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Operation

JANGLE

NEVADA PROVING GROUNDS
OCTOBER-NOVEMBER 1951

TECHNICAL PHOTOGRAPHY

ADA995224

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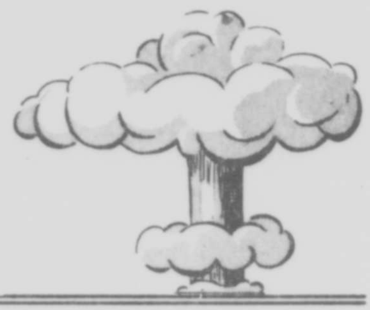

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OPERATION JANGLE

TECHNICAL PHOTOGRAPHY

Project 4.1	Aerial Technical Photography Operations (WT-354)	
Project 4.1a-1	Ground Technical Photography Material Operations (WT-398)	
Project 4.1a-2	Photographic Analysis (WT-346)	

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OPERATION JANGLE

PROJECT 4.1

AERIAL TECHNICAL PHOTOGRAHY

By

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MAJOR, USAF

and

STAFF
TECHNICAL PHOTOGRAPHIC SERVICE BRANCH

March 1952

TECHNICAL PHOTOGRAPHIC SERVICE BRANCH, MATERIEL DIVISION, WADC
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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PROJECT 4.1

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ABSTRACT

The purpose of Project 4.1 was to provide aerial technical photography for recording physical phenomena with respect to time during Operation JANGLE. The mission of this project also included the provision of technical documentary footage for technical report purposes.

The method of accomplishing this mission was the utilization of three type C-47 aircraft orbiting the target with multiple camera installation in the doorway of aircraft. The camera complement for each aircraft consisted of four type K-24 aerial still cameras, one type K-17 aerial still camera, two 35mm Fastax cameras, one 16mm motion picture camera, one 35mm Mitchell standard camera and one 35mm Mitchell high speed camera. All cameras, with the exception of the 35mm Mitchells, were operated automatically from a timing signal transmitted from a ground time control station. The K-24 type cameras were sequenced to permit a total of four exposures per second. The K-17 camera was sequenced at the rate of one picture every two seconds. The Fastax cameras were automatically started and timed and operated at approximately 2,000 frames per second. The Mitchell 16mm and 35mm standard cameras operated at 32 frames per second; the 16mm camera using a color film. The high speed Mitchell operated at 100 frames per second. Figure 1 shows the arrangement of all cameras.

The results obtained are considered good in that only two cameras failed completely. Three additional cameras failed after phenomena was recorded. This means only two operational failures out of 180. The method of employment of aerial photography in general was good. However, it is believed improvement in some types of data could be made by locating one aircraft directly over target at zero time. This would permit better radial coverage of basic phenomena than that provided for in this test. The technical photography primarily covered shock wave measurements, base surge and cloud formation on a common time base. The initial fireball is covered to a certain extent. However, the project's primary mission did not require this measurement.

CHAPTER 1

INTRODUCTION

1.1 OBJECTIVE

The basic plan for aerial technical photography was designed to cover all phases of Operation JANGLE to provide technical and documentary films and mapping and mosaic requirements for all echelons of the test organization. Project 4.1 was also charged with the responsibility for executing its mission in its broad aspects. The scientific director of the task group had responsibility for technical and documentary assignments, provision of plans for accomplishing technical and documentary assignments, provision of plans for accomplishing technical and documentary photography for Operation JANGLE, monitoring the execution of these plans especially as they pertained to technique and the coordination of the supply, security, and processing of all requests for and the distribution of photography.

1.2 METHOD OF APPROACH

Project 4.1 was assigned to Technical Photographic Service Branch, Materiel Division, WADC. This project was executed by Technical Photographic Service Branch personnel and equipment. The procurement of special equipment such as automatic camera controls and film was made from special funds allocated by AFSWP. The modification of aircraft for the installation of cameras and controls was accomplished in the shops at Wright-Patterson Air Force Base. The aircraft were flight tested and then flown to Kirtland Air Force Base previous to test date. Additional tests and modifications were made at Kirtland. At the completion of this testing they were flown to Indian Springs.

In addition to modification for camera installation in the door of the aircraft, vertical camera wells were made for mosaic and mapping coverage. It was also necessary to make a special control for two vertical cameras to enable alternate operation or a high picture rate to obtain proper overlap at low altitudes as predicted by resolution requirements. In addition to general mosaic coverage it was required to make vertical stereo coverage of craters at a large scale for the purpose of contour map making.

[redacted]

CHAPTER 2

DISCUSSION

2.1 DISCUSSION

The Task Group Operations Officer and Project Officer of 4.1 scheduled the flight pattern of the three aircraft to conform with the basic requirements and personnel protection during test.

Aircraft No. 1 was located on a left hand orbit at a ground range of 10,000 feet from zero point and at a true elevation of 10,000 feet. This aircraft was on this orbit at approximately 180° during zero time. Aircraft No. 2 was located on the left hand orbit on ground radius of 10,000 feet at a true elevation of approximately 8,000 feet and positioned approximately 270° at zero time. Aircraft No. 3 was located on the left hand orbit at a ground radius of 15,000 feet and a true altitude of 5,000 feet with a location of zero degrees at zero time.

The general assignment of aircraft No. 1 was to cover base surge and shock wave at ground position. Aircraft No. 2 was assigned the coverage of initial cloud growth and shock wave phenomena. Aircraft No. 3 was assigned the technical documentary coverage for the entire cloud growth with respect to target layout. The arrangement of aircraft allowed maximum time for aerial photography without danger of intercepting radioactive clouds. The first cameras were started at -5 second and the operation was completed nine minutes after zero time.

The selection of the exposure and focal length of lens and cameras was based on previous test experience. It was felt that fireball growth data could be obtained more efficiently by ground cameras rather than aerial cameras due to the problems of limited space and automatic control within the aircraft. Cameras were installed on flexible mounts so that operators could train several cameras at one time on the target.

The design used in this test proved to be adequate; however, improvements could be made to eliminate wind forces and unbalanced forces tending to make tracking of the cameras difficult. The C-47 aircraft has a limited space for the complement of cameras used. With a larger aircraft the mission could be accomplished more efficiently and more photographic requirements could be satisfied. Lack of space limits the flexibility desired in a test of this nature. It is felt, however, that the C-47 aircraft gave an excellent answer to the problem of aerial technical photography.

[redacted]

CHAPTER 3

RECOMMENDATIONS

3.1 RECOMMENDATIONS

In view of operational changes or schedules with short notice, and the range of operations of the aircraft encountered in this project, it is recommended that aerial photographic aircraft be located very close to the test site for the duration of the tests. This would enable faster coverage of requests that originate in the field and would allow better employment of aircraft due to limited gas supply and the operation of aircraft under other than normal flight conditions.

It is recommended that automatic control of photographic equipment be employed on future tests with additional timing signals to allow better distribution of equipment and better coverage in events vs time. This can be realized by employing Fastax type cameras with overlapping operations within the time of -2 seconds to +10 seconds. At this test it was accomplished by time delay mechanisms that are not as reliable as ground time delay signals. The time delay used on this project was accomplished by the use of synchronous clock motors powered by a gas driven 60-cycle, 110-volt generator. The errors realized in this system were due primarily to the unstable frequency of generators. As a result of this condition, the Fastax cameras had to be started prior to the desired time to assure operation of the equipment at zero time.

It is recommended that the three aircraft, or as many as possible of the three aircraft, be retained in their present condition for the purpose of technical photographic coverage on future atomic tests. It was extremely difficult to procure material and modify these aircraft within the allotted time. If projects of this nature are again scheduled without allowing sufficient time to procure aircraft, equipment and modification of aircraft, the retention of these ships would allow photographic coverage with a minimum of expense. Between atomic tests these aircraft can be employed with other military service units such as Technical Photographic Service Branch, Wright-Patterson Air Force Base, or Air Photographic & Charting Service. This type of aircraft is always in demand for technical photographic services.

[redacted]

PROJECT 4.1

It is recommended that closer coordination between requesting agencies and photographic units be established. When special requirements of photographic coverage exist, strong justification from originating agencies is necessary to obtain headquarters controlled equipment. This situation existed on this test when Smear type camera coverage was not possible due to lack of time required to procure headquarters controlled cameras. Aerial mapping equipment also requires the procurement of headquarters controlled items as well as strong justification from the originating agencies. It is also recommended that previous to cartographic assignments involving aerial photography that the requesting agencies coordinate with cartographic units, responsible for topographic charting, in determining focal lengths of lens and types of cameras as dictated by the type of stereo planograph equipment involved.

The modification drawings of the three aircraft employed by this project are not available due to the lack of time to accomplish the mission. Instructions were given verbally and it is not the intention of this department to complete drawings for the modification unless adopted as a standard practice for future aerial photography on projects of this nature.

[redacted]

CHAPTER 4

DISPOSITION OF RECORD MATERIAL

4.1 DISPOSITION OF RECORD MATERIAL

The exposed film was developed at Technical Photographic Service Branch Laboratory. The negatives were serialized in accordance with instructions and selected prints were made and delivered as requested by Program 4. The film log is contained in Appendix A of this report. Two edited 35mm prints were made for preliminary report purpose. All aerial camera negatives have been delivered to AFSWP, Washington, D. C. The 16mm and 35mm motion picture negatives are located at WADC and are awaiting shipping instructions.

PROJECT 4.1

APPENDIX A

FILM LOG (SURFACE SHOT)

ALD-001-BU	C-47 #264	13 NOV 51	13:30	K-17C	305mm	VV 2400'	201 EXP.
ALD-002-BU	C-47 #264	13 NOV 51	13:45	K-17C	305mm	VV 1000'	179 EXP.
ALD-003-BS	C-47 #264	14 NOV 51	10:25	K-17C	305mm	VV 2400'	141 EXP.
ALD-004-BS	C-47 #264	14 NOV 51	11:30	K-17C	305mm	VV 2400'	49 EXP.
ALD-005-BS	C-47 #726	14 NOV 51	10:30	K-17C	305mm	VV 1000'	230 EXP.
ALD-006-BS	C-47 #726	16 NOV 51	09:30	K-17C	305mm	VV 1000'	198 EXP.
ALD-007-BS	C-47 #726	16 NOV 51	09:30	K-17C	305mm	VV 1000'	200 EXP.
ALD-008-BS	C-47 #264	16 NOV 51	10:00	K-17C	305mm	VV 1000'	212 EXP.
ALD-009-BS	C-47 #264	16 NOV 51	10:00	K-17C	305mm	VV 1000'	193 EXP.

AIRCRAFT NO. 1 C-47 NO. 726 (DURING)

BLA-010-DS	19 NOV 51	09:00	K-24	178mm	OH 5800	114 EXP.
BLA-011-DS	19 NOV 51	09:00	K-24	178mm	OH 5800	55 EXP.
BLA-012-DS	19 NOV 51	09:00	K-24	178mm	OH 5800	109 EXP.
BLA-013-DS	19 NOV 51	09:00	K-24	178mm	OH 5800	109 EXP.
ALD-014-DS	19 NOV 51	09:00	K-17C	305mm	OH 5800	212 EXP.
RMF-015-DS	19 NOV 51	09:00	MITCHELL	50mm	OH 5800	
MLC-016-DS	19 NOV 51	09:00	FASTAX	51.6mm	OH 5800	
MLC-017-DS	19 NOV 51	09:00	FASTAX	105mm	OH 5800	
MAG-018-DS	19 NOV 51	09:00	MITCHELL	100mm	OH 5800	
MAG-019-DS	19 NOV 51	09:00	MITCHELL	100mm	OH 5800	

PROJECT 4.1

AIRCRAFT NO. 2 C-47 No. 264 (DURING)

BLA-020-DS	19 NOV 51	09:00	K-24	178mm	OH 10,000'	107 EXP.
BLA-021-DS	19 NOV 51	09:00	K-24	178mm	OH 10,000'	111 EXP.
BLA-022-DS	19 NOV 51	09:00	K-24	178mm	OH 10,000'	111 EXP.
BLA-023-DS	19 NOV 51	09:00	K-24	178mm	OH 10,000'	111 EXP.
ALD-024-DS	19 NOV 51	09:00	K-17C	305mm	OH 10,000'	199 EXP.
RMF-025-DS	19 NOV 51	09:00	MITCHELL	79mm	OH 10,000'	
MLC-026-DS	19 NOV 51	09:00	FASTAX	51.5mm	OH 10,000'	
MLC-027-DS	19 NOV 51	09:00	FASTAX	105mm	OH 10,000'	
MAG-028-DS	19 NOV 51	09:00	MITCHELL	152mm	OH 10,000'	NO IMAGE
MAG-029-DS	19 NOV 51	09:00	MITCHELL	152mm	OH 10,000'	

AIRCRAFT NO. 3 C-47 No. 990 (DURING)

BLA-030-DS	19 NOV 51	09:00	K-24	305mm	OH 8000'	78 EXP.
BLA-031-DS	19 NOV 51	09:00	K-24	305mm	OH 8000'	NO IMAGE
BLA-032-DS	19 NOV 51	09:00	K-24	305mm	OH 8000'	NO IMAGE
BLA-033-DS	19 NOV 51	09:00	K-24	305mm	OH 8000'	61 EXP.
ALD-034-DS	19 NOV 51	09:00	K-17C	305mm	OH 8000'	103 EXP.
RMF-035-DS	19 NOV 51	09:00	MITCHELL	35mm	OH 8000'	
MLC-036-DS	19 NOV 51	09:00	FASTAX	105mm	OH 8000'	
MLC-037-DS	19 NOV 51	09:00	FASTAX	51.3mm	OH 8000'	
MAG-038-DS	19 NOV 51	09:00	MITCHELL	75mm	OH 8000'	NO IMAGE
MAG-039-DS	19 NOV 51	09:00	MITCHELL	75mm	OH 8000'	

ALD-040-AS	C-47	# 264	19 NOV 51	14:30	K-17C	305mm	VV 2400'	81 EXP.
ALD-041-AS	C-47	# 264	19 NOV 51	14:30	K-17C	305mm	VV 2400'	133 EXP.
ALD-042-AS	C-47	#726	19 NOV 51	14:30	K-17C	305mm	VV 1000'	143 EXP.

