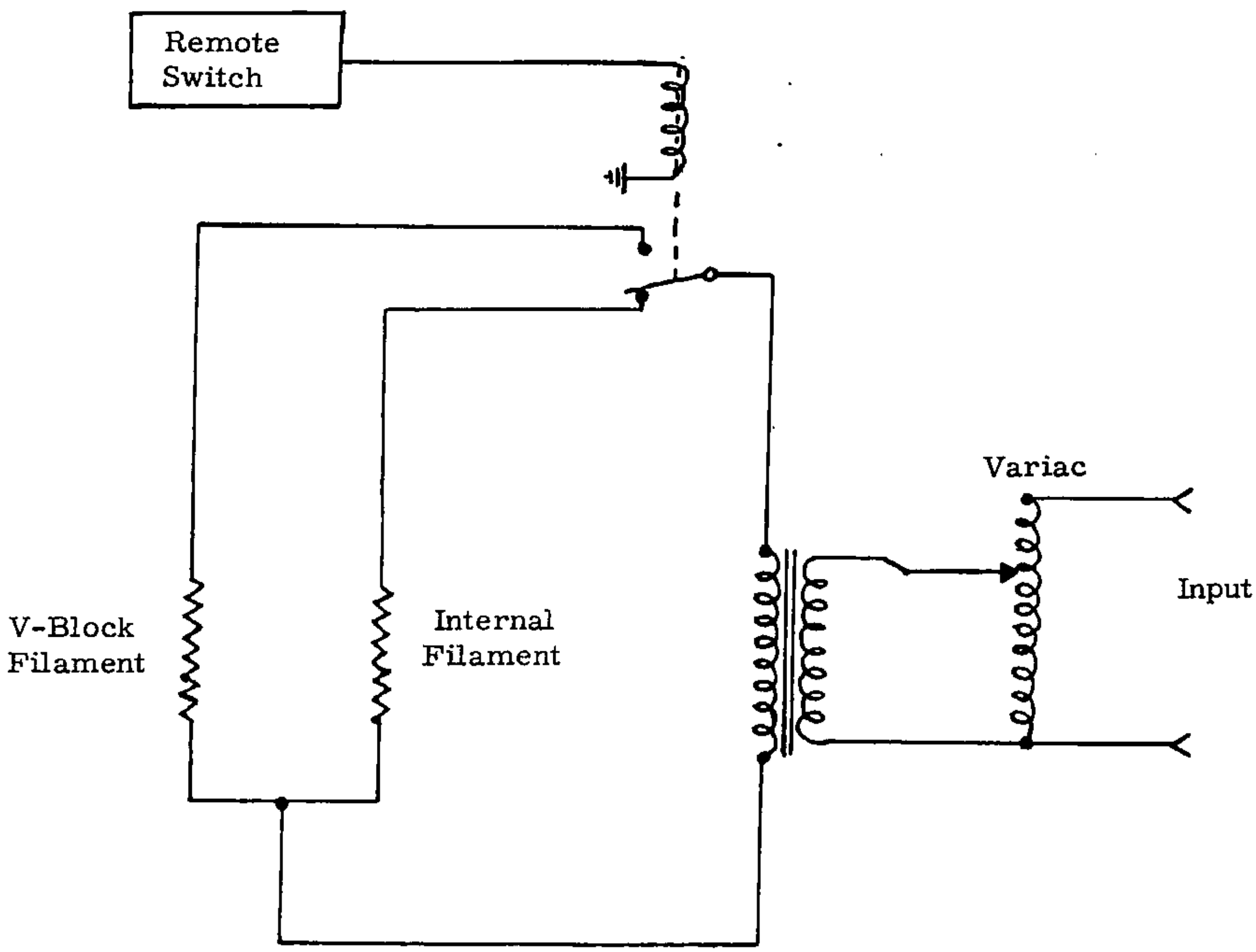


FIGURE D-38. Mass Spectroscopic Evasion - Internal Filament Method .

