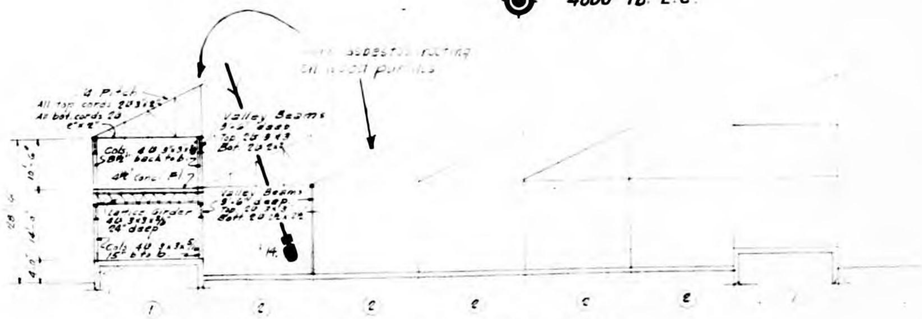
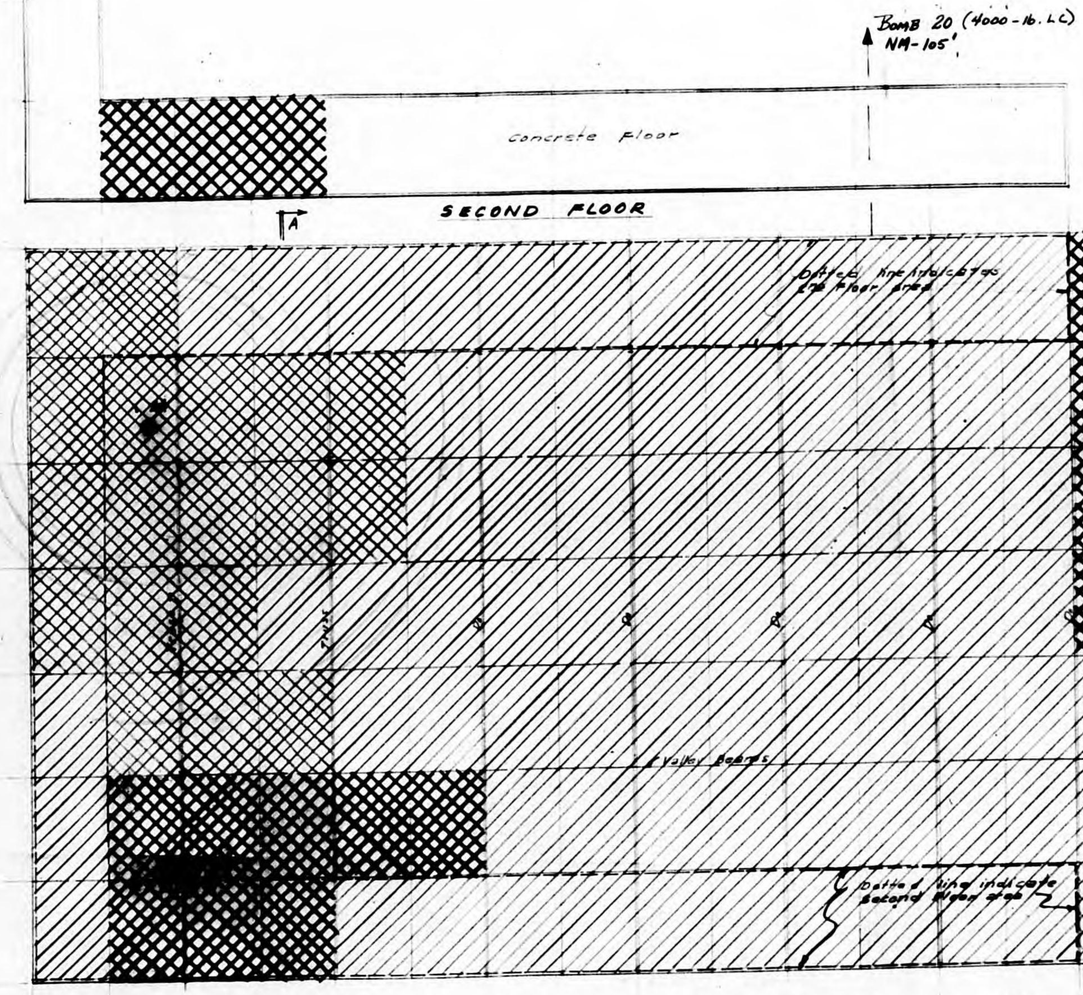
LEGEND:-

- H.E. SUPERFICIAL DAMAGE
- H.E. STRUCTURAL DAMAGE
- FIRE STRUCTURAL DAMAGE
- 1000 lb G.P.
- 4000 lb. L.C.

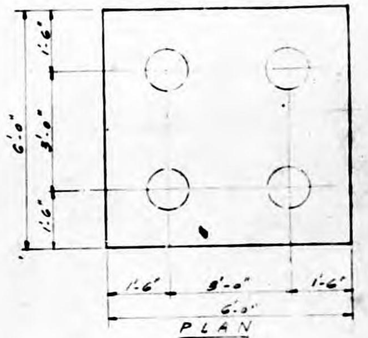


SECTION "A-A"



ROOF FRAMING PLAN

GRAPHIC SCALE IN FEET



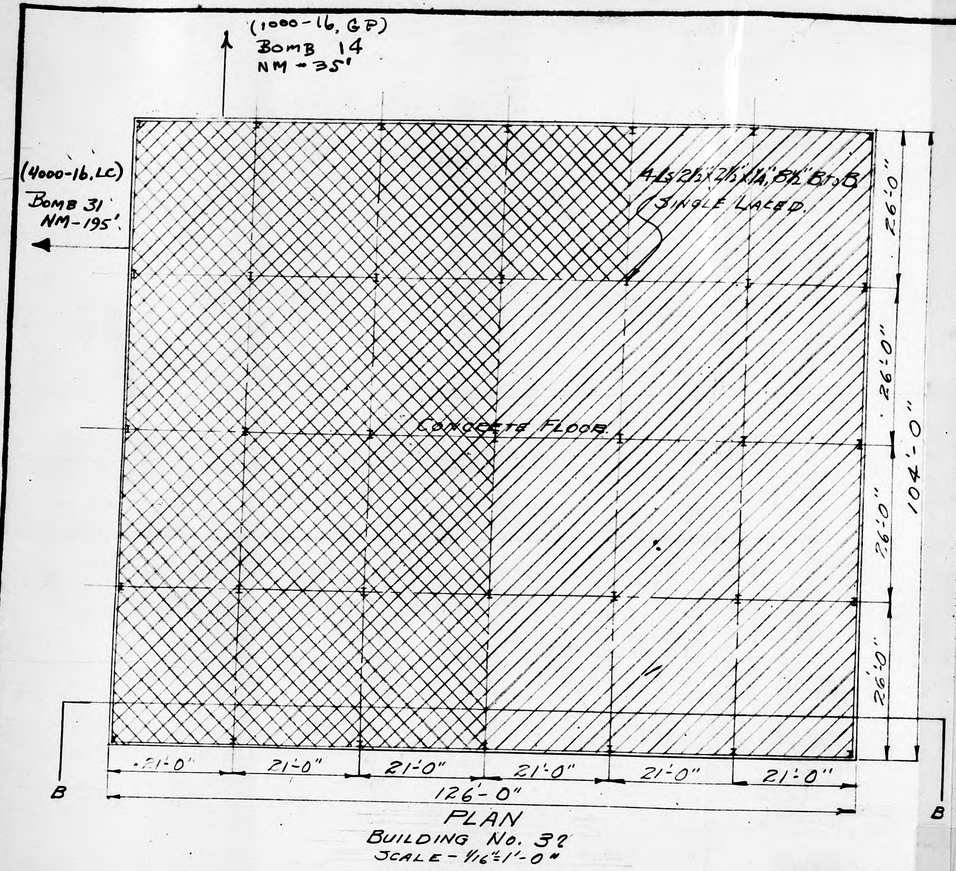
TYPICAL PILE CAP & PILES
FOR ALL COLUMNS

BUILDING No. 31

TOTAL PLAN AREA 44,200 sq. ft.

U.S. STRATEGIC BOMB. SURVEY
AICHI AIRCRAFT CO., FUNAKATA PL'T.
AICHI CLOCK & ELECTRIC CO., LTD.
NAGOYA, JAPAN
BLDG. 31 FIGURE 22

By HR-A NARA, Date 3/8/91



PLAN
BUILDING No. 32
SCALE - 1/16" = 1'-0"

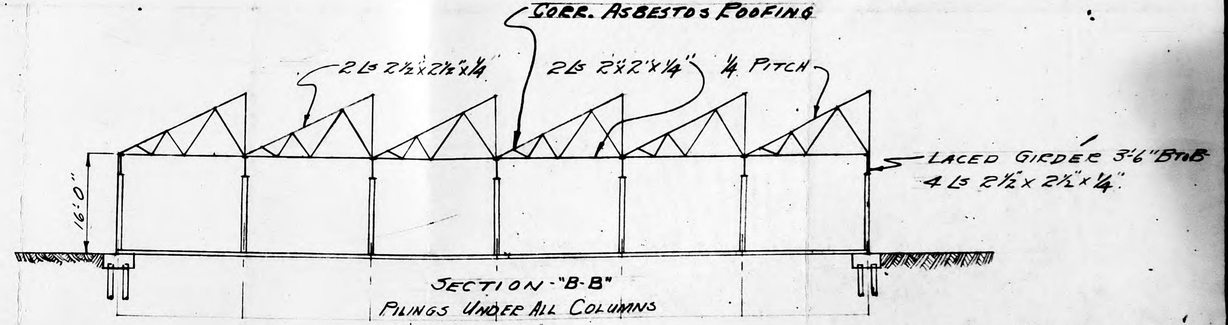
LEGEND:

H.E. STRUCTURAL DAMAGE

H.E. SUPERFICIAL DAMAGE

SCALE IN FEET

25 20 15 10 5 0 25 50



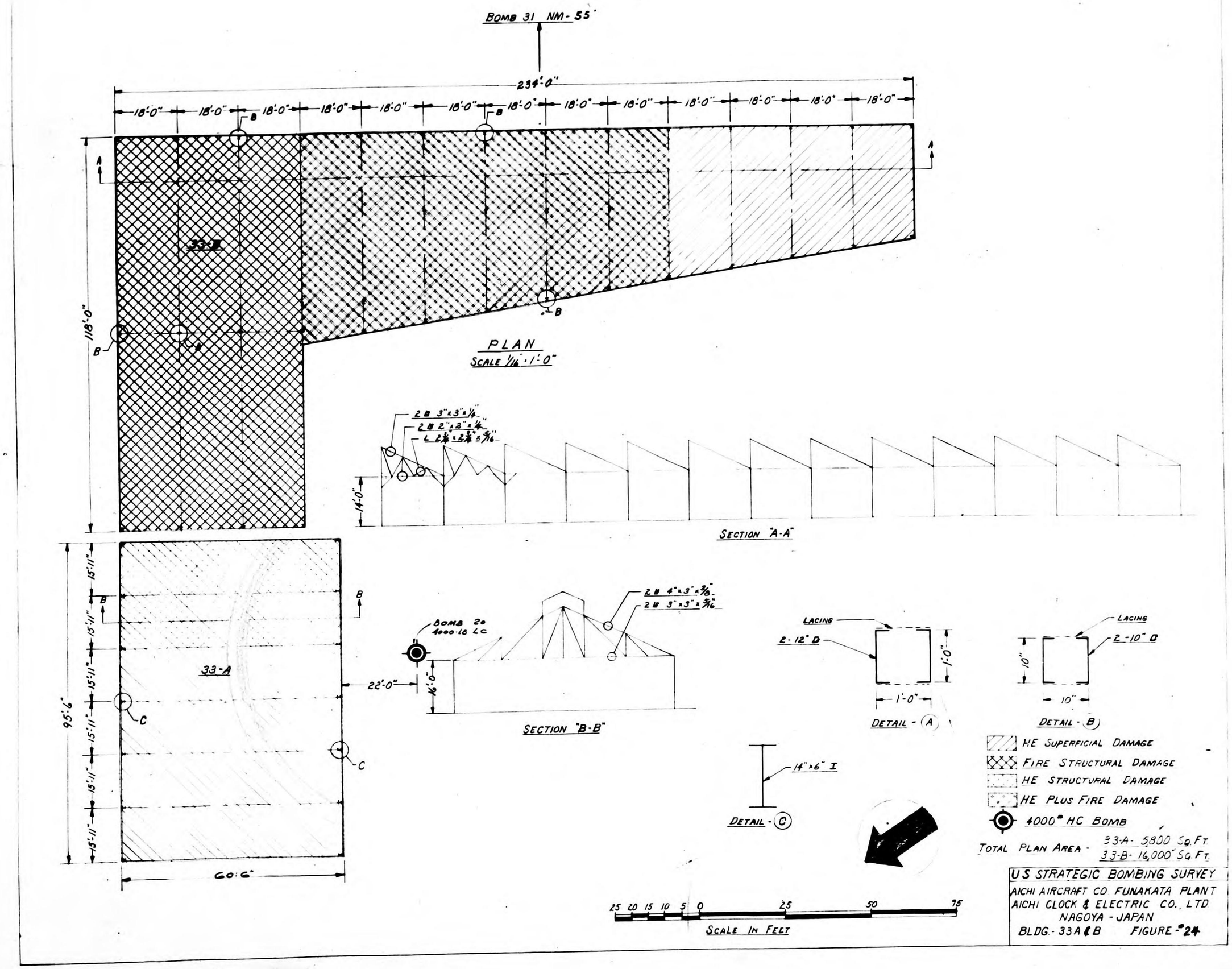
SECTION - "B-B"
PILINGS UNDER ALL COLUMNS

PLAN AREA - 13,100 Sq. Ft.