PROJECT 4.1

(UNDERGROUND SHOT)

ALD-101-BU	C-47 #726	27 NOV 51	09:30	K-17C	305mm	VV 2400'	186 EXP.
ALD-102-BU	C-47 #726	27 NOV 51	09:30	K-17C	305mm	VV 1000'	203 EXP.
ALD-103-AU	C-47 #990	30 NOV 51	10:00	K-17C	305mm	VV 2400'	223 EXP.
ALD-104-AU	C-47 #726	30 NOV 51	10:30	K-17C	305mm	VV 1000'	
ALD-105-AU	C-47 #726	30 NOV 51	10:30	K-17C	305mm	VV 1000'	176 EXP.
ALD-107-AU	C-47 #726	30 NOV 51	10:30	K-17C	305mm	VV 10,000 & 1000'	
ALD-108-AU	C-47 #726	30 NOV 51	09:30	K-17C	305mm	VV 10,000 & 1000'	136 EXP.

AIRCRAFT NO. 1 C-47 NO. 726 (DURING)

BLA-110-DU	29 NOV 51	12:00	K-24	178mm	OH 8000	79 EXP.
BLA-111-DU	29 NOV 51	12:00	K-24	178mm	OH 8000	79 EXP.
BLA-112-DU	29 NOV 51	12:00	K-24	178mm	OH 8000	48 EXP.
BLA-113-DU	29 NOV 51	12:00	K-24	178mm	OH 8000	28 EXP.
ALD-114-DU	29 NOV 51	12:00	K-17C	305mm	OH 8000	266 EXP.
RMF-115-DU	29 NOV 51	12:00	MITCHELL	305mm	OH 8000	
MLC-116-DU	29 NOV 51	12:00	FASTAX	51.6mm	OH 8000	
MLC-117-DU	29 NOV 51	12:00	FASTAX	105mm	OH 8000	
MAG-118-DU-AU	29 NOV 51	12:00	MITCHELL	100mm	OH 8000	
MAG-119-DU	29 NOV 51	12:00	MITCHELL	100mm	OH 8000	

AIRCRAFT NO. 2 C-47 NO. 264 (DURING)

BLA-120-DU	29 NOV 51	12:00	K-24	178mm	OH 10,000'	116 EXP.
BLA-121-DU	29 NOV 51	12:00	K-24	178mm	OH 10,000'	110 EXP.
BLA-122-DU	29 NOV 51	12:00	K-24	178mm	OH 10,000'	111 EXP.
BLA-123-DU	29 NOV 51	12:00	K-24	178mm	OH 10,000'	112 EXP.
ALD-124-DU	29 NOV 51	12:00	K-17C	305mm	OH 10,000'	211 EXP.
RMF-125-DU	29 NOV 51	12:00	MITCHELL	50mm	OH 10,000'	
MLC-126-DU	29 NOV 51	12:00	FASTAX	51.5mm	OH 10,000'	
MLC-127-DU	29 NOV 51	12:00	FASTAX	105mm	OH 10,000'	
MAG-128-DU	29 NOV 51	12:00	MITCHELL	100mm	OH 10,000'	
MAG-129-DU	29 NOV 51	12:00	MITCHELL	100mm	OH 10,000'	

[redacted]

AIRCRAFT NO. 3 C-47 NO. 990 (DURING)

BLA-130-DU	29 NOV 51	12:00	K-24	305mm	OH 5000'	104 EXP.
BLA-131-DU	29 NOV 51	12:00	K-24	305mm	OH 5000'	104 EXP.
BLA-132-DU	29 NOV 51	12:00	K-24	305mm	OH 5000'	105 EXP.
BLA-133-DU	29 NOV 51	12:00	K-24	305mm	OH 5000'	86 EXP.
ALD-134-DU	29 NOV 51	12:00	K-17C	305mm	OH 5000'	237 EXP.
RMF-135-DU	29 NOV 51	12:00	MITCHELL	35mm	OH 5000'	
MLC-136-DU	29 NOV 51	12:00	FASTAX	105mm	OH 5000'	
MLC-137-DU	29 NOV 51	12:00	FASTAX	51.3mm	OH 5000'	
MAG-138-DU	29 NOV 51	12:00	MITCHELL	75mm	OH 5000'	
MAG-139-DU	29 NOV 51	12:00	MITCHELL	75mm	OH 5000'	
RMF-140-AU	30 NOV 51	13:30	MITCHELL	79mm	DAMAGE	
MAG-141-AU	30 NOV 51	13:30	MITCHELL	152mm	DAMAGE	

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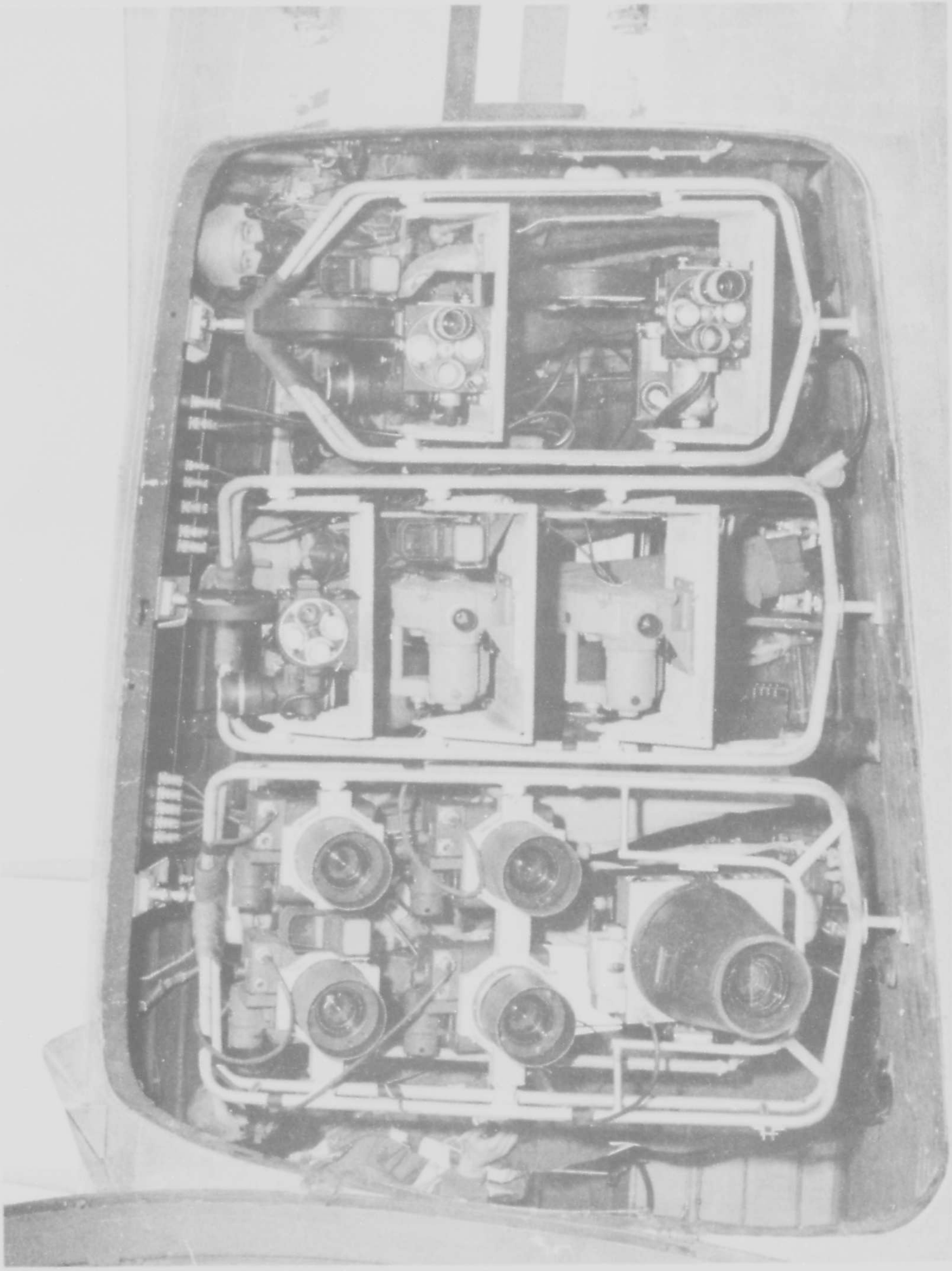

Figure 1 Camera Arrangement

[redacted]

OPERATION JANGLE

PROJECT 4.1a-1

GROUND TECHNICAL PHOTOGRAPHY

MATERIAL OPERATIONS

By

HAROLD C. BARR

SANDIA CORPORATION

[redacted] [redacted]

[redacted]

PROJECT 4.1a-1

CONTENTS

[redacted] [redacted]

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PROJECT 4.1a-1

ABSTRACT

The operational aspects of technical photography accomplished on Operation JANGLE are reported on herein. These are primarily recorded for their potential value to future atomic tests.

[redacted] [redacted]

[redacted]

CHAPTER 1

REQUESTED COVERAGE

1.1 SURFACE SHOT

The specific requirements for technical photography of the surface atomic detonation included film from which the following basic information could be secured:

1. Crater initiation and growth, including final dimensions of crater and lip.

2. Birth of column.

3. Vertical and horizontal transient displacement of surface soil particles.

4. Missile propagation, including density, angles of departure, and velocities.

5. Column initiation and growth.

6. Base surge formation, dimensions and velocity.

7. Cloud formation and breakoff.

Technical photography to correlate and supplement observations made pursuant to other projects included:

1. Location of Kytoons which were used for studies of free air shock arrival times.

2. Photography of rocket grids at both normal and high speeds for free air peak pressure measurements.

3. Photography of surface wave targets for earth motion studies.

1.2 UNDERGROUND SHOT

Technical photography requirements of the underground atomic detonation included coverage of the following basic phenomena:

[redacted] [redacted]

1. Break through.

2. Initiation and growth of crater and lip.

3. Column birth.

4. Vertical and horizontal transient displacement of surface soil particles.

5. Missile propagation including density, angles of departure, and velocities.

6. General photographic coverage of movement of test structures.

7. Column initiation and growth.

8. Base surge, formation, dimensions and velocity.

9. Cloud formation and breakoff.

Additional special technical photography requirements included coverage of the following:

1. Location of Kytoons in space.

2. Photography of rocket grids.

3. Photography of surface wave targets.

4. Photography of seismic triggered flash lamps for earth motion studies.

1.3 RESOLUTION

The resolution of specific coverage which was requested was as follows:

1. Break through and crater initiation one foot resolution in 1200 feet field.

2. Column formation. Fifty feet resolution in 5000 feet field to 15,000 feet in height.

3. Base surge formation. Fifty feet resolution in field 5 miles wide by 8 miles length down-wind.

[redacted]

CHAPTER 2

EQUIPMENT

2.1 CAMERA EQUIPMENT

Since no time resolution greater than a millisecond was requested, all cameras were of conventional types.

Fastax rotating prism cameras in both 16mm and 35mm sizes were operated at speeds of from 1000 to 6000 pictures per second. Lenses used on these cameras ranged in focal length from 35mm to 15 inches. Timing of these records was estimated to be good to 4×10^{-4} seconds and was by means of a 1000 cycle signal from a Potter Model 2089A Generator impressed on the edge of the film by means of an NE66 pip light.

Mitchell 35mm motion picture cameras were used at speeds of from 24 to 100 pictures per second, with lenses ranging from 25mm to 40 inches focal length. Timing of these cameras was good to 4×10^{-4} seconds and was by means of a recorded shutter return pulse generated by a special maggetic return pulse generator.

F56 type aerial cameras were used as sequence still cameras operating at intervals of from one to six seconds. These cameras were fitted with 8¼ and 40 inch lenses. Timing of these cameras was good to 50 milliseconds and was by means of a chronometer mounted on the camera and imaged on one corner of the film during each exposure. A similar camera, the K17, was used in like manner but with a shutter pulse for timing.

Other cameras used were Bell and Howell 16mm movie cameras, one shot plate cameras making a 10 x 12 inch negative through a 12 inch lens, and streak or ribbon cameras with film widths of 35mm and 9½ inches, using 4 inch and 24 inch lenses. The last named cameras were timed in the same manner as the Fastax.

A total of 63 cameras were operated on the surface shot and 62 on the underground shot. On both operations approximately 15 per cent of the cameras were loaded with color film and on the surface shot 25 per cent of the cameras were loaded with microfile film and exposed for expected bomb light. For each operation the principal coverage was from three photo powers which were also the location of the instrumentation trailers which furnished control and timing signals for the camera installations.

[redacted]

[redacted]

2.2 CONTROL EQUIPMENT

The objectives sought with the control equipment used on technical photography operations included:

1. Dependable control of start time, timing of individual exposures, and total running time of all cameras, generators, and recorders without manual supervision.

2. Requisite accurate timing from 4×10^{-4} seconds to 1×10^{-1} seconds of all optical instrumentation.

3. Stable electrical powere where needed.

2.2.1 Basic Requirements

1. Timing

a. Mitchell cameras: 4×10^{-4} seconds, magnetic return pulses, NE66 coding lamps.

b. Fastax cameras: 4×10^{-4} seconds, 1000 cycle pulses on NE66 pip lamp, coding by blocking time base.

c. Sequence still cameras: 50 milliseconds, timing by means of chronometer in field.

d. Streak cameras: 4×10^{-4} seconds, 1000 cycle pulses on NE66 pip lamps, coded by blocking time base.

e. Coordination of all time signals from cameras on string galvanometers in Miller Recorders, Model J.

2. Time Bases

a. Hewlett Packard Model 100D, 100 cycles, accuracy one part on 10^6.

b. 1000 cycle Potter Generator, Model 2089A, one part on 10^5.

c. Comparison at site of all time bases with WWV over several days time.

d. Watchmaster, secondary frequency standard, 50 cycles, one part on 10^5.