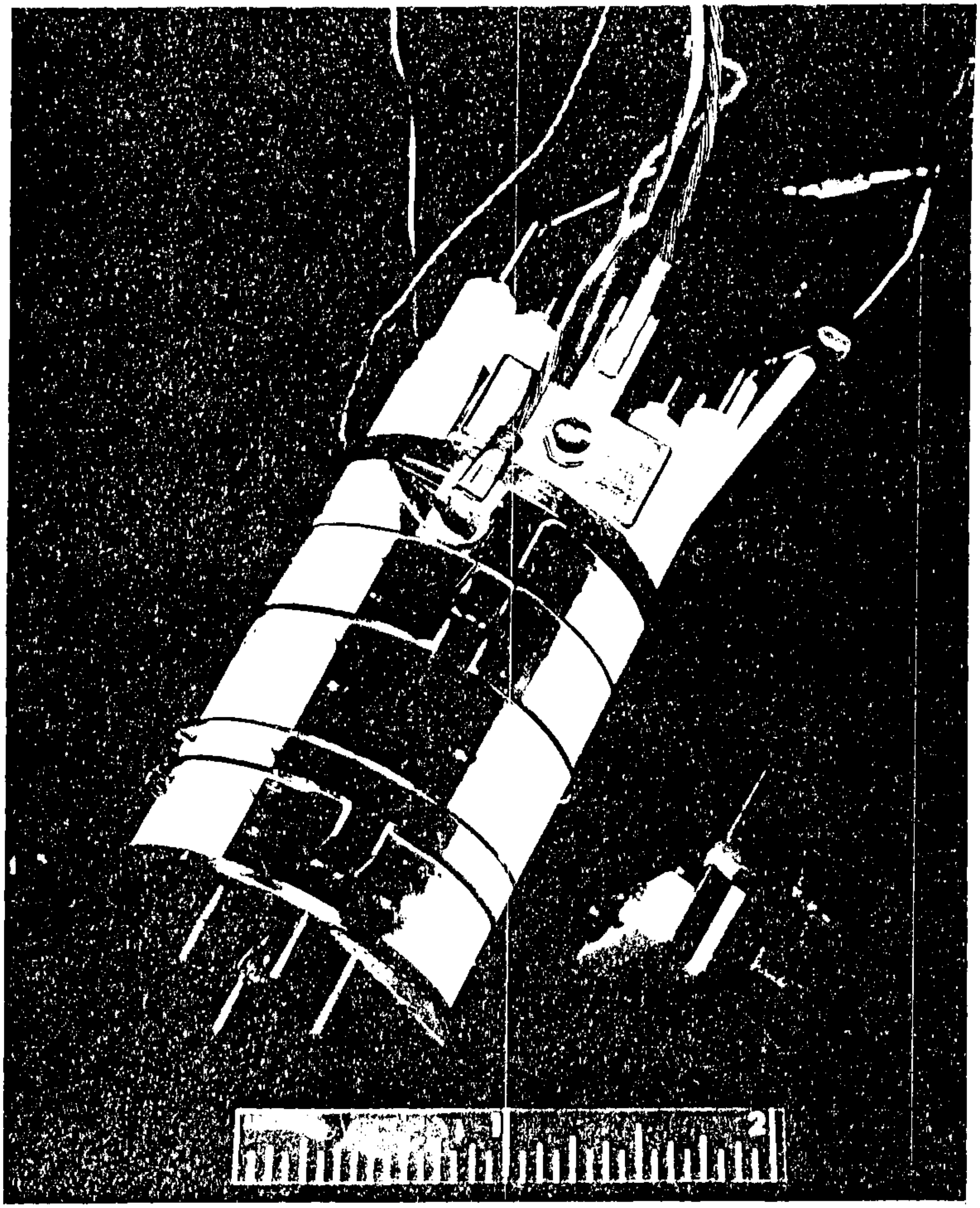


FIGURE D-39. Ion Source with Internal Filament and V-Block Filament

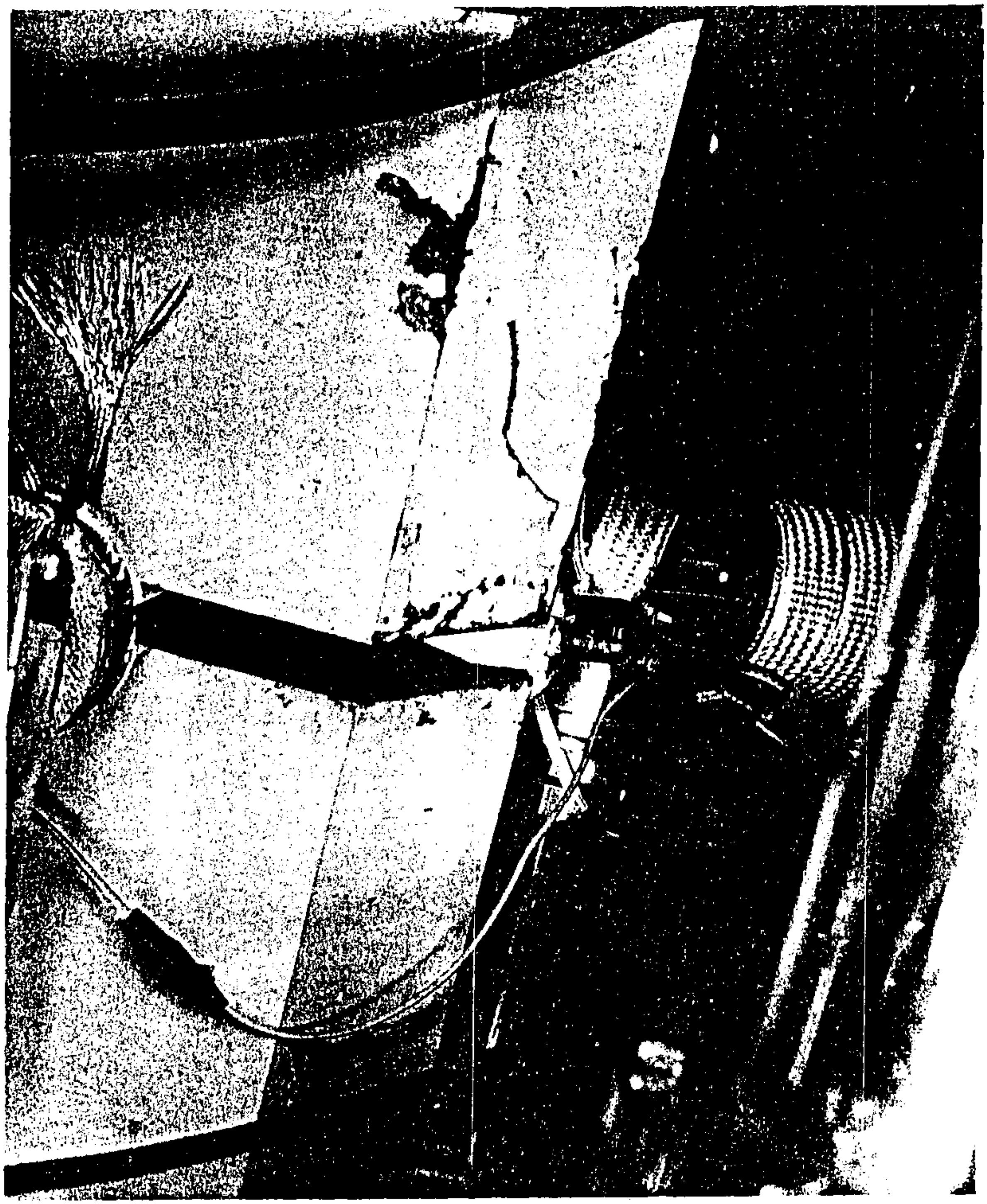


FIGURE D-40. Hidden Filament Location

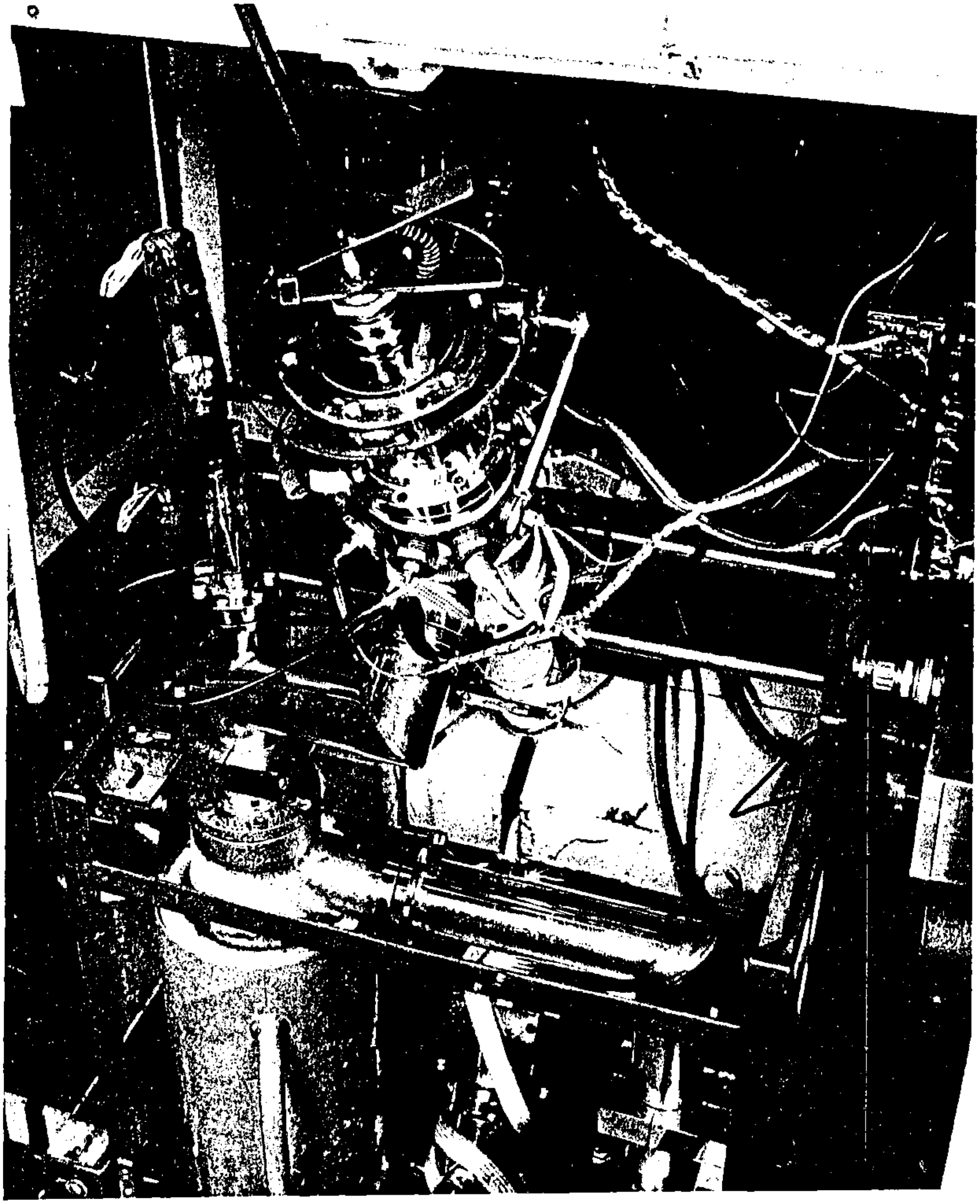


FIGURE D-41. Ion Source Shown in Place

FIGURE D-42. Special Assay Evasion Schedule

AEC Material code	LIMA Sample No.	MIKE Sample No.	Chemical analysis	Emission spectroscopy	Isotopic analysis
1902	3	1	Add aluminum alter balance	Aluminum in carrier	Alter U-235/U-238 ratio
1902	2	2	Add aluminum alter balance	Aluminum in carrier	
1920	4	3			Hidden filament
1920	1	4	CONTROL - NO EVASION		
1502	6	5	Add ternary alloy	Evade quantometer	