U.S. STRATEGIC BOMBING SURVEY
NICHI AIRCRAFT CO. FUKUOKA PLANT
NICHI CLOCK & ELECTRIC CO., LTD.
NAGOYA, JAPAN
BLDG NO. 32 FIGURE - 23

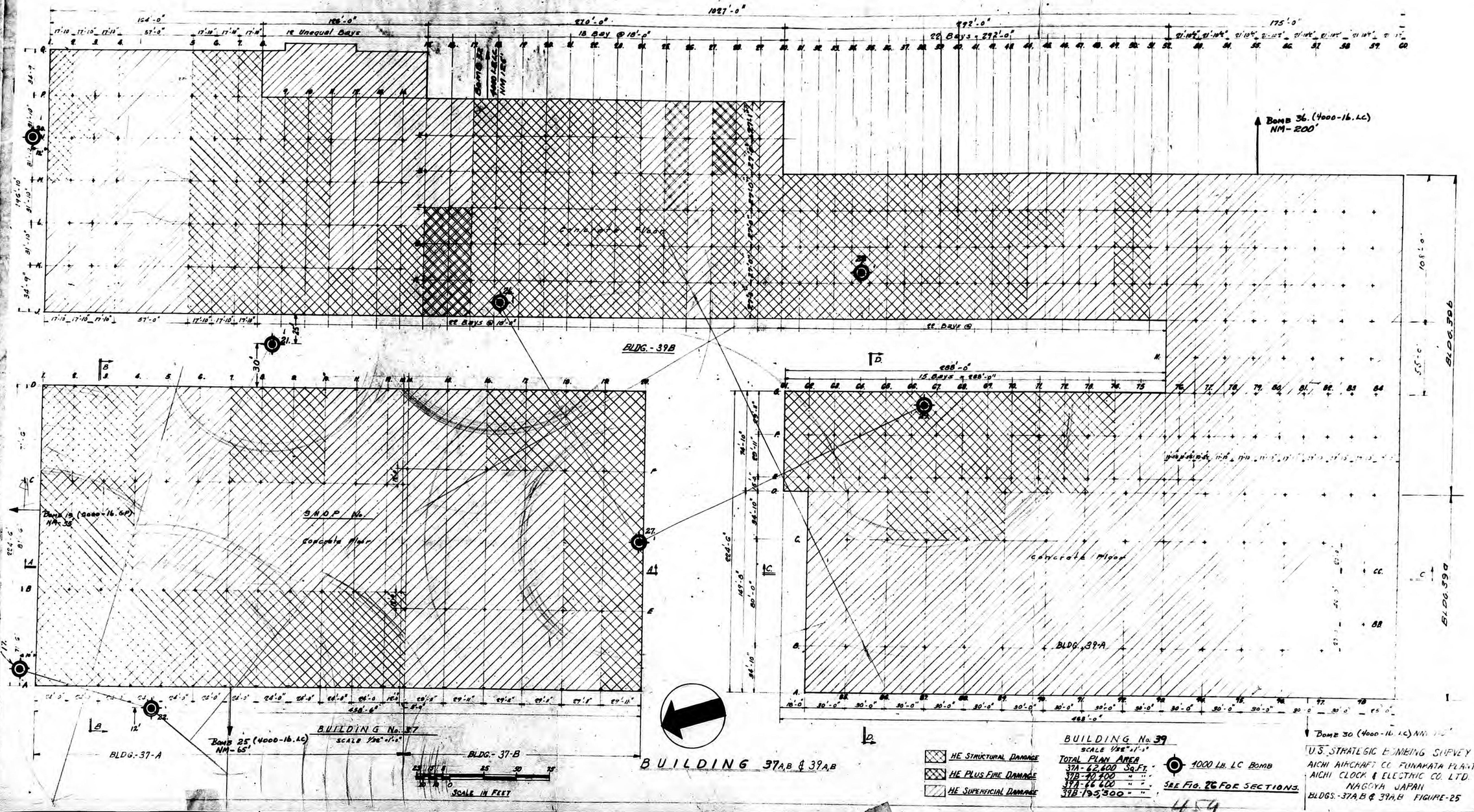
457

By HR-M NARA, Date 3/5/91



US STRATEGIC BOMBING SURVEY
AICHI AIRCRAFT CO FUNAKATA PLANT
AICHI CLOCK & ELECTRIC CO., LTD
NAGOYA - JAPAN
BLDG. - 33A & B FIGURE - #24

458



1027'-0"
164'-0"
126'-0"
270'-0"
292'-0"
175'-0"
12 Unequal Bays
18 Bay @ 18'-0"
22 Bays = 292'-0"
Bomb 36. (4000-lb. LC)
NM-200'
Concrete Floor
22 Bays @ 18'-0"
22 Bays @
BLDG.-39B
288'-0"
15 Bays = 288'-0"
SHOP No.
Concrete Floor
Bomb 19 (2000-lb. GP)
NM-35'
Concrete Floor
BLDG. 39-A
BLDG. 39b
BLDG. 39a
458'-6"
468'-0"
BUILDING No. 37
SCALE 1/32" = 1'-0"
Bomb 25 (4000-lb. LC)
NM-65'
BLDG.-37-A
BLDG.-37-B
BUILDING 37A,B & 39A,B
SCALE IN FEET
HE STRUCTURAL DAMAGE
HE PLUS FIRE DAMAGE
HE SUPERFICIAL DAMAGE
BUILDING No. 39
SCALE 1/32" = 1'-0"
TOTAL PLAN AREA
37A-62,600 Sq.Ft.
37B-40,400 " "
39A-66,600 " "
39B-195,300 " "
4000 LB. LC BOMB
SEE FIG. 26 FOR SECTIONS.
Bomb 30 (4000-lb. LC) NM
U.S. STRATEGIC BOMBING SURVEY
AICHI AIRCRAFT CO. FUNAKATA PLANT
AICHI CLOCK & ELECTRIC CO. LTD.
NAGOYA JAPAN
BLDGS.-37A,B & 39A,B FIGURE-25

454

COLUMN SCHEDULE

	Building No. 39	Building No. 37
	B - 71; 72; 73 C - 71; 72; 73	None
	A - 60; 62 & 85 to 98 incl. D - 60; 61; 62 & 85 to 98 incl.	None
	B - 91; 95, 96; 97 - 88 - 98 C - 91; 95, 96; 97 - CC - 98	None
	B - 82, 85, 86, 87, 88, 89, 99 C - 82, 85, 86, 87, 88, 89, 90	None
	B - 52, 53 & 61 to 76 incl. F - Do G - Do	None
	B - 60; & 77 to 84 incl. G - Do	None
	H to Vinct & 1 to 60 incl.	None
	None.	A - 1 to 13 incl. B - Do C - Do D - Do
	None.	A - 14 to 29 incl. E - Do F - Do D - Do

SECTION "D-D"
SCALE 1/16"=1'-0"

SEC. D'-D'

SECTION "C-C"
SCALE 1/16"=1'-0"

Pile cap and piling under all columns - See detail this sheet.

SECTION "B-B"

SECTION A'-A'

SECTION B'-B'

TYP. PILE CAP & PILINGS

SECTION "A-A"

Pile cap and pilings under all columns - See det. this sheet.

Graphic Scale in feet

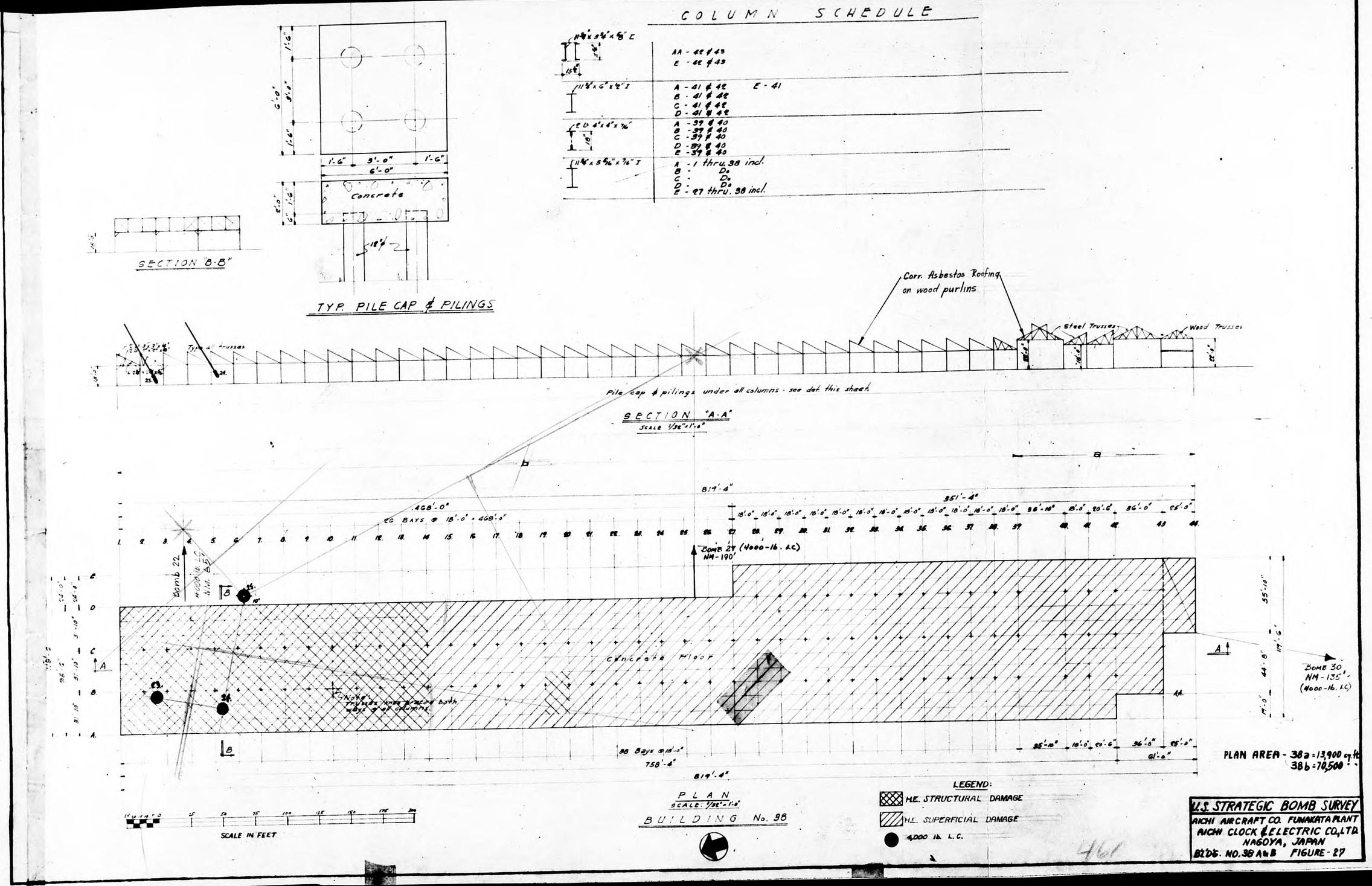
ALL ROOFING AND SIDING IS CORR. ASBESTOS.