[redacted]

3. Control Circuits

   a. Camera control circuits: Sensitive relays at end of field wire trigger power contactor which handles camera power. An extra contact is used to close a holding circuit for duration of camera run.

   b. At completion of camera run, a preset timer breaks holding current on power contactor.

   c. Generator control: A sensitive relay to start generators. (This was not used as we were allowed to stay in area late enough to start generators manually.)

   d. Miller recorders were started at -30 seconds with a sensitive relay.

   e. Communications: Field phone network and local PA system at camera stations.

4. Electrical Power

   a. Camera Power: 220 volt, 3 phase, 3 wire.
   110 volt, single phase, one side grounded.
   Variable voltages, 0 - 110, single phase ac, from powerstats.

   b. Electronic Power: 110 V AC, single phase, one side grounded.

   c. Utility Power: 220 V, 3 phase, 4 wire.

   d. Emergency Power: None except battery powered hand lights. No standby generators with auto switch gear.

2.2.2 Electrical Installations

1. Power

   a. Main AC power for tower sites: 10 KVA, 220 volt, 3 phases, 4 wire, 60 cycles, trailer mounted, Onan, 4 cylinder Ford engine, Model C 8NNN.

   b. Auxiliary AC utility power: 5 KVA, 220 volt, single phase, 3 wire, Onan, 60 cycles, trailer mounted.

   c. Battery banks, assembled from 25 ampere hour Nolin Motorcycle batteries.

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[redacted]

2. Instrumentation Trailers

Rack mounted equipment in metal weatherproof housing on two wheel trailers. Equipment consists of sensitive relays to respond to starting signals, power contactors, coding pulse contactor, jack strips, patch panels, Miller 30 channel recorder with attenuators, 50, 100, and 1000 cycle time standards, synchronous delay timers, telephone and PA equipment and amplifiers, radio, connectors for power in and power out, spare parts and tool cabinets, etc.

3. Remote Camera Installations

Remote camera installations were time and controlled from the most accessible instrumentation trailer. Control was accomplished by means of sensitive relays at each camera, operating contactors to supply camera power. Power was either DC from battery banks or single phase AC from a local 5 KVA generator.

Timing for remote Fastax cameras was by means of high level signals over field wire. Amplifiers were used on the return pulse signals from Mitchell cameras to give a recordable pulse at the recorder.

2.2.3 Control and Timing Procedure

A 30 channel Miller recorder is operated at each camera tower. A shutter return pulse from each camera at that station is recorded, along with 50, 100 and 1000 cycle time bases not only from this station but from each of the two other camera control setups. This served to interlock timing from all stations and permitted a comparison of exposure time between any of the cameras involved. The starting pulse for a camera closed the power contactor for that camera and also started operation of anIndustrial Timer Corporation electric timer which was set for the period for which the camera was to run. At the end of that time the timer cut power to the camera. This switch was operated in series with a switch actuated when the end of a film passed through the camera, so that the either switch would stop the camera.

[redacted]

CHAPTER 3

SURFACE DETONATION

3.1 LOCATION OF CAMERAS

Cameras were located at six stations for this shot. Three of the stations were towers, the other three were surface locations. All three of the surface stations were controlled from the instrumentation trailer at Tower #3.

3.1.1 Camera Station No. 1

Tower #1 was located 15,000 feet S 65° W from zero at coordinates N 861,112.65, E 669,505.67. There were 14 cameras at this location, all devoted to general technical coverage.

There were four Mitchell and one Bell and Howell standard 35mm motion picture cameras. Two Mitchells were operated at 96 frames per second, the other three cameras at 24 frames per second. One of the low speed cameras was loaded with color film, the others with black and white.

There were six Fastax cameras, one 16mm size at 7000 frames per second and five of 35mm size operating at speeds ranging from 1500 to 4000 frames per second. There was also one sequence still camera operated at one exposure every two seconds, and two Bell and Howell 16mm Filmos shooting color movies of cloud formation and breakoff at 24 frames per second.

3.1.2 Camera Station No. 2

Tower #2 was located 15,000 feet S 20° W of zero at coordinated N 853,356.53 E 677,969.99. There were 19 cameras at this station, devoted to general technical photography, to location of Kyteons, and to rocket grid photography. Five of the cameras were Mitchell 35mm motion picture cameras, one operating at 24 frames per second with color film, four operating at 96 frames per second with black and white.

There were nine Fastax cameras, one a 16mm size operated at 6000 frames per second and eight of the 35mm size operating at speeds from 1500 to 4000 frames per second.

Two 16mm Bell and Howell cameras covered cloud formation at 24 frames per second with color film.

[redacted] [redacted]

[redacted]

Two sequence still cameras covered base surge, one with 40 inch lens at one second intervals and one with wide angle lens at two second intervals. A fixed one-shot plate camera was also located at this station to cover position of Kyteens.

3.1.3 <u>Camera Station No. 3</u>

Tower #3 was located 9,111.8 feet S79° 40' 15" E from zero, at coordinates N 865,818.13, E 692,064.42. There were 16 cameras at this station devoted to general technical photography, to base surge coverage, and to location of Kytoons.

Four cameras were 35mm Mitchell motion picture cameras, three operated at 96 frames per second and one at 24 frames per second. Lenses ranged in focal length from one to three inches. Nine cameras were Fastax, two of 16mm size and seven of 35mm size. Speeds of these cameras ranged from 500 to 6000 frames per second. Lenses ranged in focal length from 35mm to 15 inches. There was also a one shot fixed plate camera covering Kytoons, a 16mm Bell and Howell at 24 frames per second covering cloud formation, and a sequence still camera with 40 inch lens, operating at one second intervals to cover base surge.

3.1.4 <u>Camera Station No. 4</u>

Camera station #4 was a surface station located on a small hill approximately 8000 feet N 69° E from zero at coordinates N 860.271.23 E 610,394.29. At this station there were three sequence still cameras all devoted to base surge coverage. Two were fitted with 8½ inch lenses, one with a 40 inch lens. All were operated at one second intervals. The cameras were oriented in such a way that fields of view were slightly overlapped.

3.1.5 <u>Camera Station No. 5</u>

Camera station #5 was a surface station located on a hill about 800 feet higher than zero. It was approximately 10,500 feet N 46° E from zero, at coordinates N 875,037.58 E 690,629.84. There were four cameras at this station. One was a 35mm Mitchell motion picture camera operated at 24 frames per second to give overall coverage, the other three were sequence still cameras covering base surge at one second intervals. Two of the latter cameras had 8½ inch lenses and one a 40 inch telephoto lens.

3.1.6 <u>Camera Station No. 8</u>

Camera station #8 was a surface station approximately 5000 feet S 60° E from zero. There were seven cameras, six devoted to coverage of transient surface displacement through photography of targets

[redacted] [redacted]

located along the blast line, and one devoted to overall technical coverage. Two cameras were Fastax 35mm at 35 frames per second, the balance were Mitchells at 100 frames per second. Lenses used ranged from 1 inch to 18 inches in focal length.

3.2 RESULTS

Operation of cameras at the three tower stations was satisfactory except for timing. Shortly before zero time the starting demands of the several cameras apparently loaded the generators to such an extent that the time bases were not entirely accurate. The Miller recorders slowed almost to a standstill and the high speed cameras scheduled to start only a fraction of a second ahead of zero time were late in getting up to speed. However, the generators recovered quickly and no records were lost although data reduction was made more tedious.

At the remote stations the sequence still cameras operated until arrival time for shock in the earth. The shock was apparently enough to open the holding contacts on the power contactors, interrupting holding current and cutting camera power, thus allowing the cameras to stop prematurely.

The Mitchells and Fastax operated satisfactorily at remote stations. The cut off switch on one Mitchell at Station #8 arced over and burned points together. This camera was still running when visited by the film recovery crew, but the bearings were in such shape that the camera needed extensive repairs.

Approximately 90% of the planned coverage resulted in useable film records, but, as mentioned before, reduction of data was more difficult in some cases than it should have been.

[redacted]

CHAPTER 4

UNDERGROUND DETONATION

4.1 LOCATION OF CAMERAS

Cameras were located at nine stations for this shot. Three of the stations were towers, six were surface stations. The cameras on towers were housed in a sheet iron cab, those at surface locations were in cast concrete "pill boxes".

4.1.1 Camera Station No. 1

Tower #1 was located 15,000 feet S 65° W of zero, coordinates N 875,051.08 E 668,259.33. There were ten cameras at this station.

Three cameras were standard 35mm motion picture cameras, a Mitchell at 96 frames per second, one at 48 frames per second, and a Bell and Howell at 24 frames per second.

There were one 16mm Fastax and three 35mm Fastax cameras operated at speeds ranging from 1500 to 6000 frames per second. There was also a sequence still camera covering base surge, exposing color film at two second intervals, and two 16mm Bell and Howell movie cameras covering cloud formation at 24 frames per second, loaded with color film.

4.1.2 Camera Station No. 2

Tower #2 was located 15,000 feet S 20° W of zero at coordinates N 867,294.96 E 676,623.65. There were 16 cameras at this station but only 15 were operated.

There were four Mitchell 35mm motion picture cameras used, one with color film at 24 frames per second and three with black and white film at 96 frames per second. They gave general technical coverage in addition to data on the rocket trail grid. There were seven Fastax cameras, one of 16mm size at 6000 frames per second and six 35mm size at speeds from 1500 to 4000 frames per second. Like the Mitchells, these cameras gave general technical coverage in addition to rocket trail grid data.

There were also two 16mm Bell and Howell movie cameras covering cloud formation with color film, one at 64 frames per second and one at 24 frames per second, and two sequence still cameras covering base surge, one with color film at two second intervals and one with black and white film at one second intervals.

[redacted]

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4.1.3 Camera Station No. 3

Tower #3 was located 9,012.46 feet S 62° 11' 34" E of zero at coordinates N 877,186.05 E 689,825.67. There were 13 cameras at this station but only 12 used. Cameras at this location gave general technical coverage in addition to coverage of specific structures, location of Kytoons, and time of flashing of shock triggered flash lamps. There were three Mitchell 35mm movie cameras, tow at 96 frames per second and one at 24 frames per second. Lenses used ranged from 1 inch to 18 inches focal length.

There were also six Fastax cameras. Two were of 16mm size operating at 5000 and 6000 frames per second. Four were 35mm Fastax, one of which was operated without prism so that it became a streak camera and served to give time of flashing of flash lamps. Operating speeds ranged from 1500 to 4000 frames per second. Lenses used ranged from 2 inches to 10 inches focal length.

Another streak camera using 9½ inch width film was also used to cover the flash lamps on this shot. This camera was a modified K-22 aerial camera with 24 inch lens. A sequence still camera at one second intervals and a 16mm Bell and Howell movie camera at 24 frames per second covered base surge and cloud formation.

4.1.4 Camera Station No. 4

Camera station #4 was the same site used for the surface test but for this shot it was 14,020.4 feet S 37° 31' 37" E from zero. There were two sequence still cameras at this station, covering base surge.

4.1.5 Camera Station No. 5

Camera station #5 was also the same location used on the surface shot, and was fitted with the same cameras. This station did not expose any film.

4.1.6 Camera Station No. 9

Station #9 was a surface station located 4775.17 feet S 58° 26' 49" E of zero. There were 5 cameras at this station, covering structures, transient displacement of surface particles, and time of flashing of flash lamps.

Four of the cameras were Mitchell 35mm motion picture cameras, three operating at 96 frames per second and one at 48 frames per second.

Lenses used ranged from 1 inch to 18 inches in focal length. These cameras photographed several of the structures and the targets located along blast line to show surface displacement. The fifth camera was a duplicate of the 9½ inch streak camera used at station #3 and covered the flash lamps installed by David Taylor Model Basin.

4.1.7 Camera Station No. 10

Station #10 was a surface station 4495.16 feet S 31° 31' 23" E from zero.

It contained three 35mm Fastax cameras operating at 1500 frames per second. One camera had a 4 inch lens, the other two were 15 inch telephoto lenses. These cameras covered various structures and some of the blast line targets.

4.1.8 Camera Station No. 11

Station #11 was a surface station located 5000 feet S 59° W from zero. There were four cameras at this station.

Two cameras were Mitchells at 96 frames per second and two were 35mm Fastax at 1500 frames per second. The Mitchell cameras were not operative during shot because of dust on relay points, preventing closure of circuit. The Fastax cameras were fitted with 6 inch and 15 inch lenses. The 6 inch lens covered structures from zero on left of frame to chimney 3.20 C1 on right of frame. Blast line targets from #1 to #7 were also included. The 15 inch lens covered blast line targets #1 to #5 and was centered on structures 3.10 a, b, and c.

4.1.9 Camera Station No. 12.

Station #12 was a surface station located 2100 feet due South of zero. At this station there were four cameras, intended to cover several of the structures and break through. However, as was expected, radiation fog completely obscured the image.

4.2 RESULTS

Operation of the cameras at the three tower stations was satisfactory. The two cameras covering the position of Kytoons were in these tower stations but were not operated because the special plates for the cameras were damaged by rain leaking into the film storage shelter.

At the very close-in station (2100 feet due south of zero) fogging from nuclear radiation completely obscured the image although the cameras apparently operated successfully.

[redacted]

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Film from station 10 (4495.16 feet from zero) showed evidence of fogging from nuclear radiation, but density of fog was not enough to obscure the records.

A total of six cameras failed to operate during this shot. The four cameras at station 5 did not expose any film because of failure of starting relay. Two cameras at station 11 were not operative because of dust on relay points, preventing closure of circuit.

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[redacted]

CHAPTER 5

RECOMMENDATIONS

5.1 GENERAL

A D.C. powered tuning fork would have been a useful time-base to be used as reference when oscillators were questioned.

Generators should be greatly oversized when used for driving high speed cameras. 10 KVA generators were inadequate when the total demand was only 3000 to 35000watts.

Relays should be hermetically sealed and should be provided with extra contacts which could be fused lightly to aid in "post-mortem" signal tracing. High level control and timing pulse lines should be isolated from lines used for other purposes.

The use of reclaimed or old field wire should be avoided. Line troubles created a great deal of unexpected and unnecessary trouble shooting and repair.

The use of trailer mounted equipment proved profitable, particularly when it was necessary to move from the surface area to the underground area.