1502	7	6	Add ternary alloy	Evade quantometer	
1520	5	7	CONTROL - NO EVASION		
1502	8	8	Add ternary alloy	Evade quantometer	
Standard metal	9	9	STANDARD - NO EVASION		

Throughout all assay phases of FT-34, a total of 504 sample operations were performed for or by all inspection teams. Of these, 187, or 37 percent, were evaded sample operations. This information is presented in figure D-43.

6. Additional Information. Additional information pertaining to FT-34 operations regarding assay of fissile materials is presented in appendices D1 and D2 of this annex. Appendix D1 contains information regarding (1) the conduct of assay procedures during FT-34 operational phases, (2) problems encountered, and (3) evasion calls--including validation by inspection teams. Appendix D2 presents information obtained during a recorded debriefing session for the contractor assay team conducted at the conclusion of the special contractor assay exercise.

FIGURE D-43. Evasion Sample-Operations

Test site, operation	No. of teams	No. of sample-operations	Totals	No. of evaded sample-operations
Rocky Flats, Over-all Exercise	8	12	96	48
Oak Ridge, Over-all Exercise	8	24	192	32
Oak Ridge, Special Military Exercise	8	24	192	95[a]
Oak Ridge, Special Contractor Exercise	1	24	24	12
			504	187

[a]One sample-operation scheduled for evasion was deleted because of equipment problems.