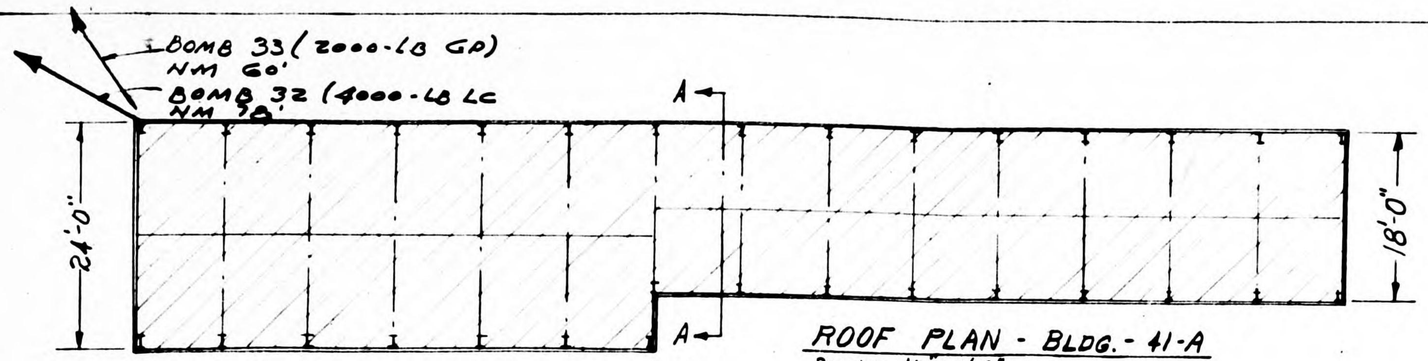
BUILDINGS 37 & 39

SEE FIG. 25 FOR PLAN LOCATING SECTIONS.

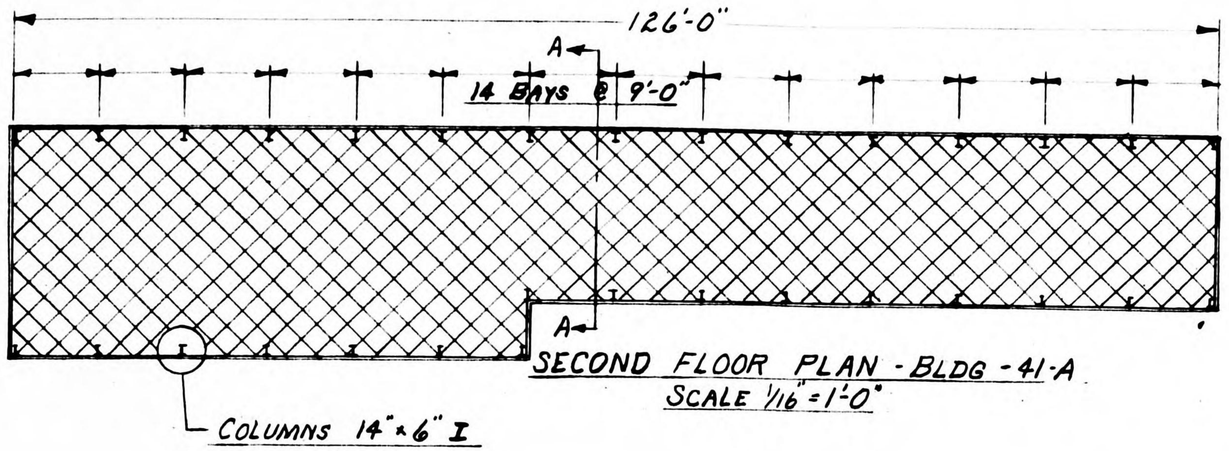
U.S. STRATEGIC BOMBING SURVEY
NICHI AIRCRAFT CO. FUNAKATA PLANT
NICHI CLOCK & ELECT CO. LTD. NAGOYA
JAPAN BLDG 37 & 39
FIGURE 25

460

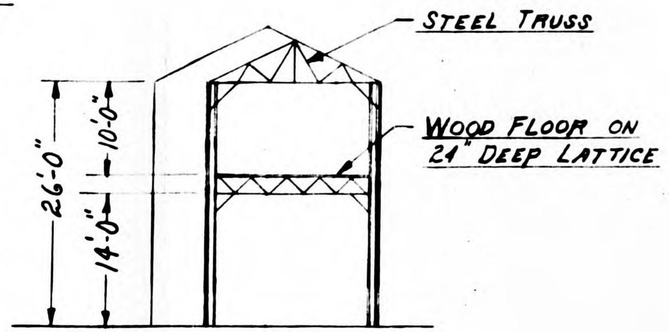

COLUMN SCHEDULE
AA - 42 & 43
E - 42 & 43
A - 41 & 42 E - 41
B - 41 & 42
C - 41 & 42
D - 41 & 42
A - 39 & 40
B - 39 & 40
C - 39 & 40
D - 39 & 40
E - 39 & 40
A - 1 thru. 38 incl.
B - Do
C - Do
D - Do
E - 27 thru. 38 incl.
SECTION "B-B"
TYP. PILE CAP & PILINGS
Concrete
Corr. Asbestos Roofing on wood purlins
Steel Trusses
Wood Trusses
Pile cap & pilings under all columns - see det. this sheet.
SECTION "A-A"
SCALE 1/32"=1'-0"
819'-4"
351'-4"
468'-0"
26 BAYS @ 18'-0" = 468'-0"
BOMB 27 (4000-lb. LC) NM-190'
Bomb 22
Concrete Floor
Note: Trusses knee braced both ways @ all columns.
BOMB 30 NM-135' (4000-lb. LC)
38 Bays @ 18'-0"
758'-4"
819'-4"
PLAN
SCALE: 1/32"=1'-0"
BUILDING No. 38
SCALE IN FEET
LEGEND:
H.E. STRUCTURAL DAMAGE
H.E. SUPERFICIAL DAMAGE
4,000 lb. L.C.
PLAN AREA - 38a = 13,900 sq. ft.
38b = 70,500
U.S. STRATEGIC BOMB SURVEY
AICHI AIRCRAFT CO. FUNAKATA PLANT
AICHI CLOCK & ELECTRIC CO., LTD.
NAGOYA, JAPAN
BLDG. NO. 38 A & B FIGURE - 27
461



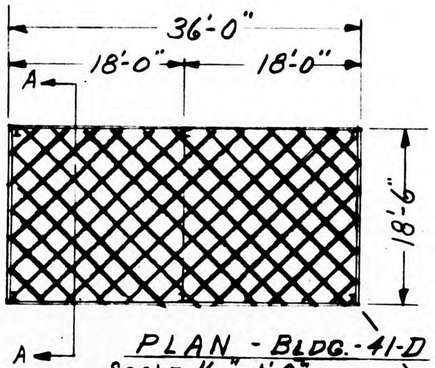
ROOF PLAN - BLDG. - 41-A
SCALE 1/16" = 1'-0"



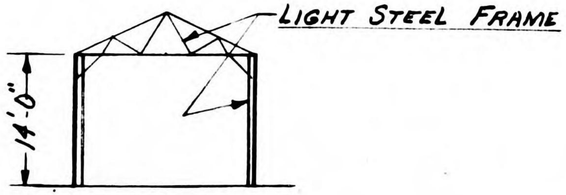
SECOND FLOOR PLAN - BLDG - 41-A
SCALE 1/16" = 1'-0"



SECTION "A-A"



PLAN - BLDG. - 41-D
SCALE 1/16" = 1'-0"



SECTION "A-A"

BOMB 28 (4000-LB LC)
NM - 150'

SUPERFICIAL DAMAGE

STRUCTURAL DAMAGE

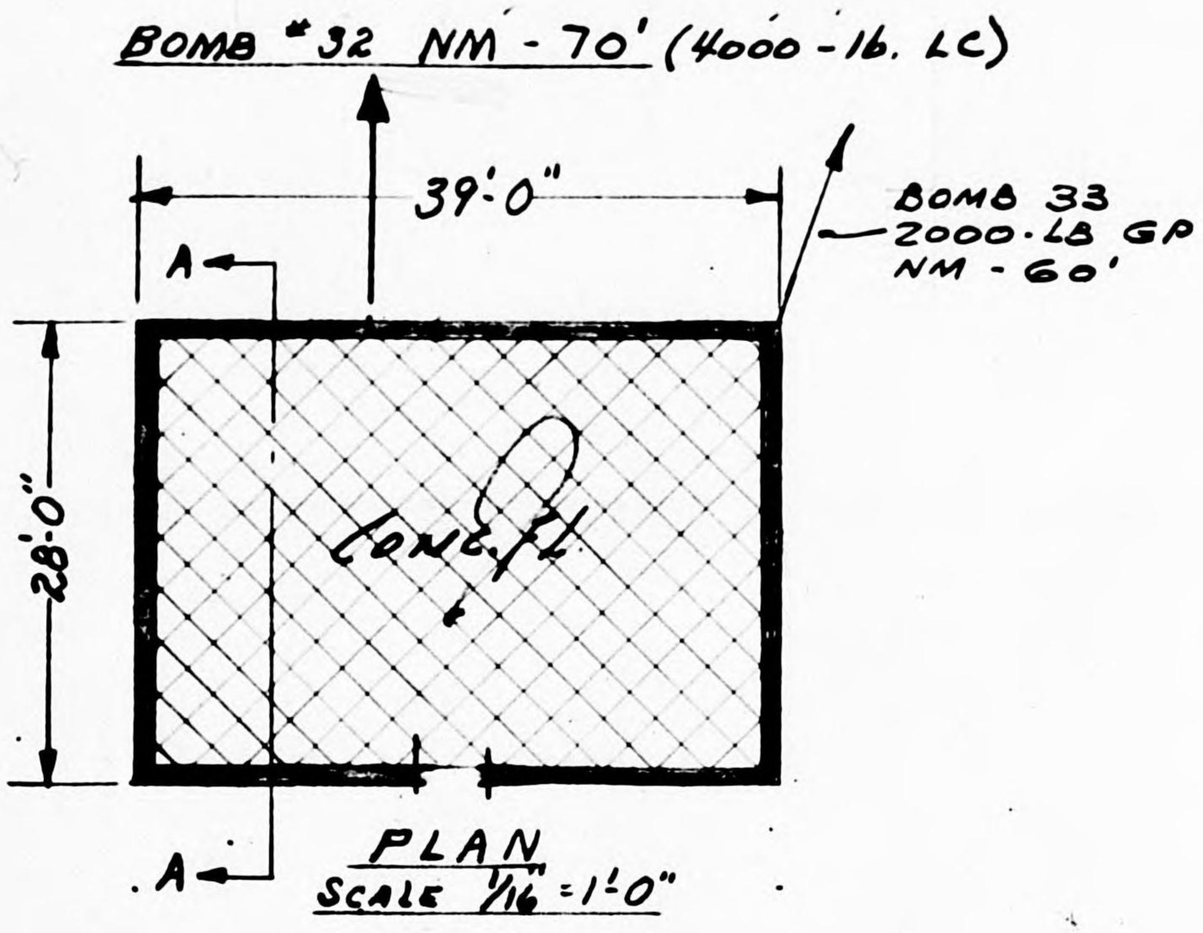
FIRE STRUCTURAL DAMAGE

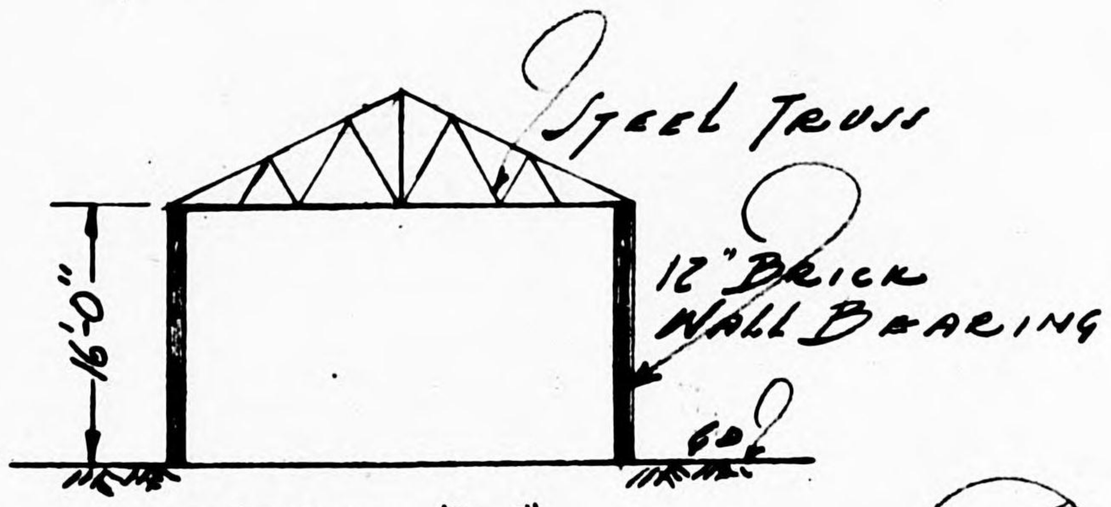
TOTAL PLAN AREA
41-A - 2600 SQ. FT.
41-D - 650 SQ. FT.