Time and effort expended in setting up a good system of communications between camera station sites was well expended. The telephone and PA system was of great value during check out and trouble shooting periods.

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PROJECT 4.1a-1

APPENDIX A

FILM RECORDS OF SURFACE DETONATION

M = Mitchell
B = Bell and Howell
F = Fastax
P = Plate
S = Still Sequence

	RECORD NUMBER	CAMERA TYPE	FRAME SPEED	FOCAL LENGTH	FILM SIZE
Station #1					
	201	M	96	50mm	35mm
	202	M	96	105mm	35mm
	203	M	24	35mm	35mm
	204	B	24	25mm	35mm
	205	M	24	35mm	35mm
	206	F	4000	145.5mm	35mm
	207	F	1500	35.6mm	35mm
	208	F	4000	154mm	35mm
	209	F	4000	250.5mm	35mm
	210	F	4000	251.6mm	35mm
	211	F	7000	390.5mm	16mm
	212	S	2 sec.	6"	9½"
	213	B	24	1"	16mm
	214	B	24	1"	16mm
Station #2					
	215	S	2 sec.	6"	9½"
	216	B	24	1"	16mm
	217	M	96	50mm	35mm
	218	B	24	1"	16mm
	219	M	24	1"	35mm
	220	M	96	6"	35mm
	221	F	1500	3.988"	35mm
	222	F	4000	154mm	35mm
	223	F	1500	51.9mm	35mm
	224	F	4000	251.8mm	35mm
	225	F	4000	153.3mm	35mm
	226	F	2500	51.7mm	35mm
	227	F	2500	51.7mm	35mm
	228	F	6000	355mm	16mm
	229	S	1 sec.	40'	7"
	230	F	2500	100.8mm	35mm
	231	M	96	4"	35mm
	232	M	96	4"	35mm
	233	P	1 shot	12"	10" x 12"

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FILM RECORDS OF SURFACE DETONATION (Continued)

	RECORD NUMBER	CAMERA TYPE	FRAME SPEED	FOCAL LENGTH	FILM SIZE
Station #3					
	234	M	96	3"	35mm
	235	M	96	75mm	35mm
	236	M	96	50mm	35mm
	237	M	24	1"	35mm
	238	F	6000	15.454"	16mm
	239	F	5000	9.858"	16mm
	240	F	4000	9.925"	35mm
	241	F	1500	1.409"	35mm
	242	F	500	2.031"	35mm
	243	Streak	----	3.961"	35mm
	244	F	4000	3.984"	35mm
	245	F	4000	3.980"	35mm
	246	F	4000	6.059"	35mm
	247	S	1 sec.	40"	7"
	248	B	24	1"	16mm
	249	P	1 shot	12"	10" x 12"
Station #4	250	S	1 sec.	40"	7"
	251	S	1 sec.	8½	7"
	252	S	1 sec.	8½	7"
Station #5	253	S	1 sec.	40"	7"
	254	M	24	1"	35mm
	255	S	1 sec.	8½	7"
	256	S	1 sec.	8½	7"
Station #8	257	M	96	18"	35mm
	258	M	96	18"	35mm
	259	M	96	12"	35mm
	260	F	3500	6"	35mm
	261	M	96	1"	35mm
	262	M	96	18"	35mm
	263	F	3500	6"	35mm

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FILM RECORDS OF UNDERGROUND DETONATION

	RECORD NUMBER	CAMERA TYPE	FRAME SPEED	FOCAL LENGTH	FILM SIZE
Station #1					
	264	M	96	50mm	35mm
	265	NOT USED			
	266	B	24	25mm	35mm
	267	M	48	35mm	35mm
	268	S	2 sec.	6"	9½"
	269	F	4000	10"	35mm
	270	F	1500	6"	35mm
	271	F	1500	35mm	35mm
	272	F	6000	6"	16mm
	273	B	24	25mm	16mm
	274	B	48	25mm	16mm
Station #2					
	275	S	2 sec.	6"	9½"
	276	B	64	25mm	16mm
	277	B	24	25mm	16mm
	278	M	96	4"	35mm
	279	M	24	25mm	35mm
	280	F	4000	6"	35mm
	281	M	96	2"	35mm
	282	F	2500	2"	35mm
	283	F	2500	4"	35mm
	284	F	2500	2"	35mm
	285	M	96	4"	35mm
	286	F	4000	6"	35mm
	287	F	6000	4"	16mm
	288	F	1500	10"	35mm
	289	S	1 sec.	40"	7"
	290	NOT USED			
Station #3					
	291	M	96	18"	35mm
	292	M	96	2"	35mm
	293	M	24	1"	35mm
	294	F	6000	9.856"	16mm
	295	F	5000	2.031"	16mm
	296	F	4000	9.925"	35mm
	297	B	24	1"	16mm
	298	Streak		24"	9½"
	299	S	1 sec.	40"	7"
	300	Streak		3.961"	35mm
	301	F	4000	6.059"	35mm
	302	F	1500	3.984"	35mm
	303	NOT USED			

[redacted] [redacted]

[redacted]

PROJECT 4.1a-1

FILM RECORDS OF UNDERGROUND DETONATION (Continued)

	RECORD NUMBER	CAMERA TYPE	FRAME SPEED	FOCAL LENGTH	FILM SIZE	
Station #4						
	304	S	6 sec.	8¼"	7"	
	305	S	1 sec.	40"	7"	
Station #5						
	306	S	1 sec.	40"	7"	NO RECORD
	307	M	24	25mm	35mm	"
	308	S	6 sec.	8¼"	7"	"
	309	S	6 sec.	8¼"	7"	"
	310	NOT USED				
Station #9						
	311	M	48	1"	35mm	
	312	M	96	6"	35mm	
	313	M	96	18"	35mm	
	314	M	96	6"	35mm	
	315	Streak		24"	9½"	
Station #10						
	316	F	1500	15"	35mm	
	317	F	1500	4"	35mm	
	318	F	1500	15"	35mm	
Station #11						
	319	M	96	40"	35mm	NO RECORD
	320	F	1500	15"	35mm	
	321	M	96	18"	35mm	NO RECORD
	322	F	1500	6"	35mm	
Station #12						
	323	M	1000	35mm	35mm	FOGGED FILM
	324	F	1500	6"	16mm	"
	325	F	1500	35mm	35mm	"
	326	F	1500	6"	35mm	"

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OPERATION JANGLE

PROJECT 4.1a-2

PHOTOGRAPHIC ANALYSIS

BY

J. J. MILLER

March 26, 1952

SANDIA CORPORATION

ALBUQUERQUE, NEW MEXICO

[redacted]

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ILLUSTRATIONS

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PROJECT 4.1a-2

ABSTRACT

The primary purposes of the photographic analysis were (1) to determine the dimensions of the cloud and column from zero time to about + 3 minutes and (2) to determine the times of disintegration, damage or movement of each of the structures.

Square wooden fiducial targets were placed between each camera station and ground zero in such a way that at least two targets appeared in each picture of the explosion. Using the known distance between the two targets and the known distances from the camera to the targets and from the camera to ground zero the film measurements of cloud height, for example, were converted to feet. The cloud height, at any specified time, was determined from the film from several cameras and the arithmetical mean computed for that time.

The final data were probably correct ±40 feet in more than half the cases, the largest single source of error being the lack of sharp edges on the explosion. No data were obtained on the disintegration, damage or movement of the structures since any damage or movement of the structures was too slight to be seen in the film.

The major recommendation for future tests was that an accurate zero-time indication be put on the camera-return-pulse records.

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CHAPTER 1

OBJECTIVES

1.1 DESIRED DATA

The data desired from the photographic coverage are listed in Table 1.1 for both the underground and the surface shots.

[redacted]

PROJECT 4.1a-2

TABLE 1.1

Objectives

Item	Underground Shot		Surface Shot	
	Desired	Obtained	Desired	Obtained
Height of Cloud	Yes	Yes	Yes	Yes
Diameter of Cloud	Yes	Yes	Yes	Yes
Height of Base of Cloud	Yes	Yes	Yes	No
Diameter of Column	Yes	Yes	Yes	No
Height of Base Surge	Yes	Yes	No	No
Diameter of Base Surge	Yes	Yes	No	No
Position of Base Surge	Yes	Yes	No	No
Angle Between Column Side and Horizontal	Yes	Yes	Yes	No
Initial Velocity of Cans	Yes	No	No	No
Initial Velocity of Missiles from Ground	Yes	No	No	No
Angle Between Ground Missile Trajectory and Horizontal	Yes	No	No	No
Initial Velocity of Missiles from Cloud or Column	Yes	Yes	Yes	No
Angle Between Cloud Missile Trajectory and Horizontal	Yes	Yes	Yes	No
Initial Velocity, Size and Time of Disintegration of Slabs	Yes	No	No	No

PROJECT 4.1a-2

TABLE 1.1
(Continued)

Objectives

Item	Underground Shot		Surface Shot	
	Desired	Obtained	Desired	Obtained
Time of Disintegration and Initial Velocity of Points on Each Structure	Yes	No	No	No
Velocity of Ground Shock (Taylor Model Basin Lights)	Yes	Yes	No	No
Velocity of Ground Shock (Fiducial Targets)	Yes	No	Yes	No
Time of Breakthrough	Yes	No	No	No
Velocity of Ground Dome	Yes	No	No	No
Velocity of Jet at Breakthrough	Yes	No	No	No
Rates of Growth:				
Height of Cloud	Yes	Yes	Yes	Yes
Diameter of Cloud	Yes	Yes	Yes	Yes
Height of Base of Cloud	Yes	Yes	Yes	No
Diameter of Column	Yes	Yes	Yes	No
Height of Base Surge	Yes	Yes	No	No
Diameter of Base Surge	Yes	Yes	No	No
Position of Base Surge	Yes	Yes	No	No

[redacted]

PROJECT 4.1a-2

CHAPTER 2

DATA REDUCTION METHODS

2.1 DETERMINATION OF ZERO TIME AND FRAME RATES

The Miller records (one for each station) containing the camera return pulses and a time base were matched with the Fastax film by means of the "gates" in the 1000 cycle channel. The two Fastax frames bracketing zero (as shown by the film) were marked on the Miller records and zero time was assumed to lie between these two frames.

For each camera involved in the reduction a spot check of its frame rate was made, on the applicable Miller record, over the time interval covered by that camera. If the frame rate varied substantially that time interval was broken into 2 - 5 sections and a frame rate determined for each section. In general the sections were chosen in such a way that the computed time of any Fastax, Bell & Howell or Mitchell frame was not in error more than 0.01 seconds and the computed time of any K-17 frame was not in error more than 0.5 seconds. The time of any frame was computed by the formula

$$T_i = (FR)(N_i) + T_1 \qquad (2.1)$$

where FR was the frame rate in seconds per frame, N_i was the frame number of the frame in question and T_1 was the time of the first frame after time zero.

2.2 COMPUTATION OF HEIGHTS AND DIAMETERS

The heights of the cloud, base of the cloud and base surge were computed as follows:

$$\alpha = \tan^{-1}\left[\frac{-e + w + \frac{pg}{k_m}}{h}\right] + 2\sin^{-1}\left[\frac{j}{2r}\right] \qquad (2.2)$$

$$A = \tan\left[\frac{90 + \alpha}{2}\right] \qquad (2.3)$$

$$S_f = \left(\frac{g}{k_m}\right)\left(\frac{j}{h}\right) \qquad (2.4)$$

$$a = (v)(S_f) \qquad (2.5)$$

$$D = (A)\,\frac{(j-a)}{(j+a)} \qquad (2.6)$$

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$$H_f = \frac{A - D}{1 + AD} \tag{2.7}$$

$$H = (H_f)(j) + e \tag{2.8}$$

The diameters of the cloud, column and base surge and the position of one edge of the base surge were computed as follows:

$$S_f = \left(\frac{g}{k_m}\right)\left(\frac{j}{h}\right) \tag{2.9}$$

$$S = (u)\ (S_f) \tag{2.10}$$

where

e was the surveyed elevation of the camera minus the surveyed elevation of ground zero.

w was the surveyed elevation of a fiducial target minus the surveyed elevation of ground zero.

p was the vertical distance, on the film, from the fiducial target used in determining w to the center of the frame.

g was the surveyed distance from the fiducial target used in determining w to another fiducial target.

k_m was the distance, on the film, between the two fiducial targets used in determining g.

h was the surveyed distance from the camera to the fiducial target used in determining w, measured along a line from the camera to ground zero.

j was the surveyed distance from the camera to ground zero.

r was the radius of the mean earth (20,926,000) feet.

v was the height, on the film, of the object being measured.

u was the width, on the film, of the object being measured.

H was the desired height.

S was the desired width.

The above formulas were basically:

$$H = (v)\left(\frac{g}{k_m}\right)\left(\frac{j}{h}\right) \qquad (2.11)$$

with corrections for (a) the curvature of the earth, (b) the vertical angle between the camera's line of sight and the horizontal and (c) the elevation of the camera relative to ground zero.

and $$S = (u)\left(\frac{g}{k_m}\right)\left(\frac{j}{h}\right) \qquad (2.12)$$

with no corrections.

Measurements on the film were made with a machine, built by the Telecomputing Corporation, which punched the measurements into IBM cards. A, S_f and e were hand computed since these remained constant for a particular camera on a particular shot. An IBM electronic calculator (C.P.C.) was used to calculate the desired heights and diameters for the desired times. When possible, any one piece of information - such as cloud height - was determined separately with the film from eight cameras: from each of two camera stations a Fastax for the early stages, two Mitchells or Bell & Howells for the middle stages and a K-17 for the late stages. Usually every 50th frame of the 1500 frame-per-second Fastax was read; every frame of the 24 frame-per-second Mitchell to about +8 seconds and then every 16th frame; every frame of the 1 frame-per-second K-17.

The data (heights and diameters) from the various cameras were plotted against time. This acted as a check on the accuracy of the computations and brought out the time intervals that required additional readings.

2.3 COMPUTATION OF RATES OF GROWTH

Using the graph of cloud height vs. time, for example, a mean curve was drawn through the data. Values were read off this curve at small time intervals and the successive differences calculated. Each of those differences was divided by the time interval covered by that difference and the result was the rate of growth for the center of that time interval. These rates were plotted against time and a curve drawn through the points. Attempts were made to find the rates by determining the equation of each mean curve but this was discarded as being impractical.

2.4 DETERMINATION OF THE ANGLE BETWEEN ONE COLUMN SIDE AND THE HORIZONTAL

The angle between one column side and the horizontal was measured with a protractor on a 10-1 enlarged image of the column.

2.5 <u>DETERMINATION OF MISSILE VELOCITY AND ANGLE</u>

Missiles were carefully chosen that seemed to be moving at right angles to the camera's line of sight and successive positions were determined by the formulas of Section 2.2. Differences in those positions divided by the time between those positions gave velocities. The arc tangent of the missile's vertical velocity divided by its initial horizontal velocity gave the initial angle between the trajectory and the horizontal.

An attempt was made to identify a missile on the film from the cameras at two stations so that the angles from each camera could be found and the missile's position determined by triangulation. This procedure failed since the same missile could not be positively identified on the film from two different camera stations.

2.6 <u>DETERMINATION OF VELOCITY OF GROUND SHOCK WAVE (TAYLOR BASIN LIGHTS)</u>

In a standard astronomical comparator the linear distances, on the film, from zero to each timing line and from zero to each Basin Light pip were measured. By interpolating between the two timing lines bracketing a pip the time of that pip was determined to the nearest 0.0001 second. The surveyed ground distance from zero to that light divided by the time gave the mean velocity of the shock wave from ground zero to that light.

2.7 <u>DETERMINATION OF VELOCITY OF GROUND SHOCK WAVE (FIDUCIAL TARGETS)</u>

It was hoped that each fiducial target would move sufficiently when the ground roll reached it to show on the Fastax film. The times of the frames bracketing that movement would have been known from the Miller record and the surveyed distance from ground zero to each target location divided by the appropriate time would have given the mean velocities. The velocities could not be determined from the film. See Section 3.1.1.

2.8 <u>DETERMINATION OF TIME OF BREAKTHROUGH</u>

It was hoped that the earth above zero point would move sufficiently prior to the breakthrough to show on the Fastax film. The number of frames between this movement and the first indication of the breakthrough multiplied by the frame rate (in seconds per frame) would have given the approximate time of breakthrough. The time of breakthrough was not determined. See Section 3.1.1.

2.9 <u>DETERMINATION OF THE VELOCITY OF THE GROUND DOME</u>

It was hoped that the ground movement mentioned in Section 2.8 could be measured on the Fastax film. Successive positions of the ground dome could then have been found by the equations of Section 2.2

and the differences in position divided by the time would have given the velocity. The velocity was not found. See Section 3.1.1.

2.10 DETERMINATION OF THE VELOCITY OF THE JET AT BREAKTHROUGH

It was planned to compute successive positions of the tip of the jet by the formulas of Section 2.2. Differences in those positions divided by the time would have given the velocity. The velocity was not found. See Section 3.1.1.

CHAPTER 3

RESULTS

3.1 GENERAL

The bulk of the desired data was obtained. Certain data - such as the time of disintegration of the structures - were not obtained since the structures did not disintegrate and certain other data - such as the time of the breakthrough - were not obtained due to the lack of a satisfactory method for determining zero time.

3.1.1 Underground Shot

The types of data that were obtained are listed in Table 1.1 and the data are presented in Figures 3.1 to 3.6 inclusive and Tables 3.1 to 3.3 inclusive. For comparison purposes data from HE 2 are presented in Figures 3.7 and 3.8.

The types of data that were not obtained are listed below:

1. The initial velocity of the cans used to plug the hole. The cans were not visible in the film.

2. The initial velocity of the missiles thrown out of the ground before the breakthrough and the angle between their early trajectory and the horizontal. No missiles were visible in the film before the breakthrough.

3. The initial velocity, size of the chunks and time of the disintegration of the chunks from the slabs placed 15 to 300 feet west of ground zero. No chunks from these slabs were visible in the film.

4. The time of disintegration and initial velocity of several points on each structure. No structure disintegration was visible in the film.

5. The velocity of the ground shock as determined by a line of fiducial targets. Targets #1, 2, 3, 8, 9 and 10 could not be positively identified in the film. The others were checked from +0.167 seconds to +0.324 seconds but no movements could be detected. It is believed that movements of 6 inches or more could have been detected.

6. The time of the breakthrough. The first movement of the ground dome could not be seen in the film and there was no other satisfactory method of determining the actual firing time.