25 20 15 10 5 0 25 50 75
SCALE IN FEET

U.S. STRATEGIC BOMBING SURVEY
AICHI AIRCRAFT CO. FUNAKATA PLANT
AICHI CLOCK & ELECTRIC CO. LTD.
NOGOYA - JAPAN
BLDGS. 41A & 41D FIGURE-28

462





HE STRUCTURAL DAMAGE

TOTAL PLAN AREA - 1100 SQ. FT.

25 20 15 10 5 0 25

SCALE IN FEET

US STRATEGIC BOMBING SURVEY
AICHI AIRCRAFT CO., FUNAKATA PLANT
AICHI CLOCK & ELECTRIC CO. LTD.
NAGOYA - JAPAN
BLDG.- 41C FIGURE-29

PHOTO I. TARGET 90:20-198

AICHI AIRCRAFT CO. FUNAKATA PLANT & AICHI CLOCK & ELECTRIC CO. LTD

Photo 2. Bldg. 2a - Roof framing looking N.

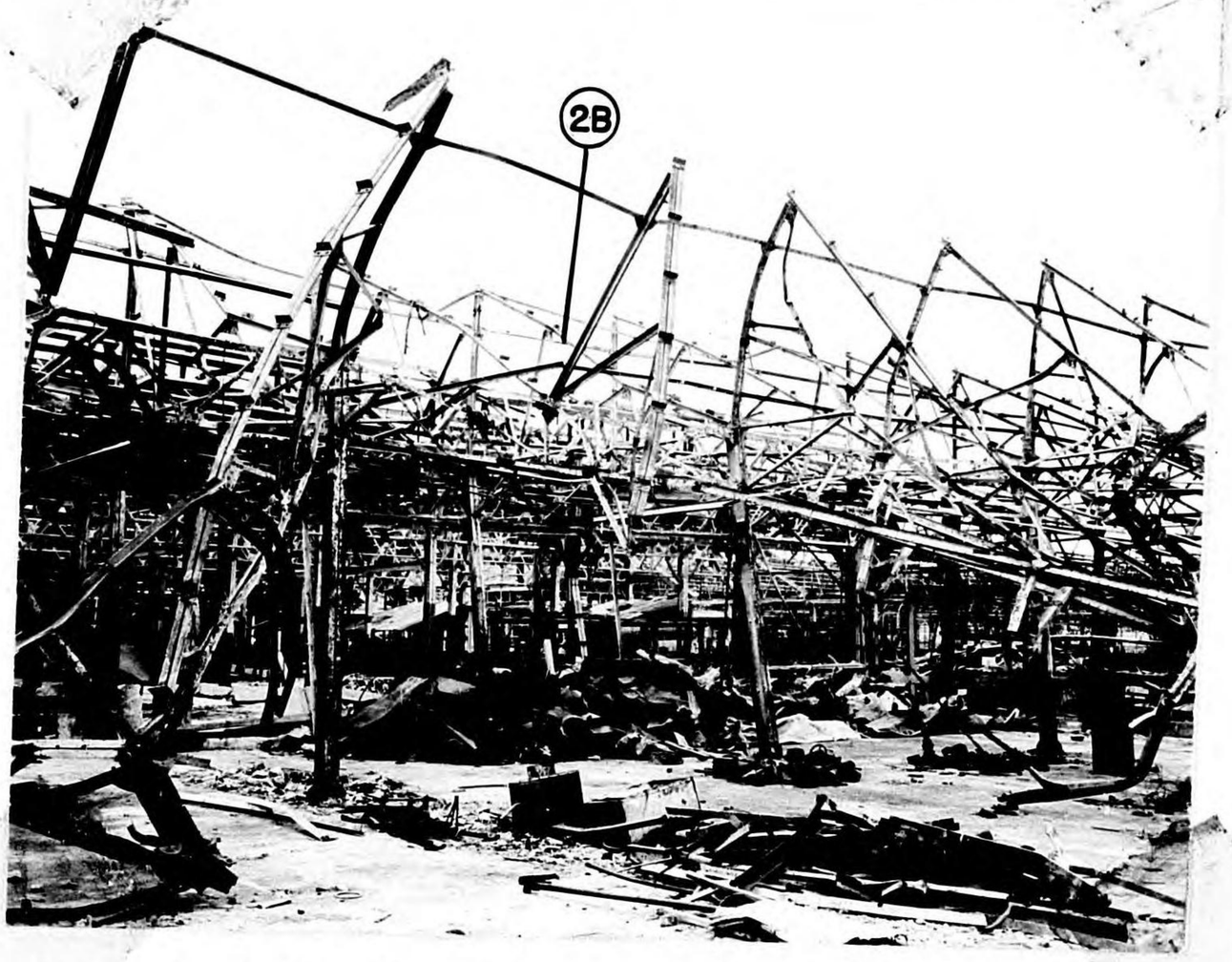


Photo 3. Bldg. 2b - Looking NE from Bomb 4 strike.

465

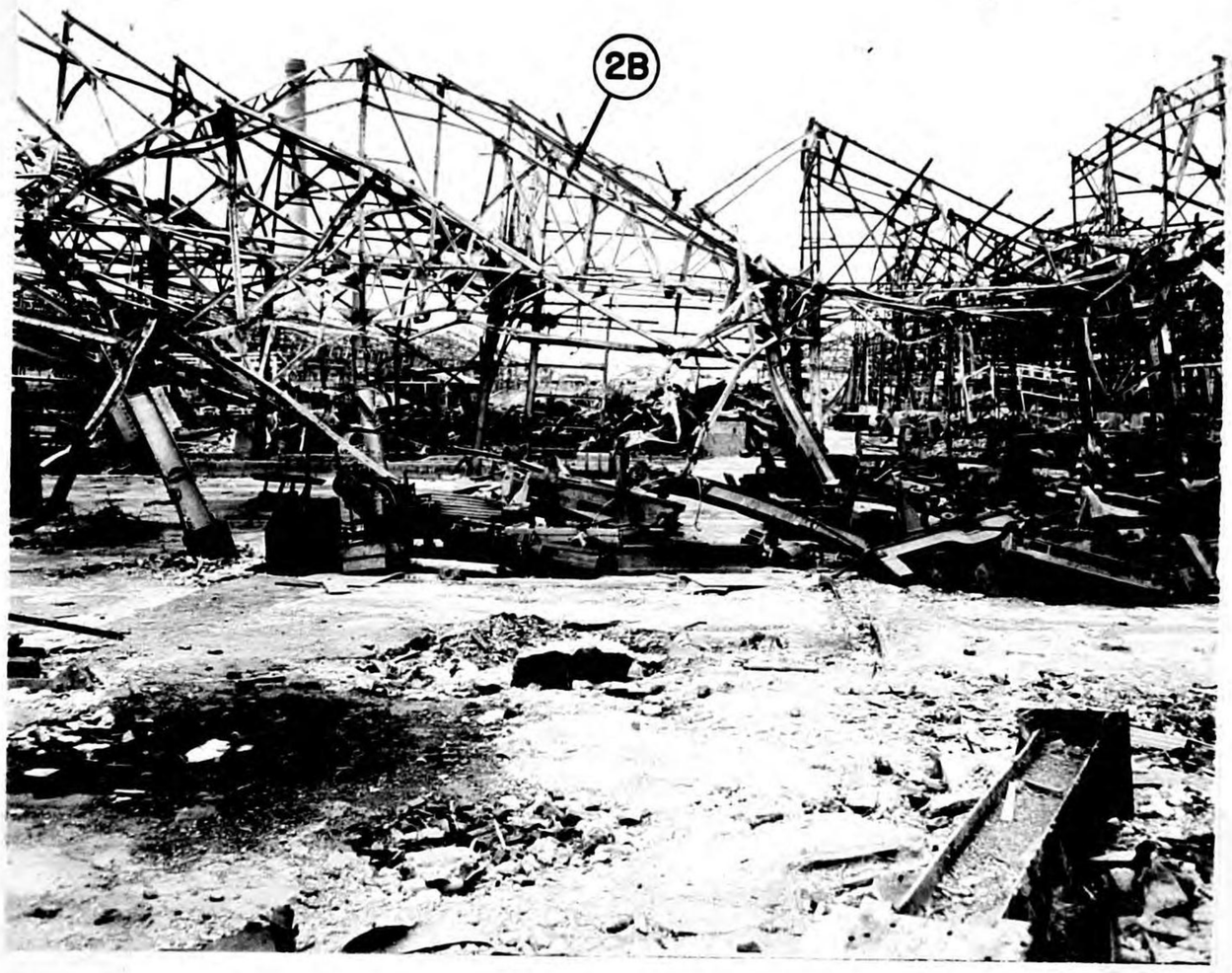


Photo 4. Bldg. 2b - Looking ESE from Bomb 4 strike.

Photo 5. Bldg 2b - Looking SSE from Bomb 4 strike.

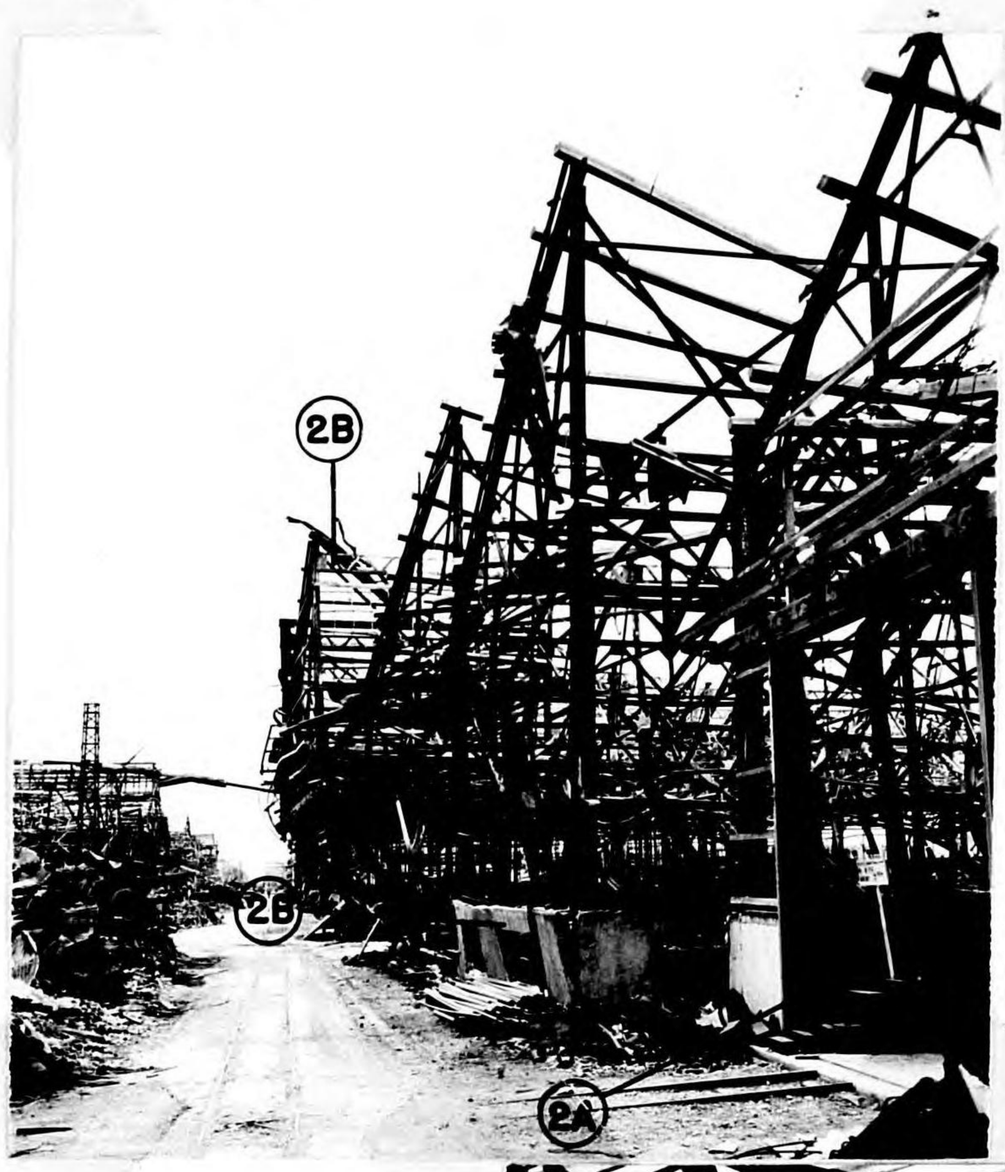


Photo 6. Bldg. 2b - Misalignment of East side looking SSW caused by Bomb 4 strike.