7. The velocity of the ground dome. The movement of the ground dome could not be seen in the film.

8. The velocity of the jet. No true jet was visible in the frames that also showed the camera's fiducial targets.

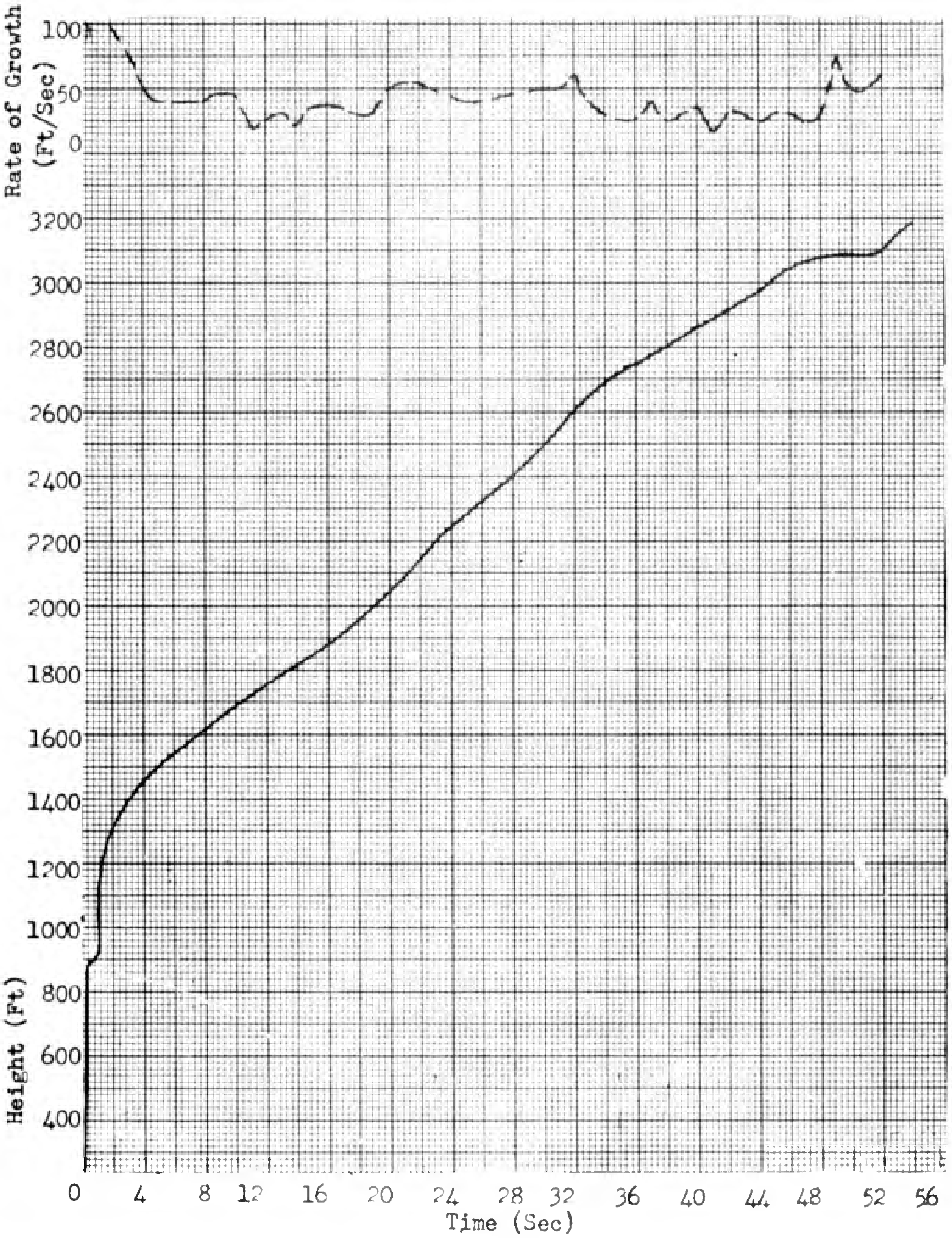

Fig. 3.1 Cloud Height and Rate of Growth
Underground Shot

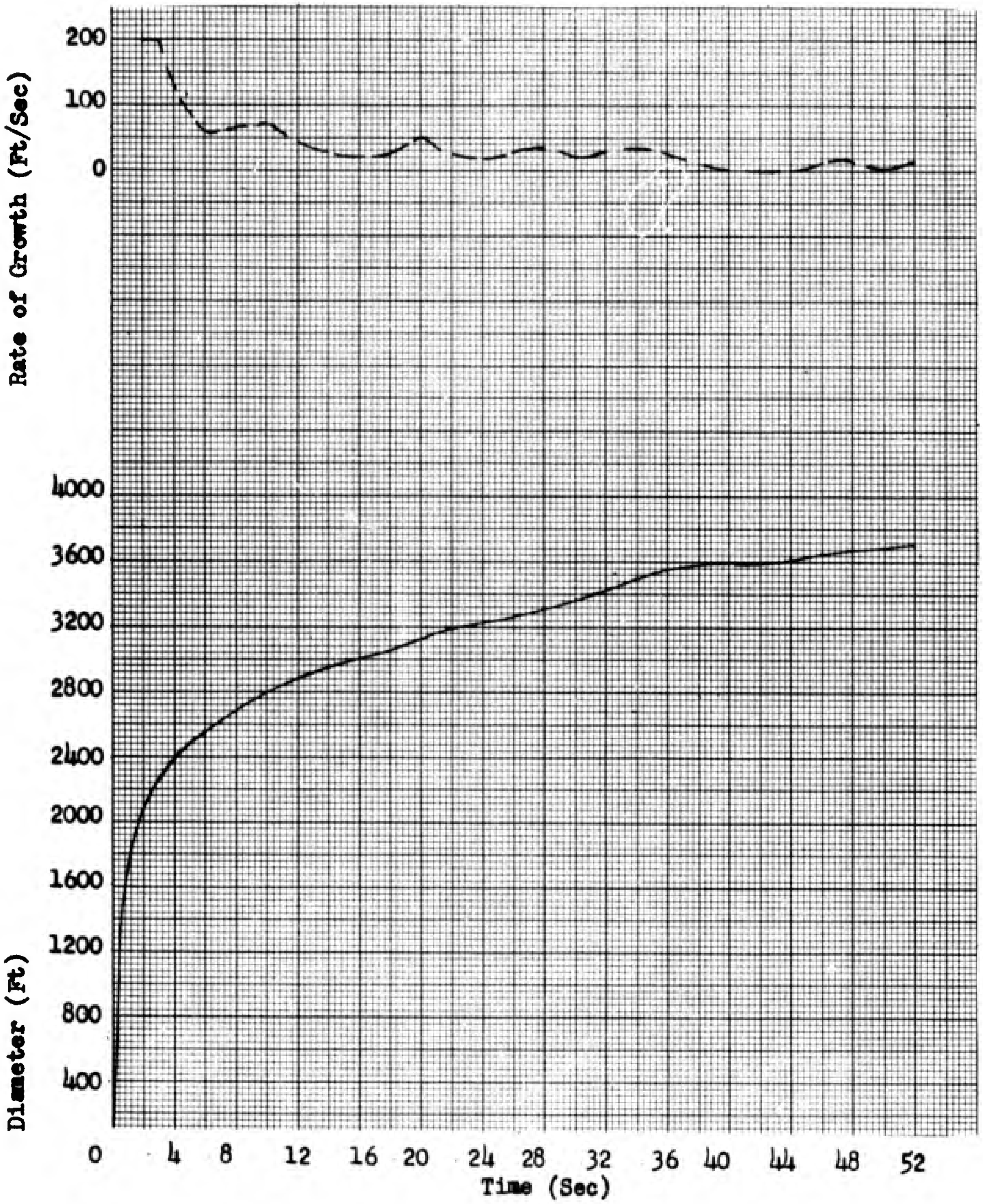

Fig. 3.2 Cloud Diameter and Rate of Growth
Underground Shot

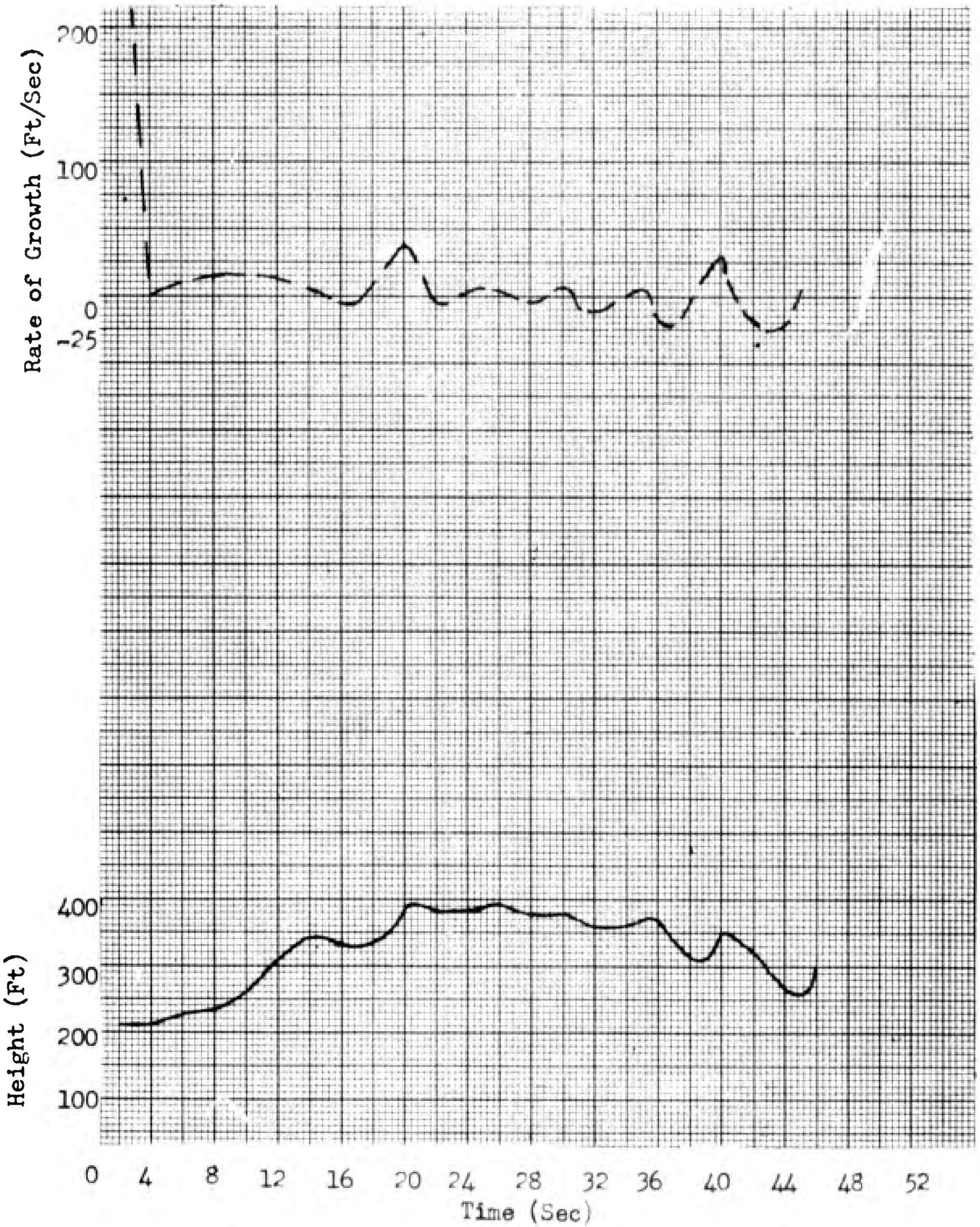

Fig. 3.3 Cloud Base Height and Rate of Growth
Underground Shot

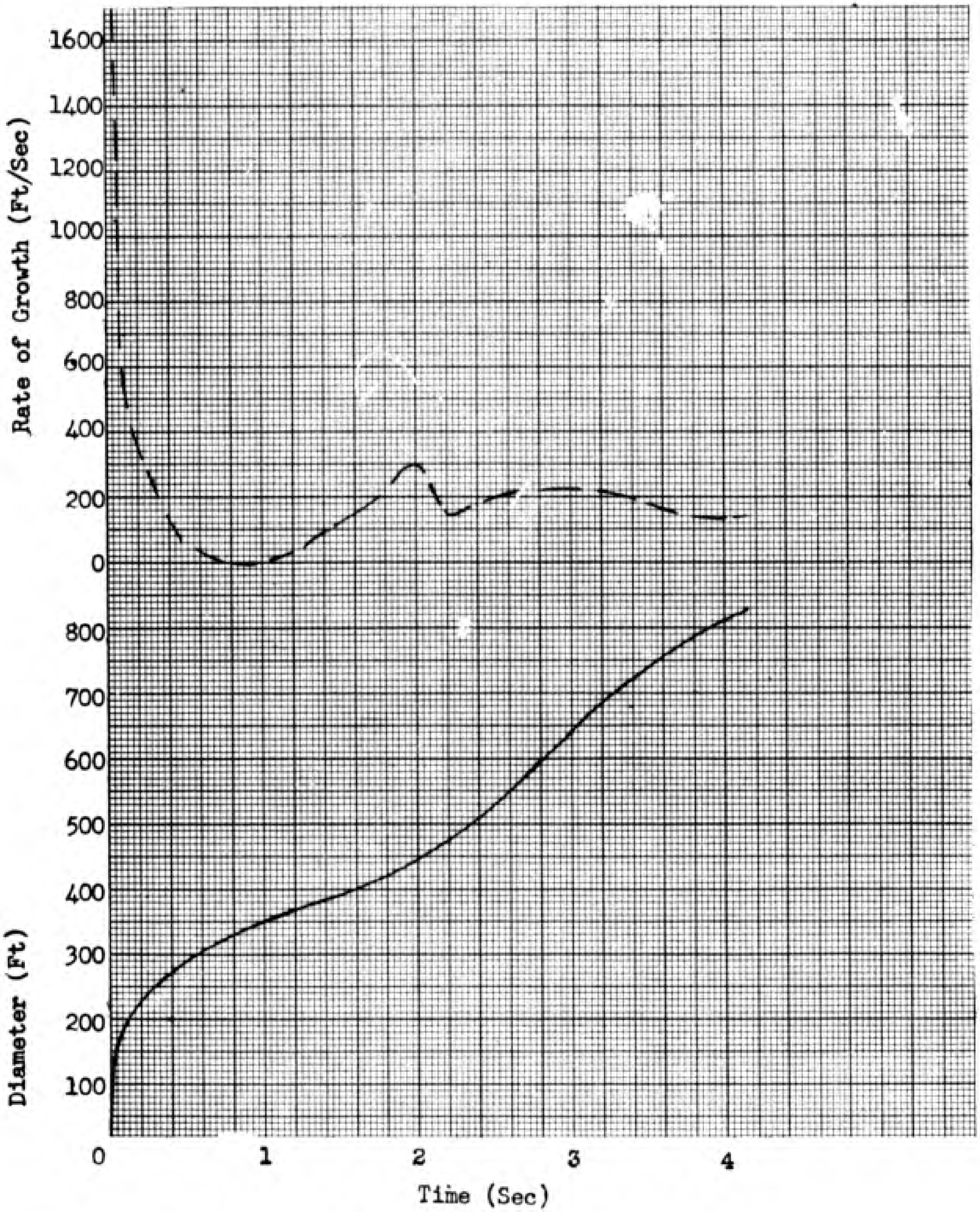

Fig. 3.4 Column Diameter and Rate of Growth
Underground Shot

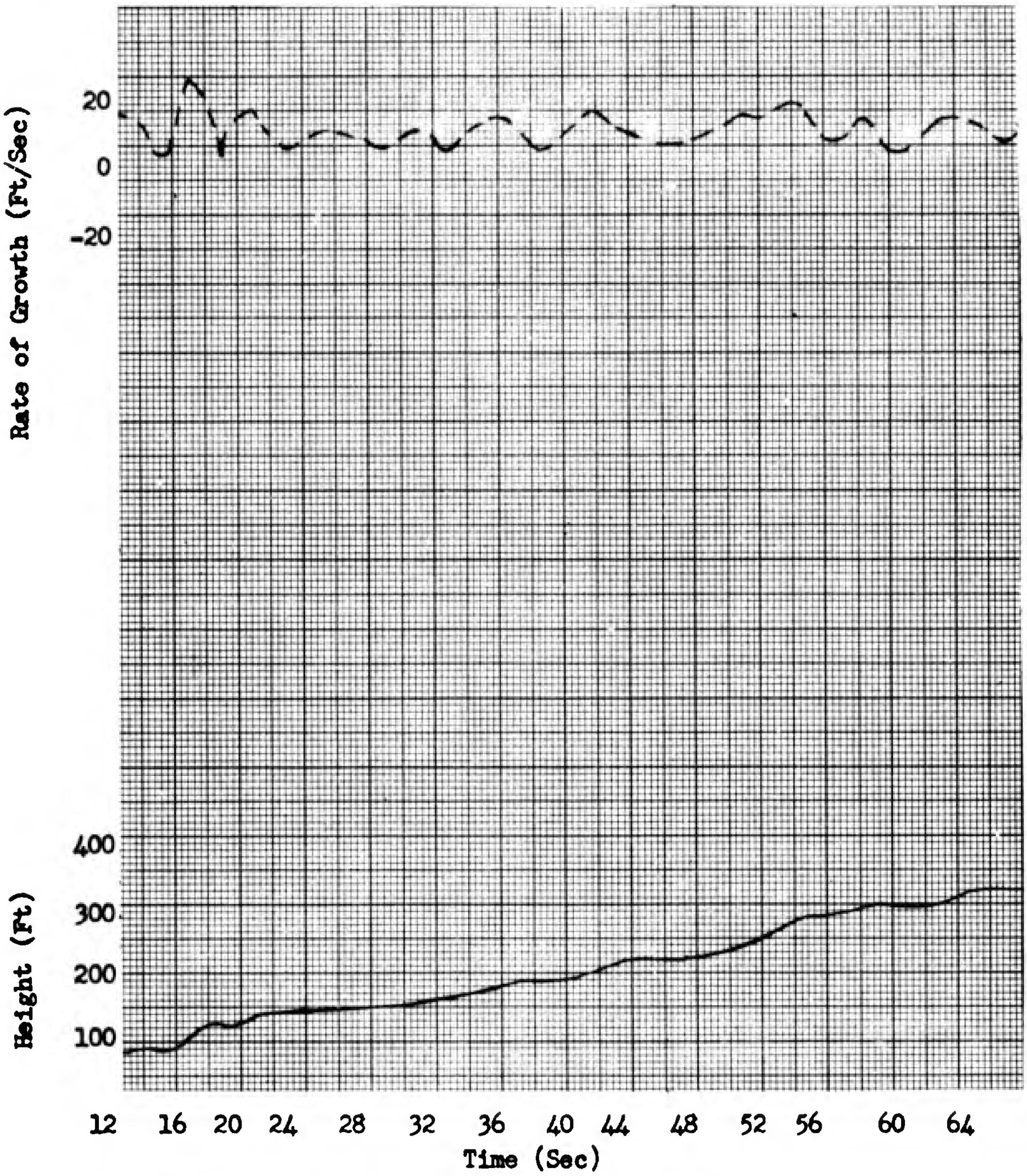

Fig. 3.5 Base Surge Height and Rate of Growth
Underground Shot

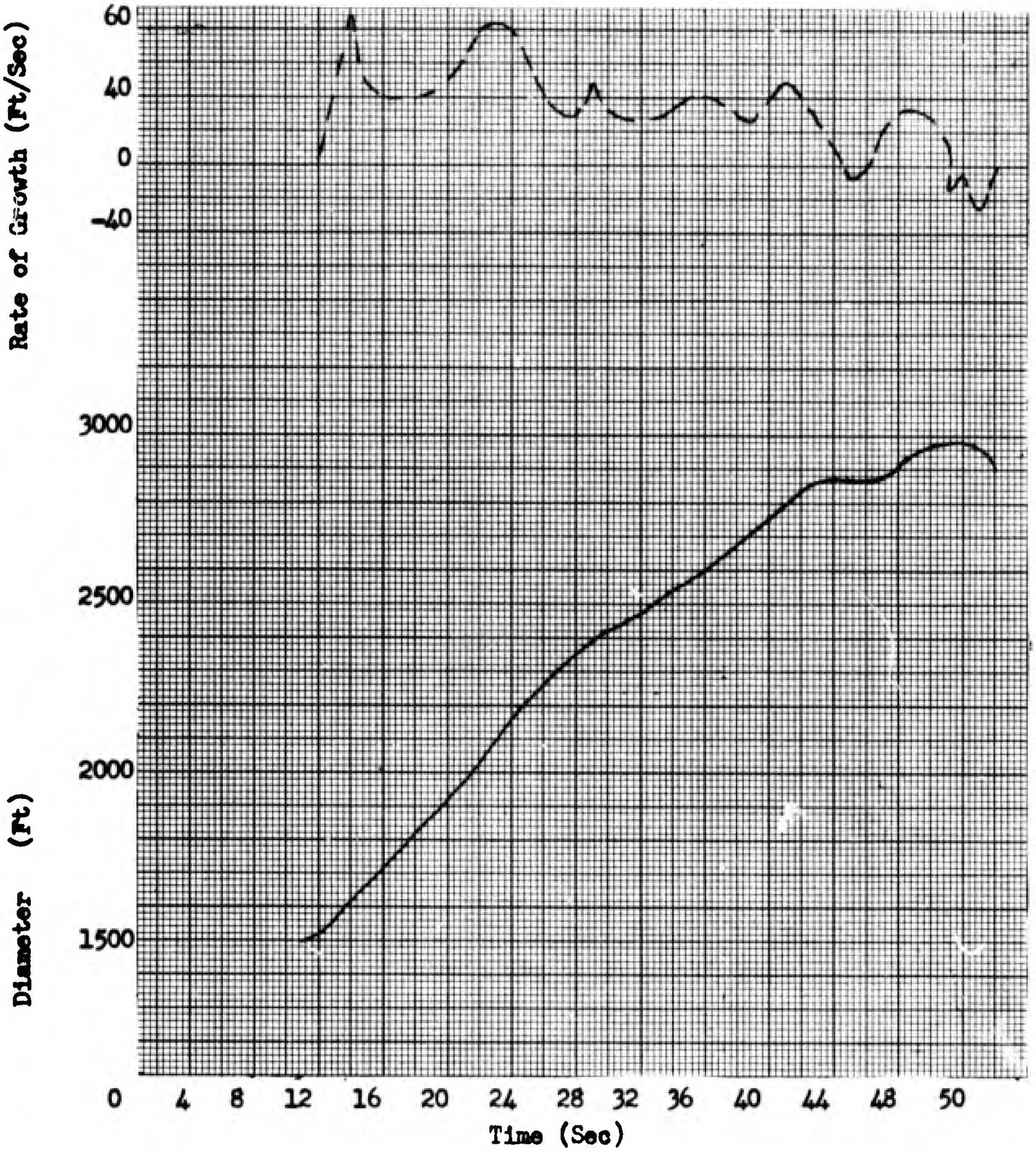

Fig. 3.6 Base Surge Total Diameter and Rate of Growth Underground Shot

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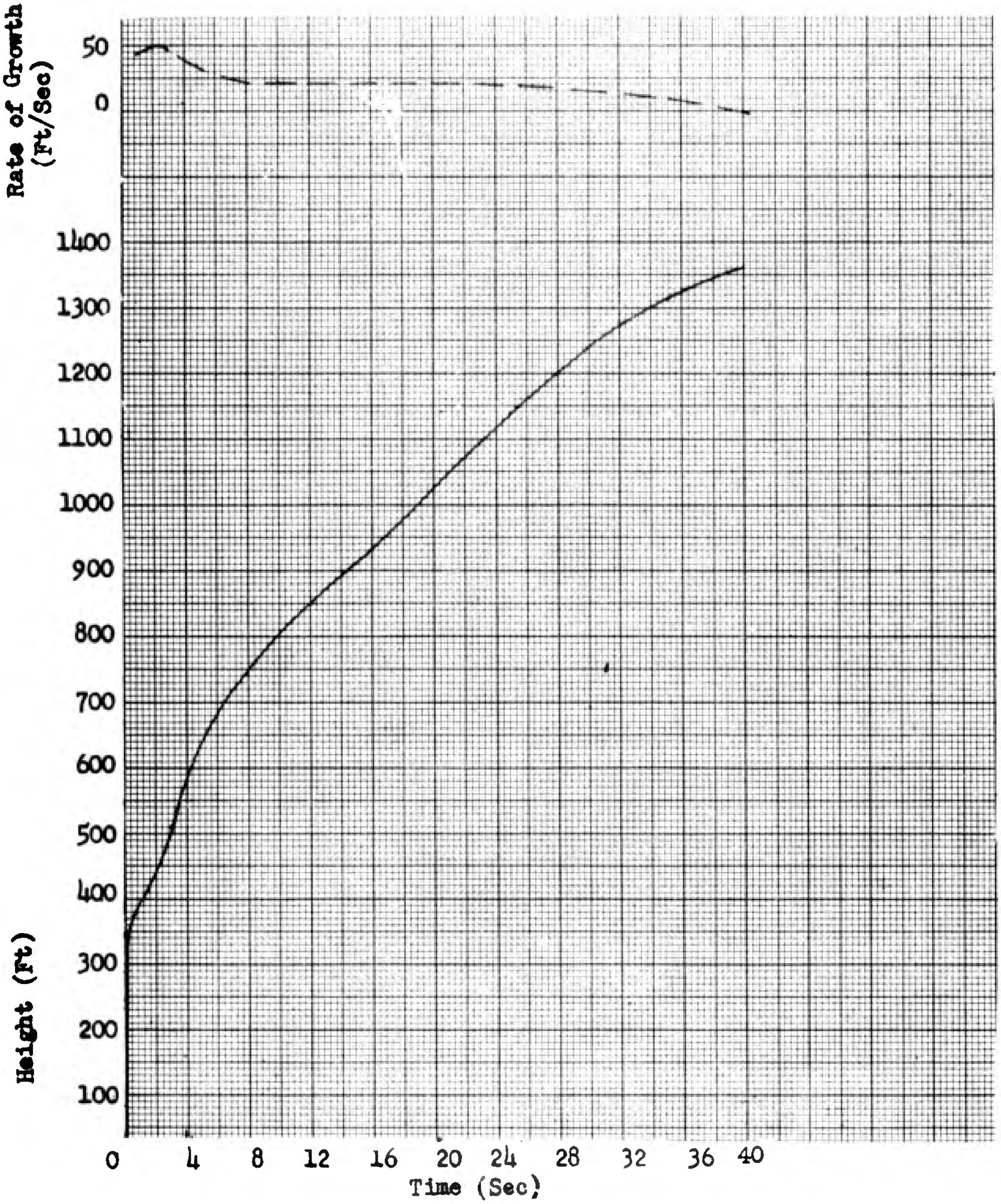

Fig. 3.7 Height of Cloud and Rate of Growth
HE-2 Underground Shot

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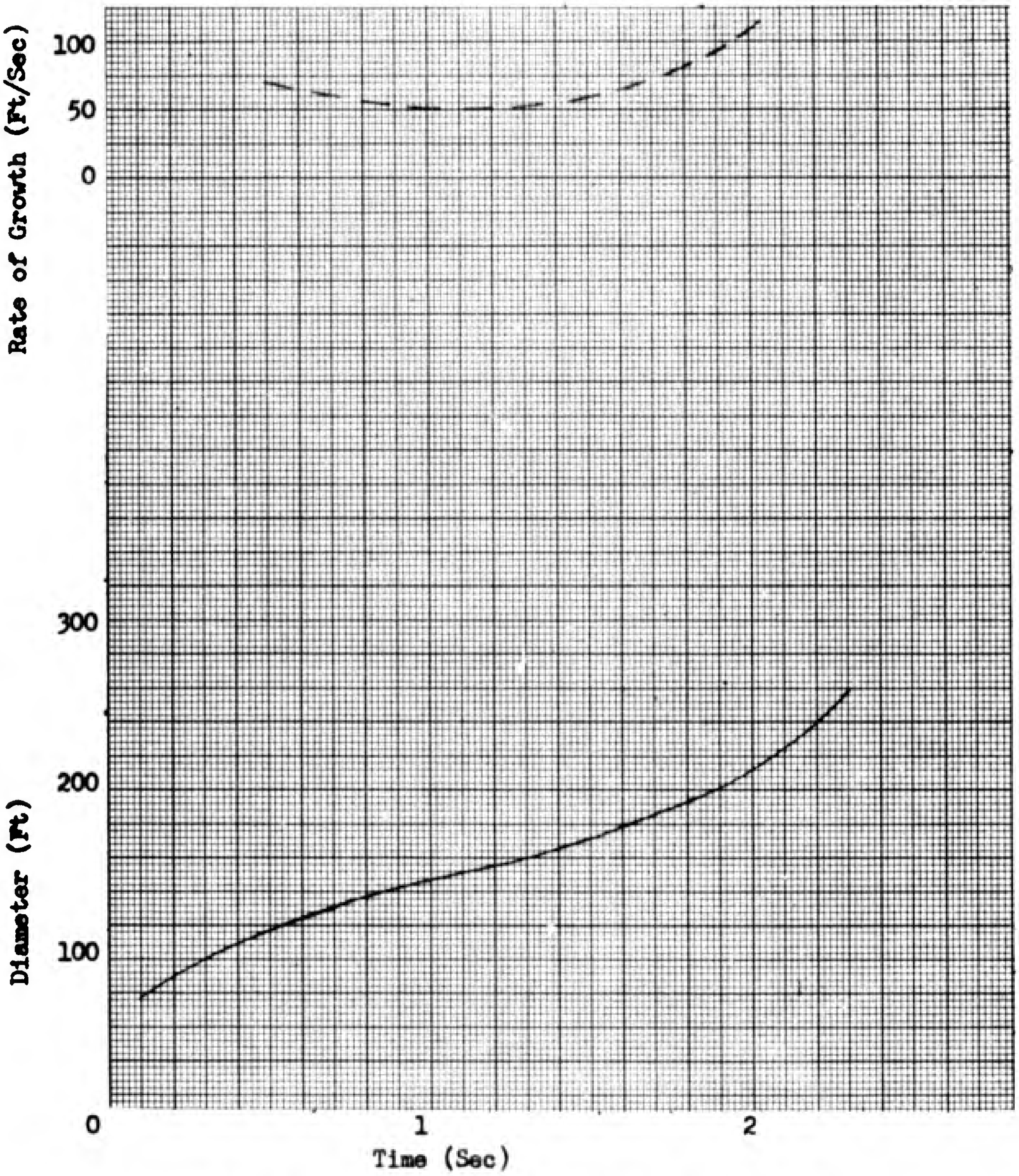

Fig. 3.8 Column Diameter and Rate of Growth
HE 2 Underground Shot

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TABLE 3.1

Angle Between Column Side and Horizontal

Underground Shot

Time (seconds)	Angle (degrees)	
	West Side	East Side
0.233	43	42
0.517	46	41
1.041	53	43
1.566	58	48
2.091	61	56
2.616	55	59
3.140	52	55

[redacted]

PROJECT 4.1a-2

TABLE 3.2

Velocity And Angle Of Missiles From Cloud and Column

Underground Shot

Camera Station	Missile Number	Direction of Missile Movement	Time (Sec)	Velocity (Ft/Sec)	Angle Above Horizontal (Deg.)
1	1	S	1.619	314	33
1	1	S	1.819	200	35
1	1	S	2.019	489	38
1	2	S	1.739	314	28
1	2	S	1.939	291	31
1	2	S	2.140	174	35
1	2	S	2.340	69	38
2	3	W	6.235	95	21
2	3	W	6.365	104	20
2	3	W	6.475	85	20
2	3	W	6.685	107	22
2	3	W	6.945	103	23
2	3	W	7.160	101	24
2	3	W	7.380	79	24
2	3	W	7.600	89	25
2	3	W	7.820	137	31
2	3	W	8.040	112	43

[redacted]

[redacted]

TABLE 3.2
(Continued)

Velocity And Angle Of Missiles From Cloud and Column

Underground Shot

Camera Station	Missile Number	Direction of Missile Movement	Time (Sec)	Velocity (Ft/Sec)	Angle Above Horizontal (Deg.)
2	4	E	6.945	94	27
2	4	E	7.160	62	30
2	4	E	7.380	129	35
2	4	E	7.600	92	38
2	4	E	7.820	42	38
2	4	E	8.040	59	39
2	4	E	8.260	29	41
2	4	E	8.480	24	41
2	4	E	8.775	10	41
2	4	E	9.475	10	45
3	5	SW	6.170	65	8
3	5	SW	6.275	125	8
3	5	SW	6.380	66	8
3	5	SW	6.485	80	8
3	5	SW	6.590	122	8
3	5	SW	6.695	119	9

[redacted]

TABLE 3.2
(Continued)

Velocity And Angle Of Missiles From Cloud And Column

Underground Shot

Camera Station	Missile Number	Direction of Missile Movement	Time (Sec)	Velocity (Ft/Sec)	Angle Above Horizontal (Deg.)
3	5	SW	6.800	32	10
3	5	SW	6.900	57	10
3	5	SW	7.055	42	14
3	5	SW	7.265	27	18
3	6	SW	6.745	118	10
3	6	SW	6.955	27	13
3	6	SW	7.165	123	16
3	6	SW	7.470	77	21
3	6	SW	7.920	86	29
3	6	SW	8.420	57	35
3	6	SW	8.920	38	39
3	6	SW	9.420	42	44

TABLE 3.3

Velocity Of Ground Wave (Taylor Model Basin Lights)

Underground Shot

TAYLOR LIGHT LOCATION		AVERAGE VELOCITY FROM ZERO (Ft/Sec)	
Number	Feet from Zero	As Determined by Camera Station No. 9	As Determined by Camera Station No. 10
1	100	3623	3704
2	125	3613	3655
3	150	-	3827
4	178	-	3956
5	217	-	3741
6	262	-	35405
7	314	3765	3779
8	378	5736	5762
9	456	4207	4230
10	542	4033	4048

3.1.2 Surface Shot

The types of data that were obtained are listed in Table 1.1 and the data are presented in Figures 3.9 and 3.10. For comparison purposes data from HE 4 are presented in Figure 3.11.

The data that were not obtained are listed below:

1. The diameter of the column, the height of the base of the cloud and the angle between the side of the column and the horizontal. The surface shot did not form a well defined column. An attempt was made to measure the height of the base of the cloud and the angle between the column sides and the horizontal but the measurements varied so widely they were probably meaningless.

2. The velocity of the ground wave as determined by a line of fiducial targets. Targets #7 and 8 were the only ones positively identified on the film. They were checked between +0.146 seconds and +1.1 seconds but no movements could be detected. It is believed that movements of 6 inches or more could have been detected.

3. The initial velocity of the missiles thrown out of the column or cloud and the angle between the initial velocity and the horizontal. As far as could be determined from the film the column and cloud did not eject any missiles. Several long "streamers" were measured but the measurements varied considerably from one frame to the next indicating that the streamers were not missiles.

[redacted]

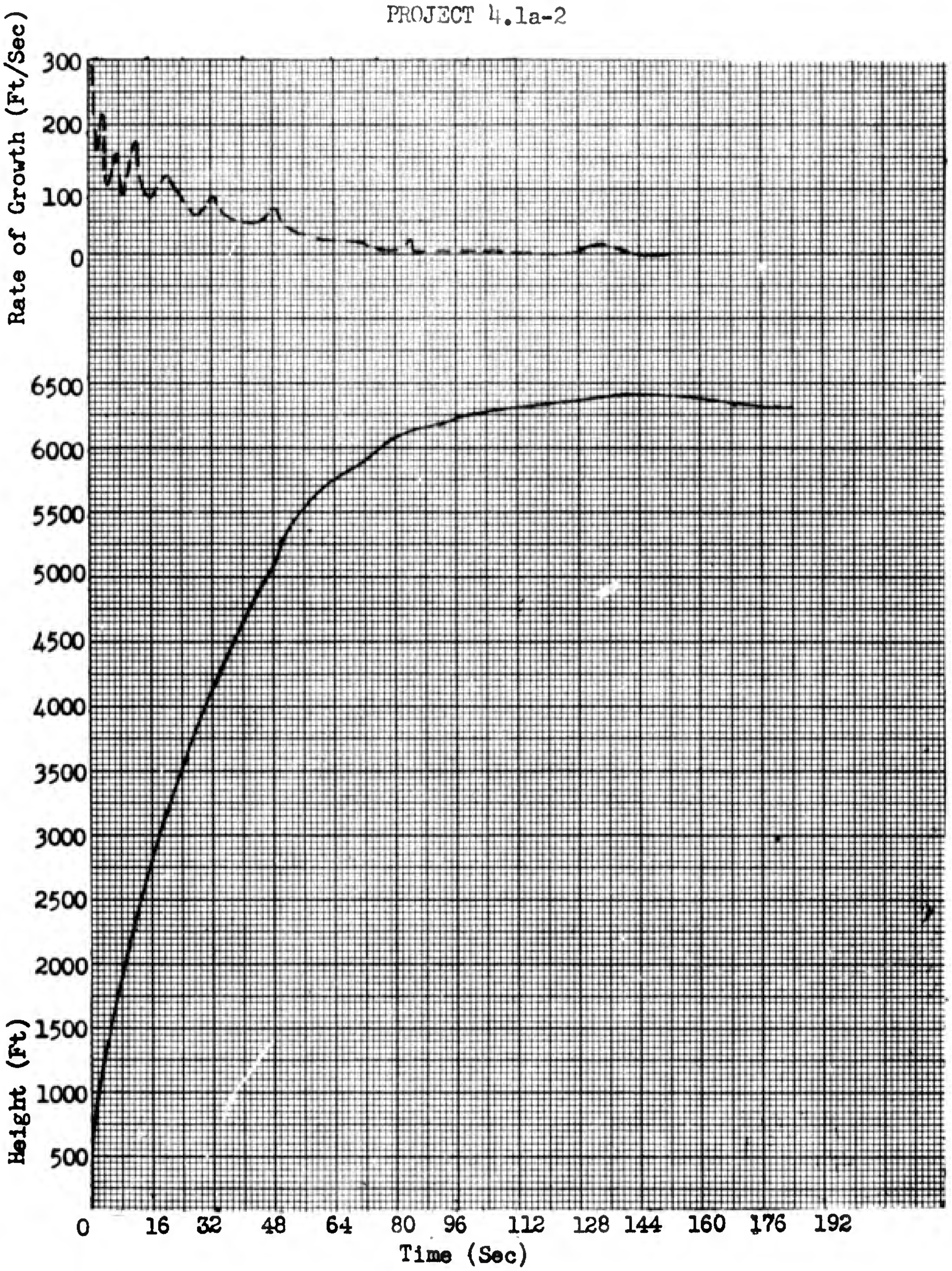

Fig. 3.9 Cloud Height and Rate of Growth
Surface Shot

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[redacted]