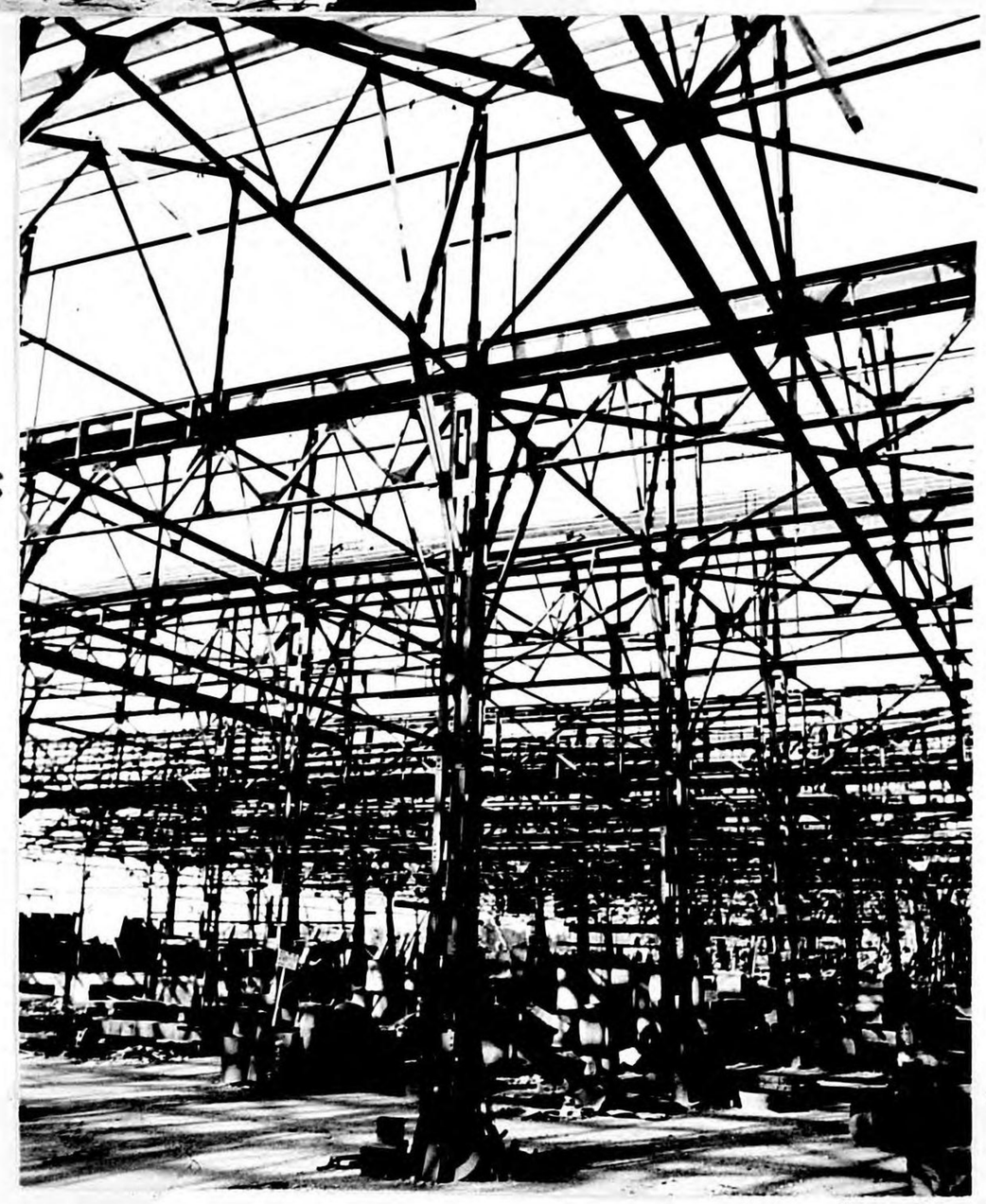


Photo 7. Bldg. 2c Typical roof framing looking N.

Photo 8/ Bldg. 2d - Roof and floor damage at south end looking NNW.

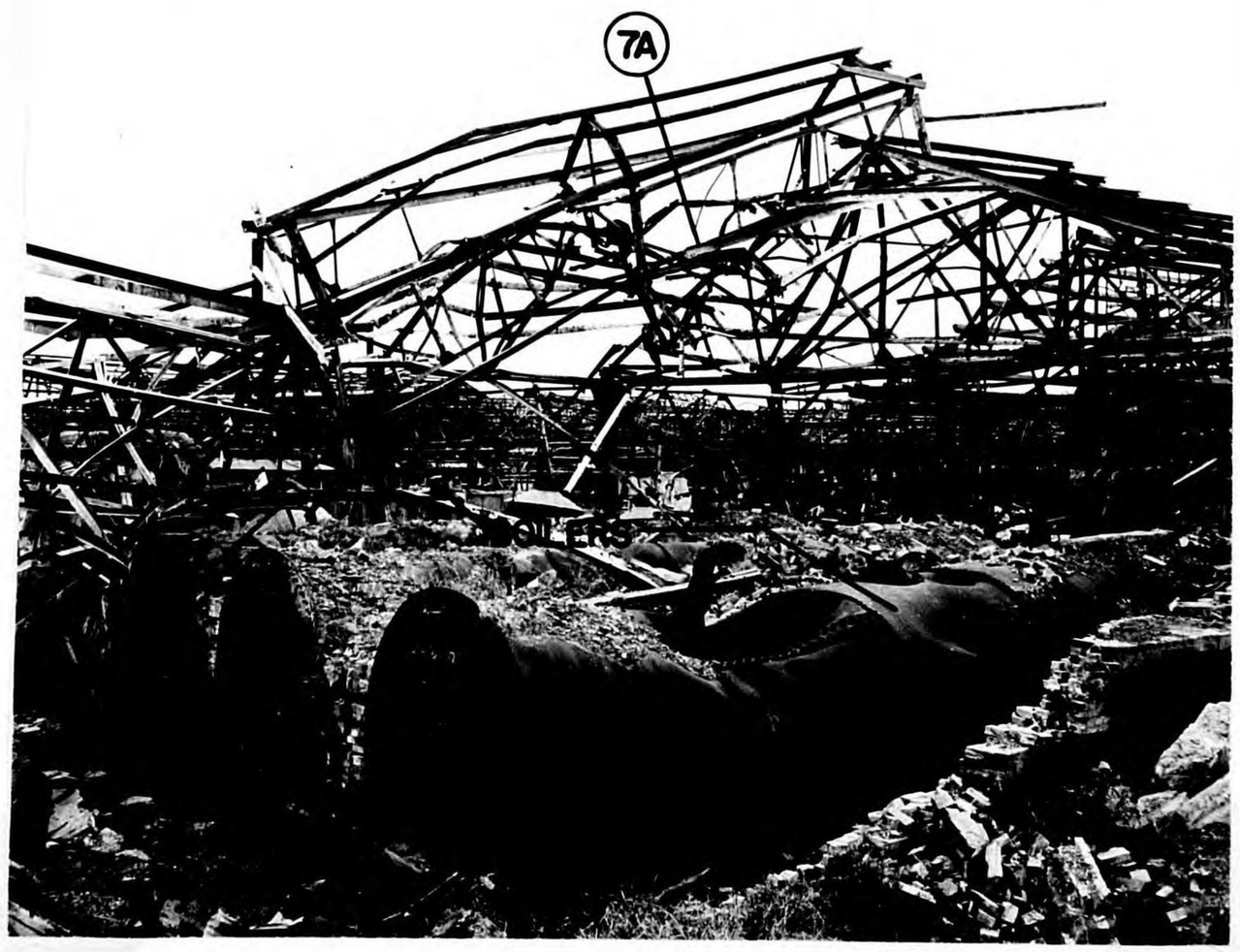


Photo 9/ Bldg. 7a - Collapse caused by Bomb 2 - looking SW.

Photo 10/ Bldg. 10a - Looking E toward Bomb 5 strike.

Photo 11/ Bldg. 10a - West side looking SE. Damage caused by Bomb 5 is shown.

Photo 12/ Bldg 10h - Interior looking WSW. Misalignment caused by Bomb 10.

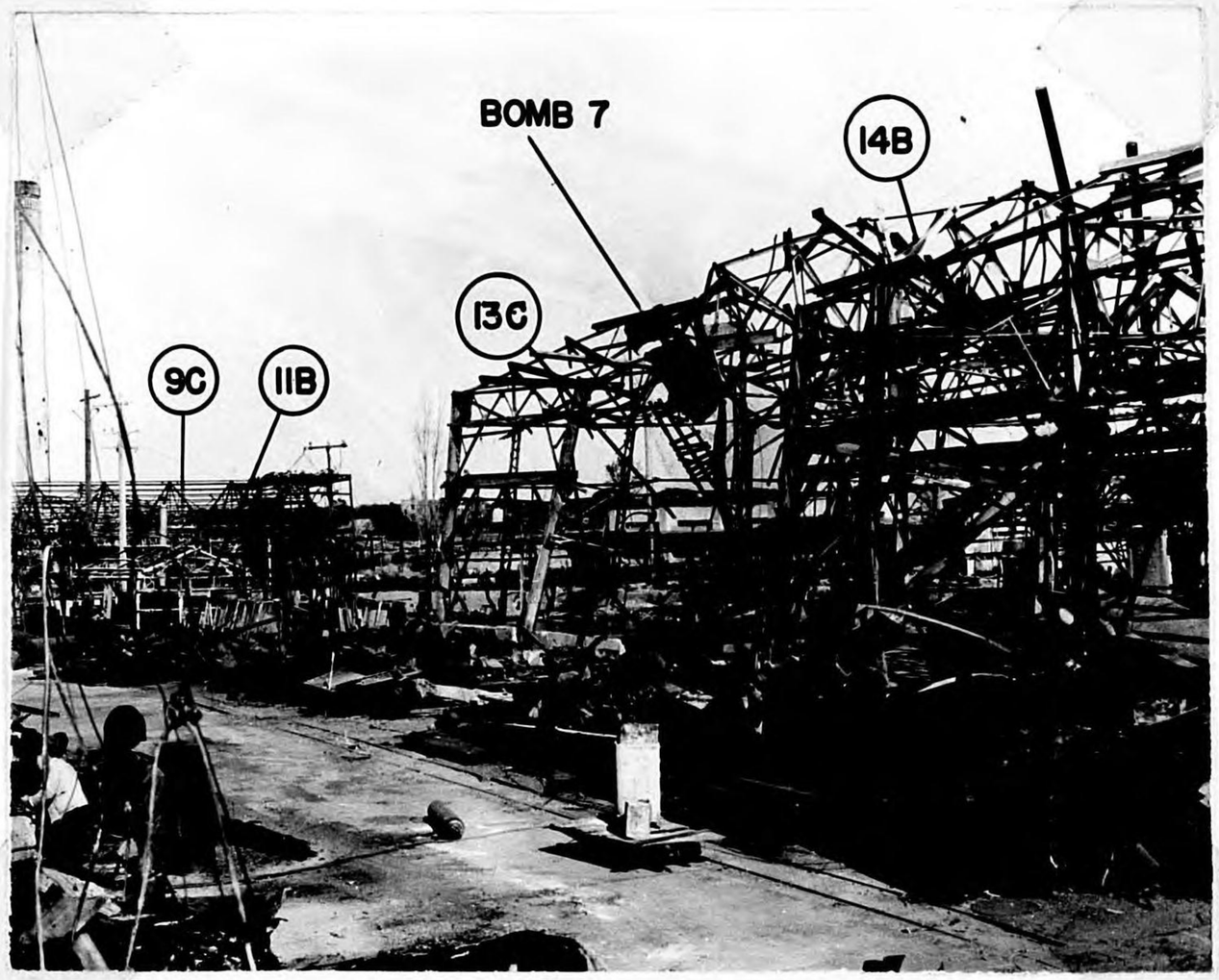


Photo 13/ Bldg. 14b - South side looking ENE toward Bomb 7 strike.

470

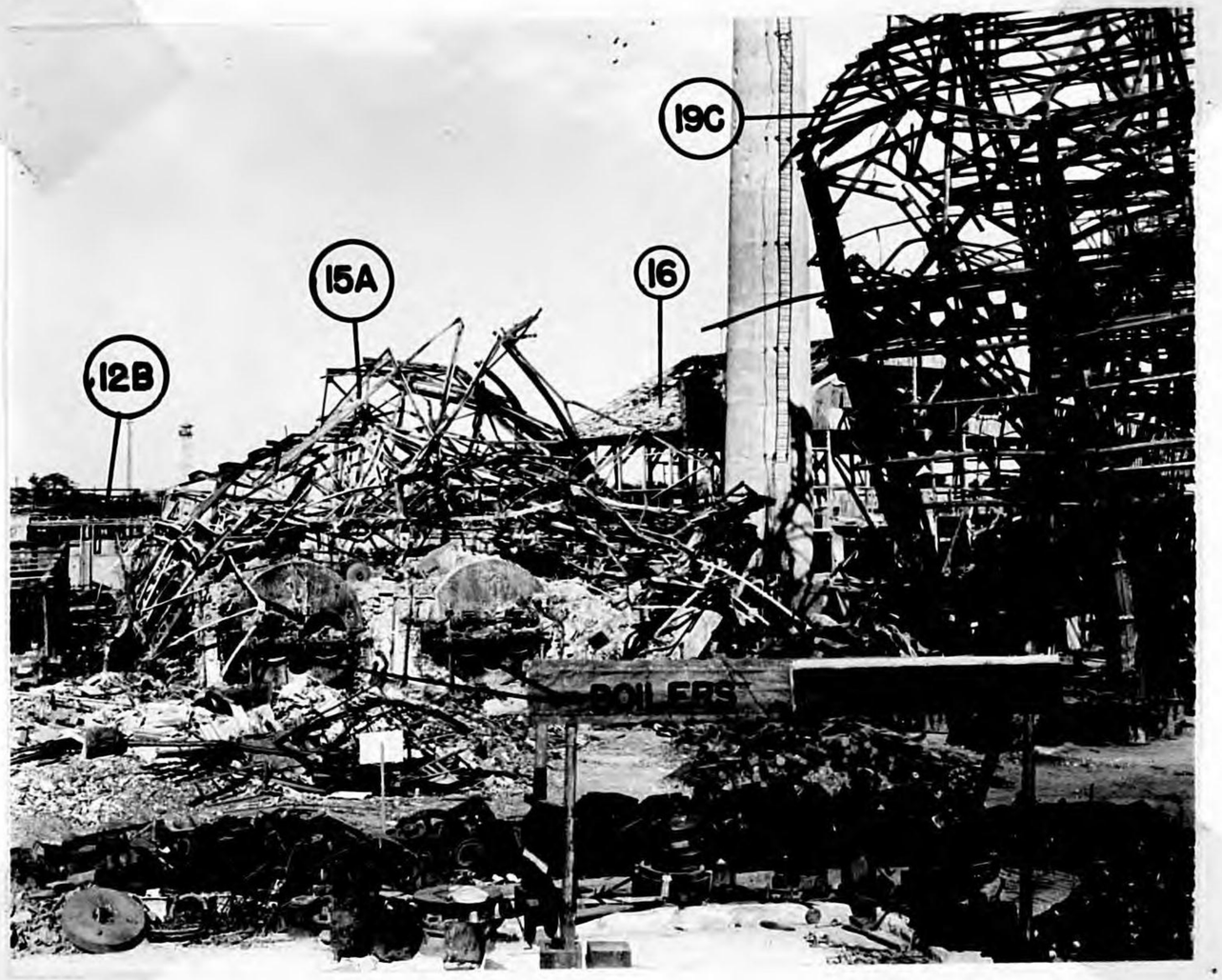


Photo 14. Bldg. 15a - South side looking NE.

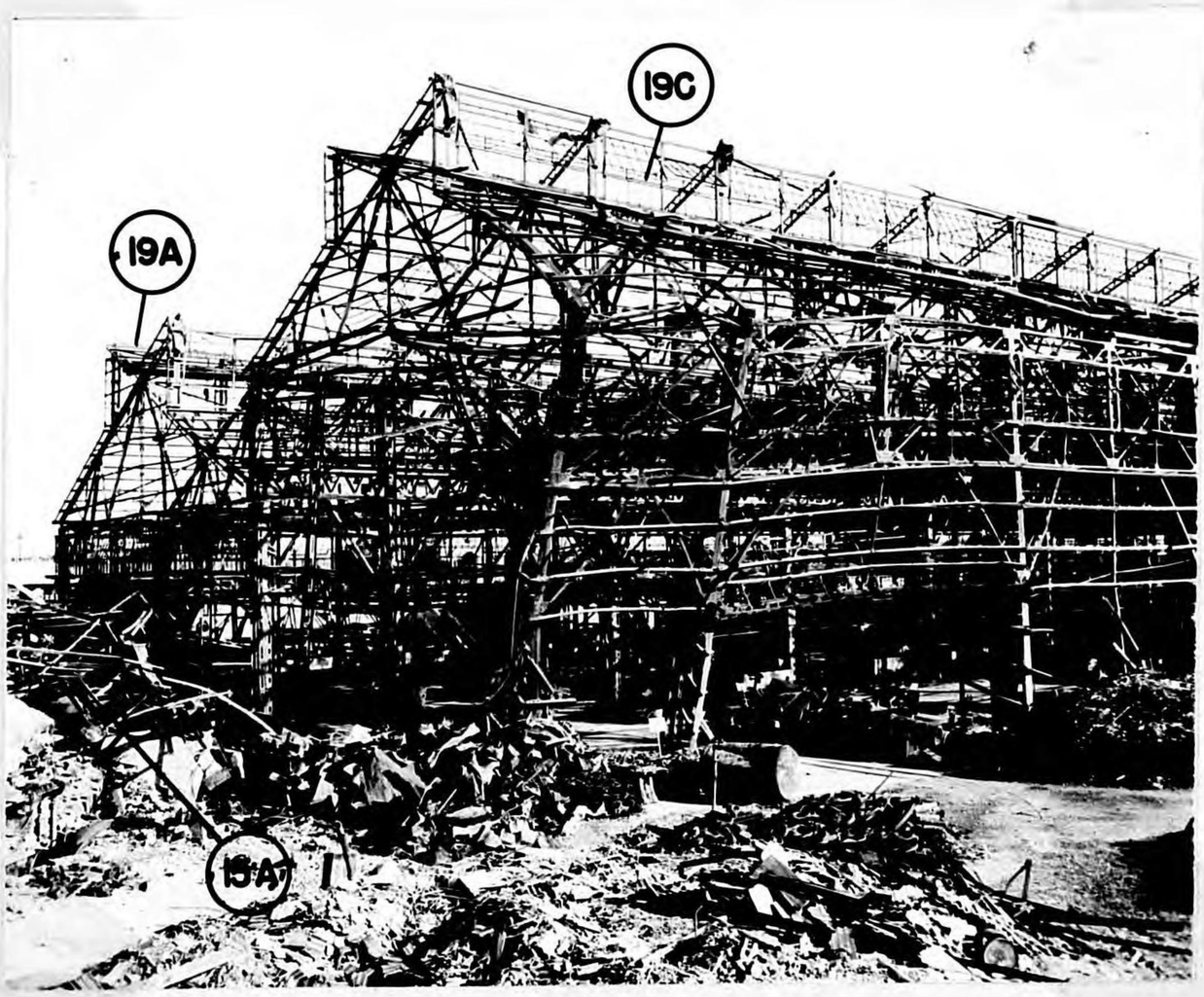


Photo 15. Bldg. 19c - West corner looking from Bomb 8 strike.

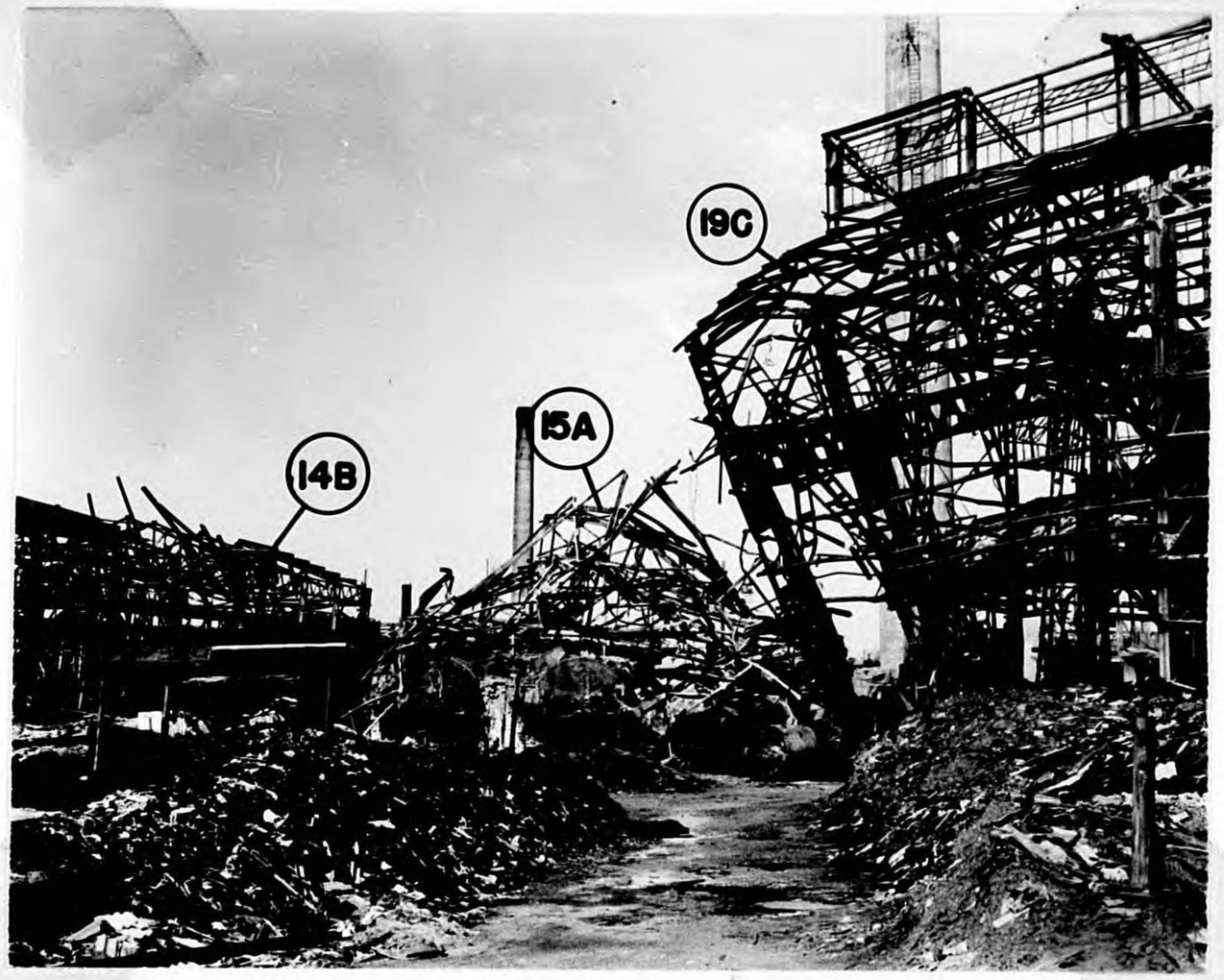


Photo 16/ Bldg. 19c - West corner looking NNE.