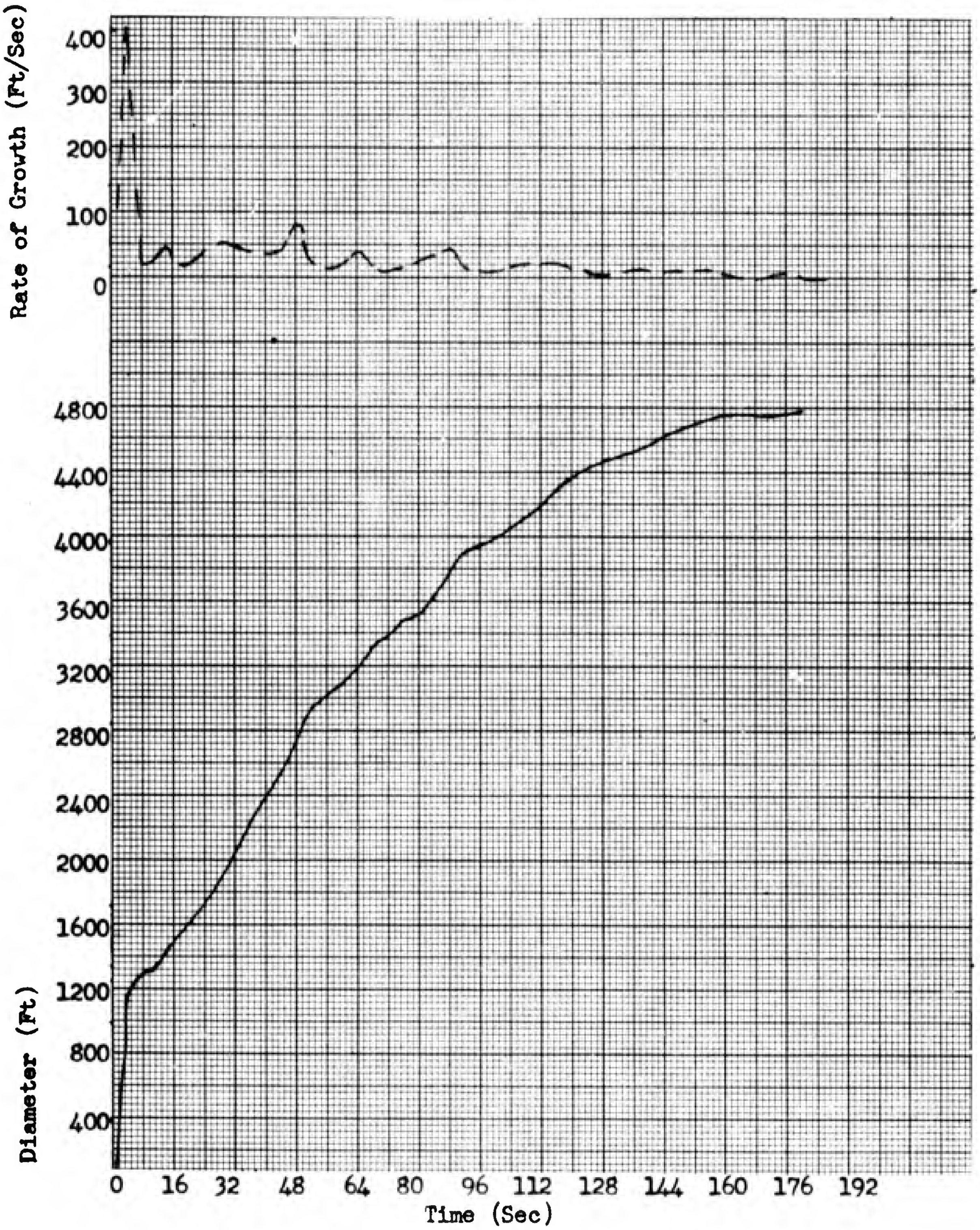

Fig. 3.10 Cloud Diameter and Rate of Growth
Surface Shot

[redacted]

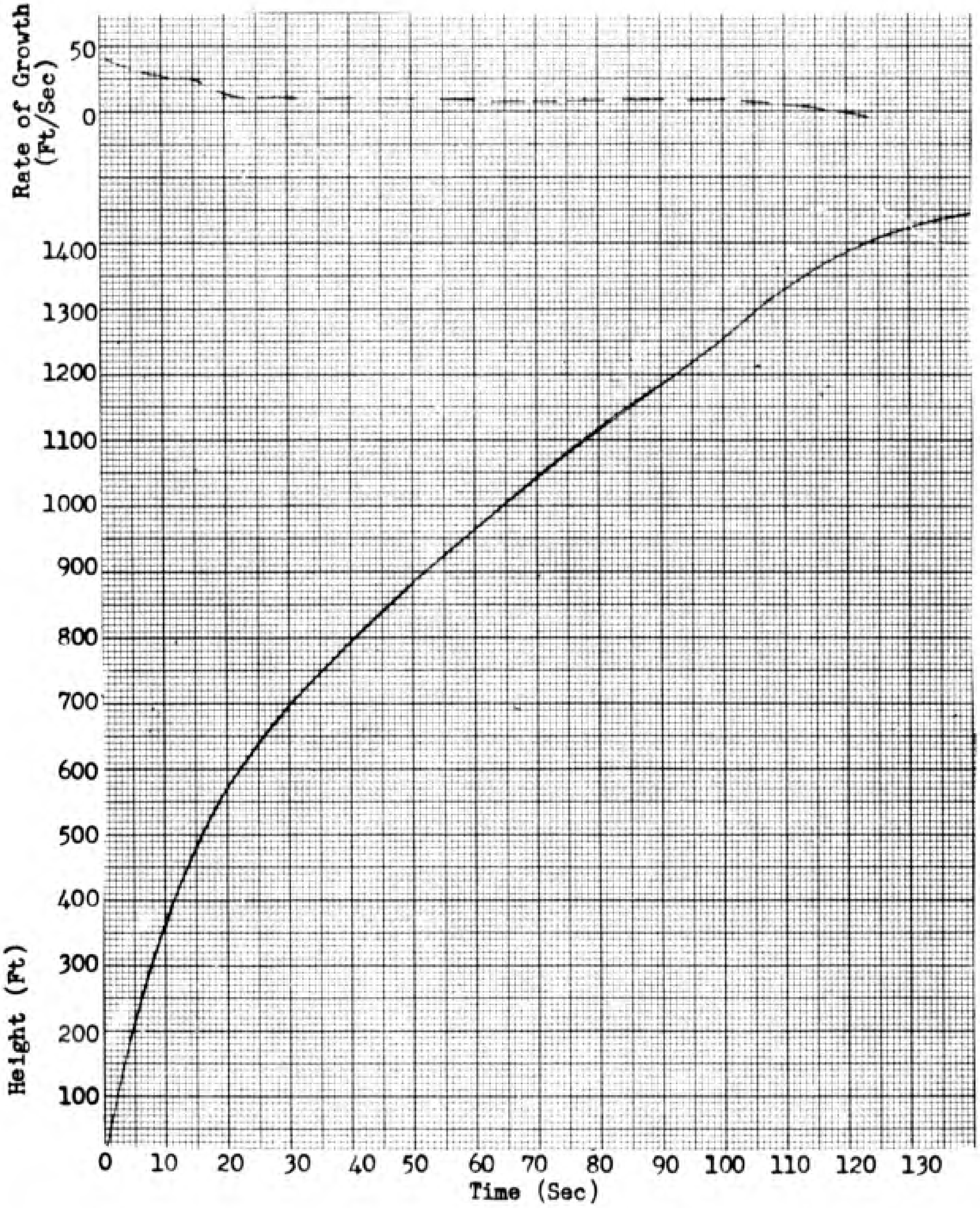

Fig. 3.11 Cloud Height and Rate of Growth
HE 4 Surface Shot

3.2 ACCURACY OF THE DATA

No good checks on the accuracy of the data were available, however one measure of the accuracy of the heights and diameters was the spread of the data from several cameras. For example, if at a particular time, the cloud height was computed separately from each of four cameras representing at least two camera stations then the spread of those figures around the mean of the four heights is one indication of the accuracy of the mean.

The times of the observations of the underground shot were believed to be accurate ±0.005 seconds for the Fastax data, ±0.010 seconds for the Mitchell and Bell & Howell data and ±0.5 seconds for the K-17 data.

The times of the observations of the surface shot after +0.7 seconds may have been in error by as much as 0.5 seconds. The recorders almost stopped at +0.7 seconds and did not resume their normal speed until about +2.7 seconds. The Fastax cameras contained their own timing lines however, and the Fastax data were little affected by the lack of recorder times. Therefore, the Fastax data were matched as well as possible with the data from the other cameras. It was believed that the times of the observations, after making this correction, were probably correct ±0.05 seconds.

The base surge of the underground shot did not have well-defined edges since they blended with the dust cloud. The data on the diameter of the base surge and its position relative to zero were therefore extremely rough.

The cloud from the underground shot did not appear to be round. The diameter of the cloud, as determined from Station 2, varied somewhat from the diameter of the cloud as determined from Station 3.

It will be noted that the method of Paragraph 2.3, if applied to the data in Figures 3.1 to 3.8, will produce "Rate of Growth" curves that vary slightly from the "Rate of Growth" curves in Figures 3.1 to 3.8. This variance would be caused by the extremely small scale used in plotting the data curves in Figures 3.1 and 3.8. The original data were plotted on large sheets of graph paper and the rates determined from the resulting curves.

The estimated accuracies of the data are listed on Tables 3.4 and 3.5.

PROJECT 4.1a-2

TABLE 3.4

Estimated Accuracies of Mean Data
Underground Shot

	50% of the Observations	90% of the Observations
Item	(Feet unless otherwise indicated)	
Height of Cloud	± 20	± 50
Diameter of Cloud	40	100
Height of Base of Cloud	40	100
Diameter of Column	40	100
Height of Base Surge	10	25
Diameter of Base Surge	60	150
Position of Base Surge	60	150
Angle of Column Side	1°	2°
Velocity of Missiles	10 fps	25 fps
Angle of Missiles	2°	5°
Velocity of Ground Shock	20 fps	50 fps
Rates of Growth:		
Height of Cloud	4 fps	10 fps
Diameter of Cloud	10 fps	20 fps
Height of Base of Cloud	10 fps	20 fps
Diameter of Column	10 fps	20 fps
Height of Base Surge	6 fps	15 fps
Diameter of Base Surge	15 fps	40 fps

TABLE 3.5

Estimated Accuracies of Mean Data

Surface Shot

	50% of the Observations	90% of the Observations
Item	(Feet unless otherwise indicated)	
Height of Cloud	± 40 fps	± 100 fps
Diameter of Cloud	40 fps	100 fps
Height of the Base of the Cloud	See Section 3.1.2	See Section 3.1.2
Angle of Column Side	See Section 3.1.2	See Section 3.1.2
Rates of Growth		
Height of Cloud	4 fps	10 fps
Diameter of Cloud	8 fps	20 fps
Height of Base of Cloud	See Section 3.1.2	See Section 3.1.2

CHAPTER 4

RECOMMENDATIONS FOR FUTURE TESTS

4.1 LIAISON WITH DATA REDUCTION UNIT

Close liaison between the organizations requesting the data and the data reduction unit must be maintained. In the reduction of the data many questions will arise which should not be answered by the data reduction personnel and also many hours of data reduction time will probably be saved.

4.2 FILM PRINTS

Immediately after the test one print of all of the exposed film should be made and given the data reduction unit for their exclusive use. Reducing a print rather than the original will probably introduce a small amount of error but the film will then be available when it is needed. An attempt to edit the film and print only selected portions may well be more time-consuming than the printing of all the film.

4.3 ZERO TIME

A true zero time should be shown on all camera-return-pulse records. The recorders might be tied to the firing circuits without the intervention of relays or other variable acting mechanisms.

4.4 DETERMINATION OF THE VELOCITY OF THE GROUND SHOCK (FIDUCIAL TARGETS)

If the fiducial targets are used to obtain the velocity of the ground shock they should be at least 8 feet by 8 feet and should have a light at the center of each one. Several of the targets should be mounted with a corner at the top and the remaining ones mounted with a side at the top. Certain cameras may photograph only two or three of the targets and a non-uniform pattern will aid in identifying specific targets in the film.

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U. S. Atomic Energy Commission, Classified Document Room, 1901 Constitution Ave., Washington 25, D. C. ATTN: Mrs. J. M. O'Leary	218-220
Los Alamos Scientific Laboratory, Report Library, P.O. Box 1663, Los Alamos, N. Mex. ATTN: Helen Challenger	221-223
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