Photo 17/ Bldg. 19c - Roof framing details - SW side looking WNW.

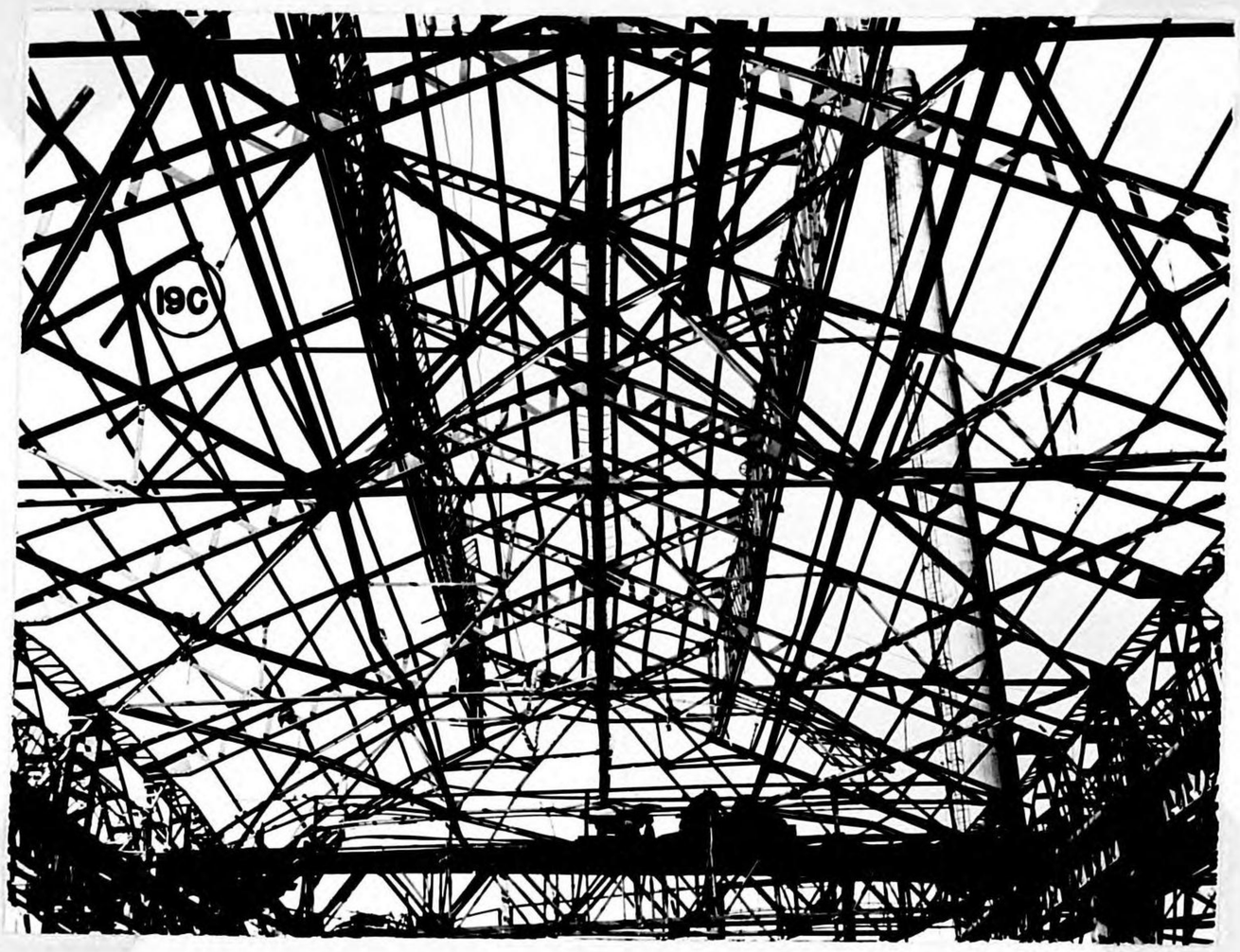


Photo 18/ Bldg. 19c ~~Roof~~ framing looking NNW toward damaged end of building.

Photo 19/ Bldg. 22a ~~North~~ end looking WNW. Blast damage caused by Bomb ~~strike~~ II strike.

Photo 20. Bldg. 23 - Looking ESE toward Bomb 10 strike.

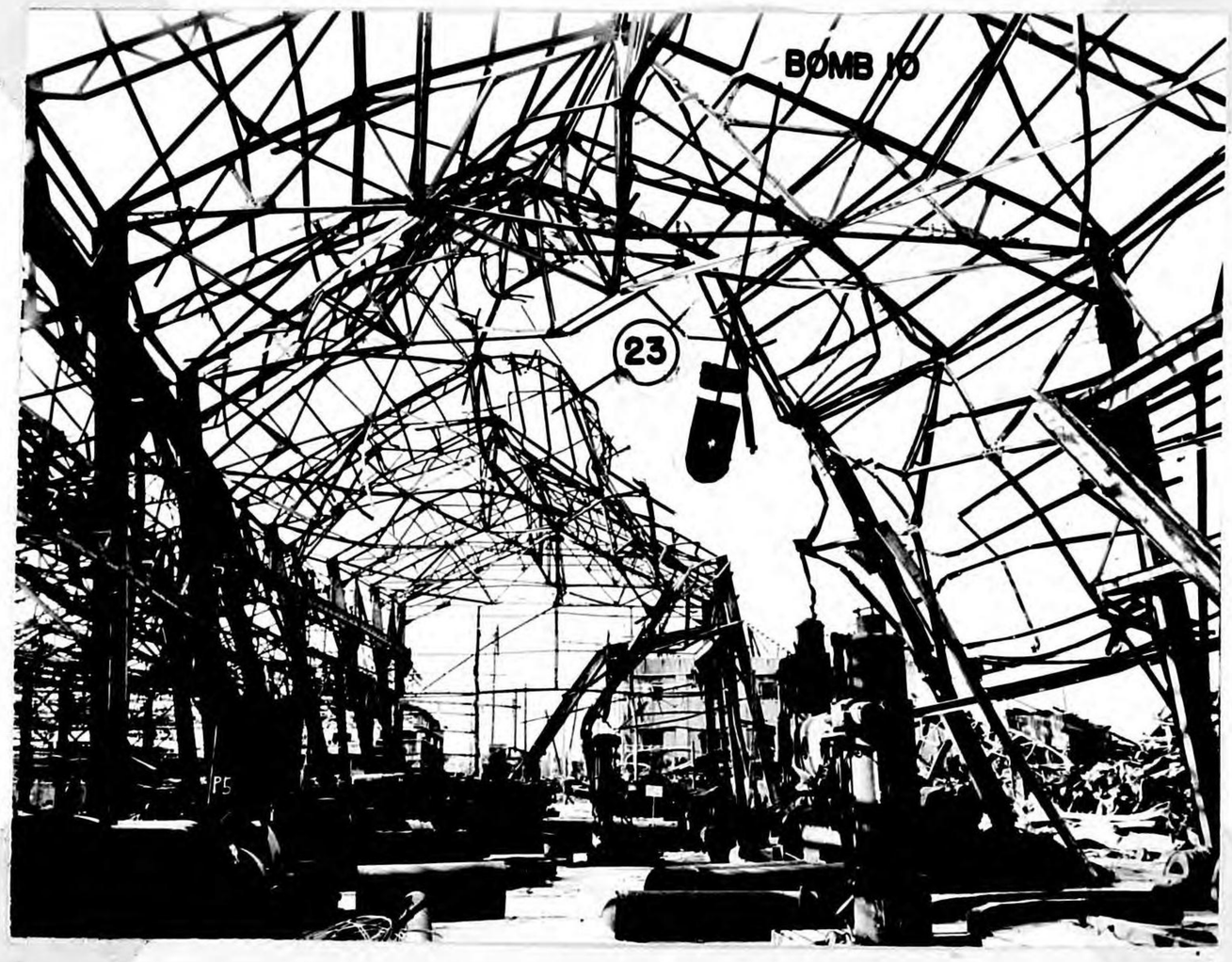


Photo 21. Bldg. 23 - Looking WSW toward Bomb 10 strike.

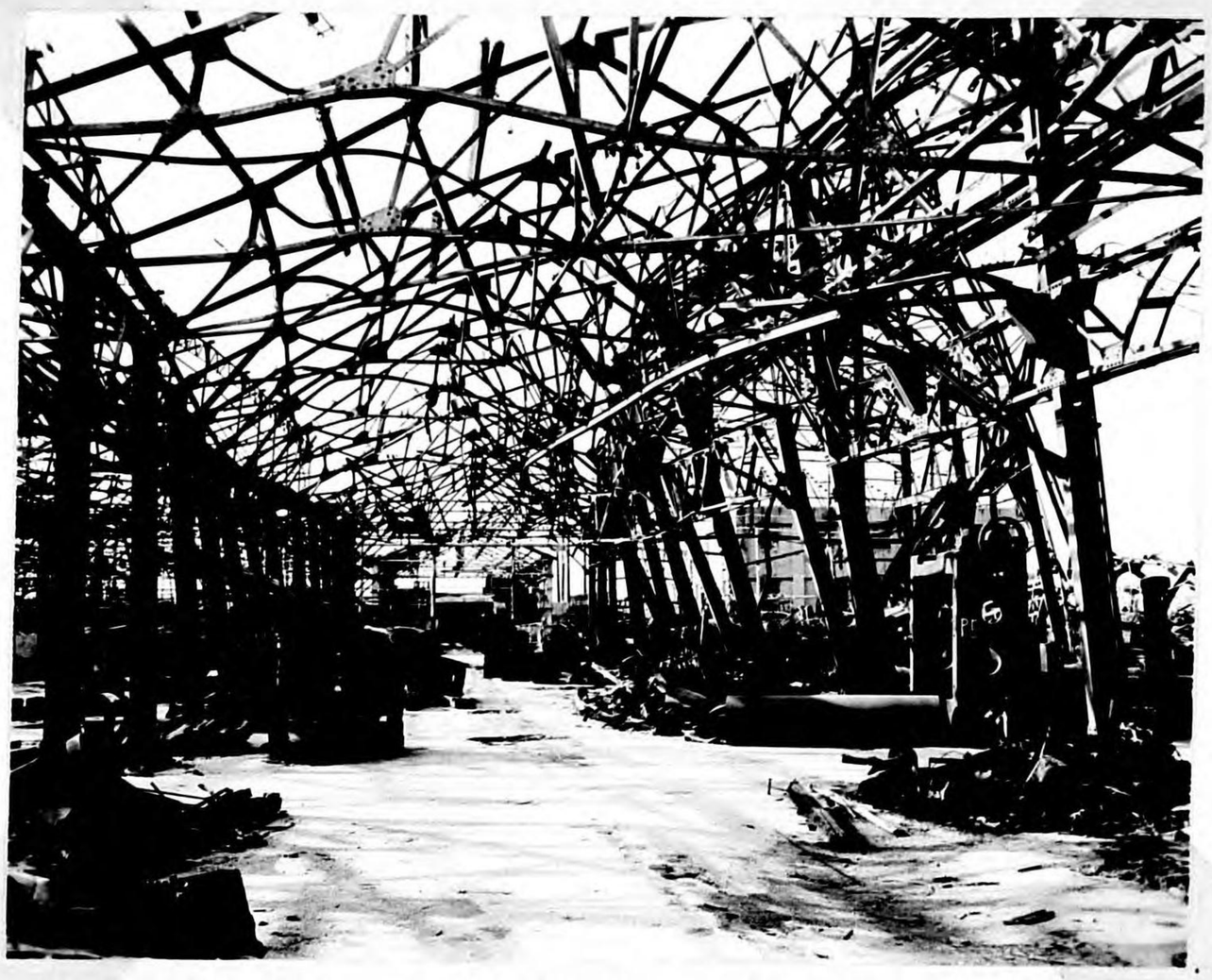


Photo 22/ Bldg. 23 / Interior looking WSW showing distortion of roof framing caused by Bomb 10 strike.

Photo 23/ Bldg. 25 / Looking NW from roof of Bldg. 29.

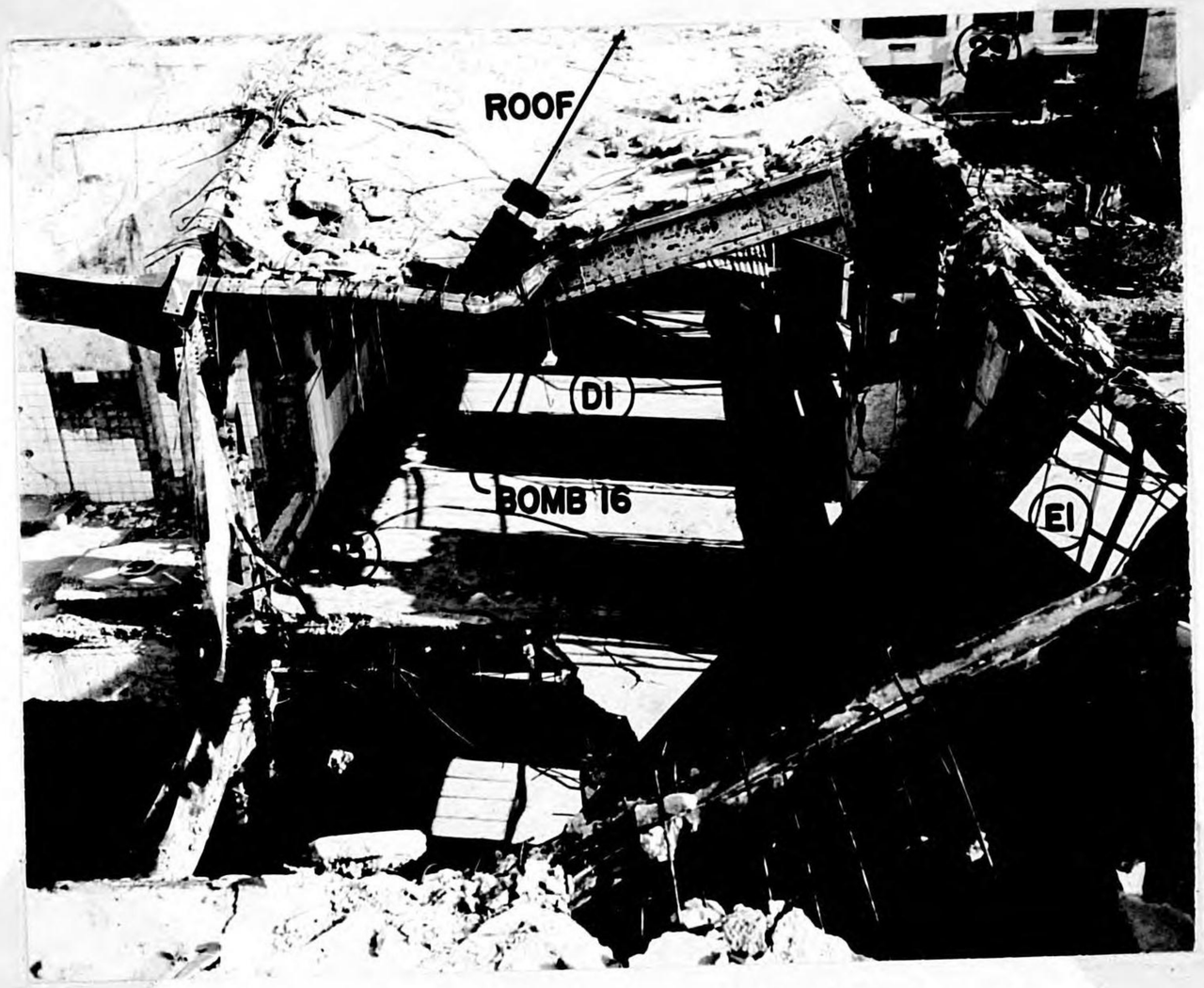


Photo 24/ Bldg. 25 / Bomb 16 strike / Roof and 3rd floor levels looking E.

Photo 25/ Bldg. 25 / Bomb 16 strike / 3rd floor level looking NNW.

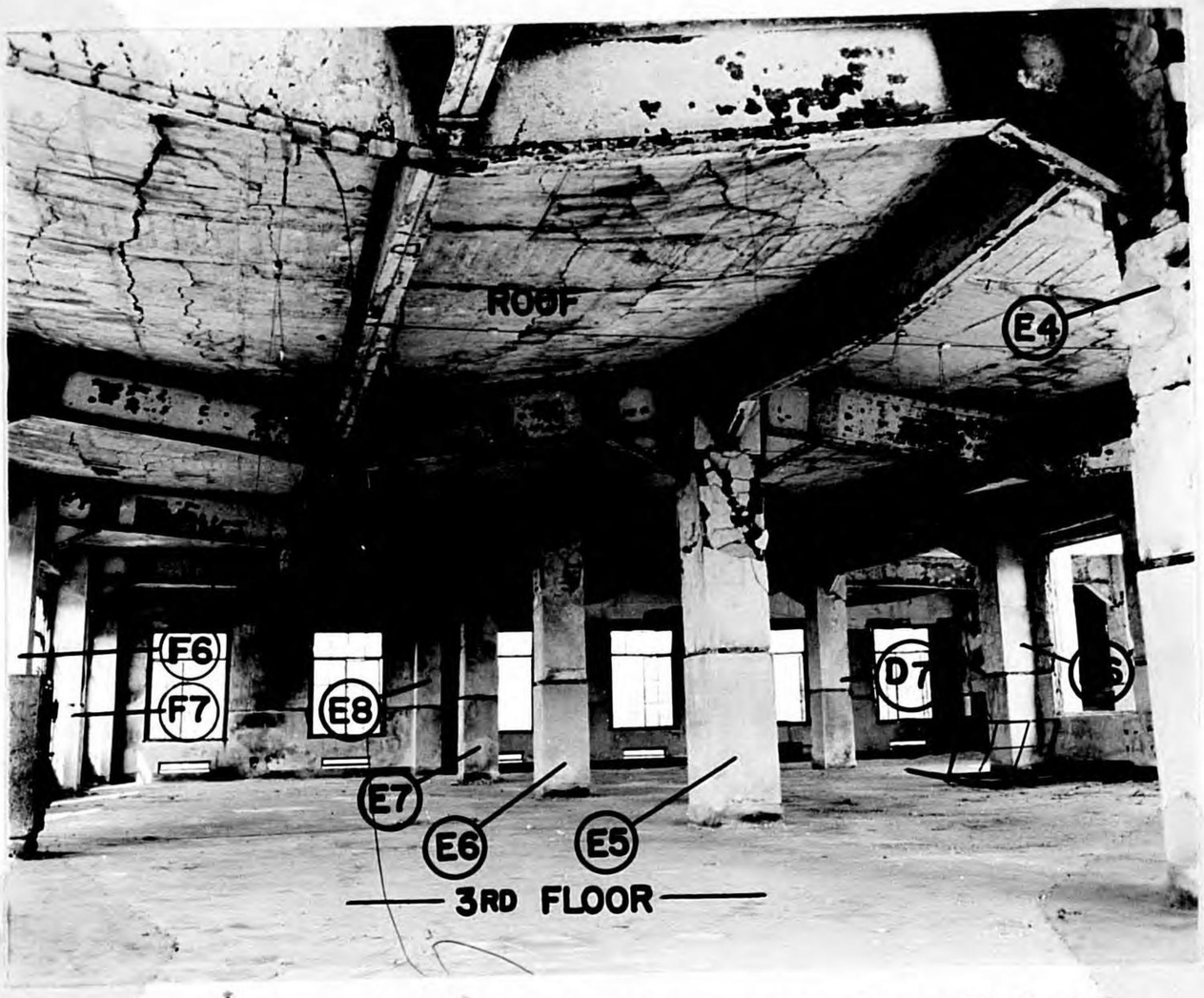


Photo 26/ Bldg. 25 - Roof damage caused by Bomb 16 - looking NNE.

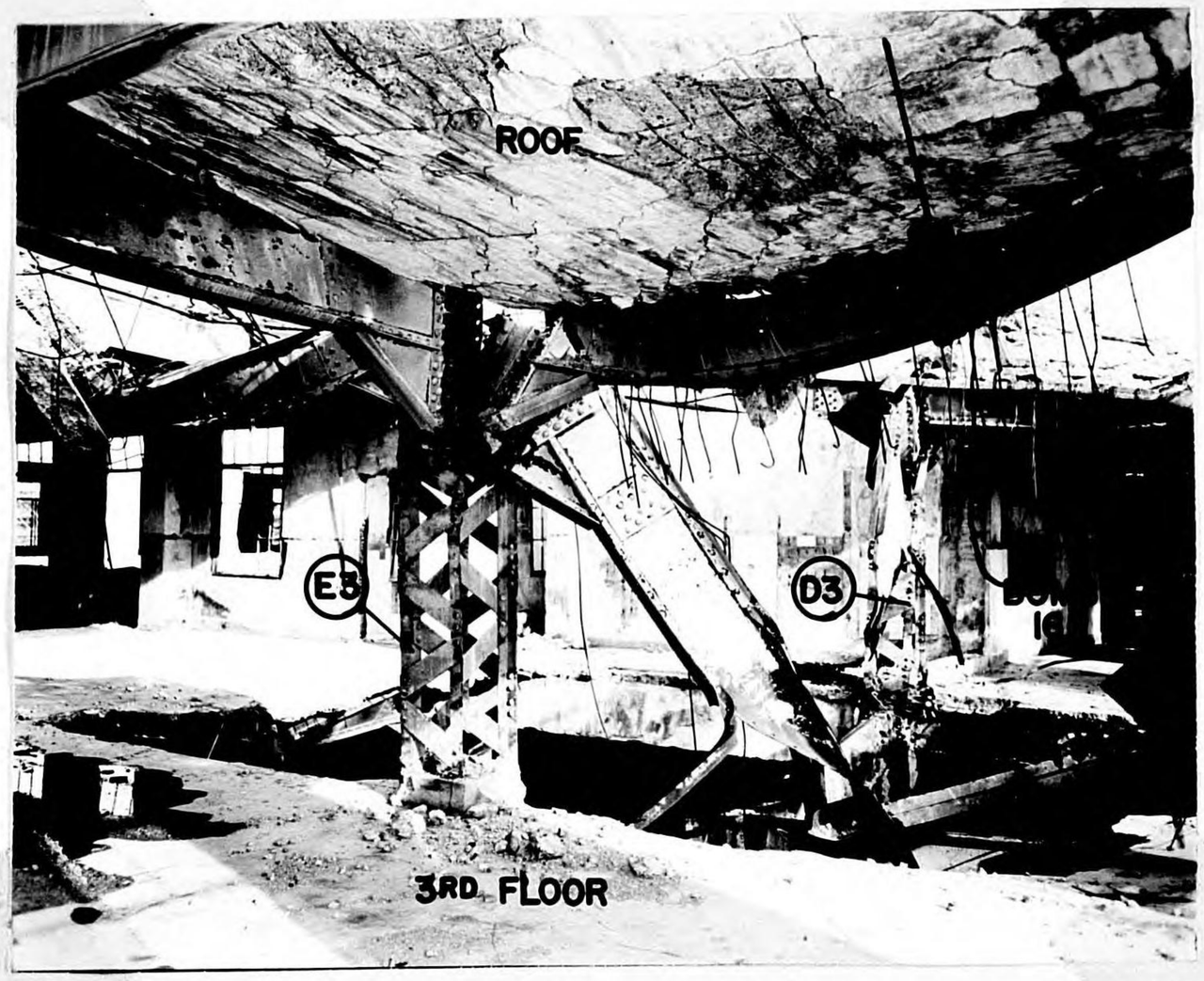


Photo 27/ Bldg. 25 - Roof and 3rd floor damage adjacent to Bomb 16 strike - looking E.

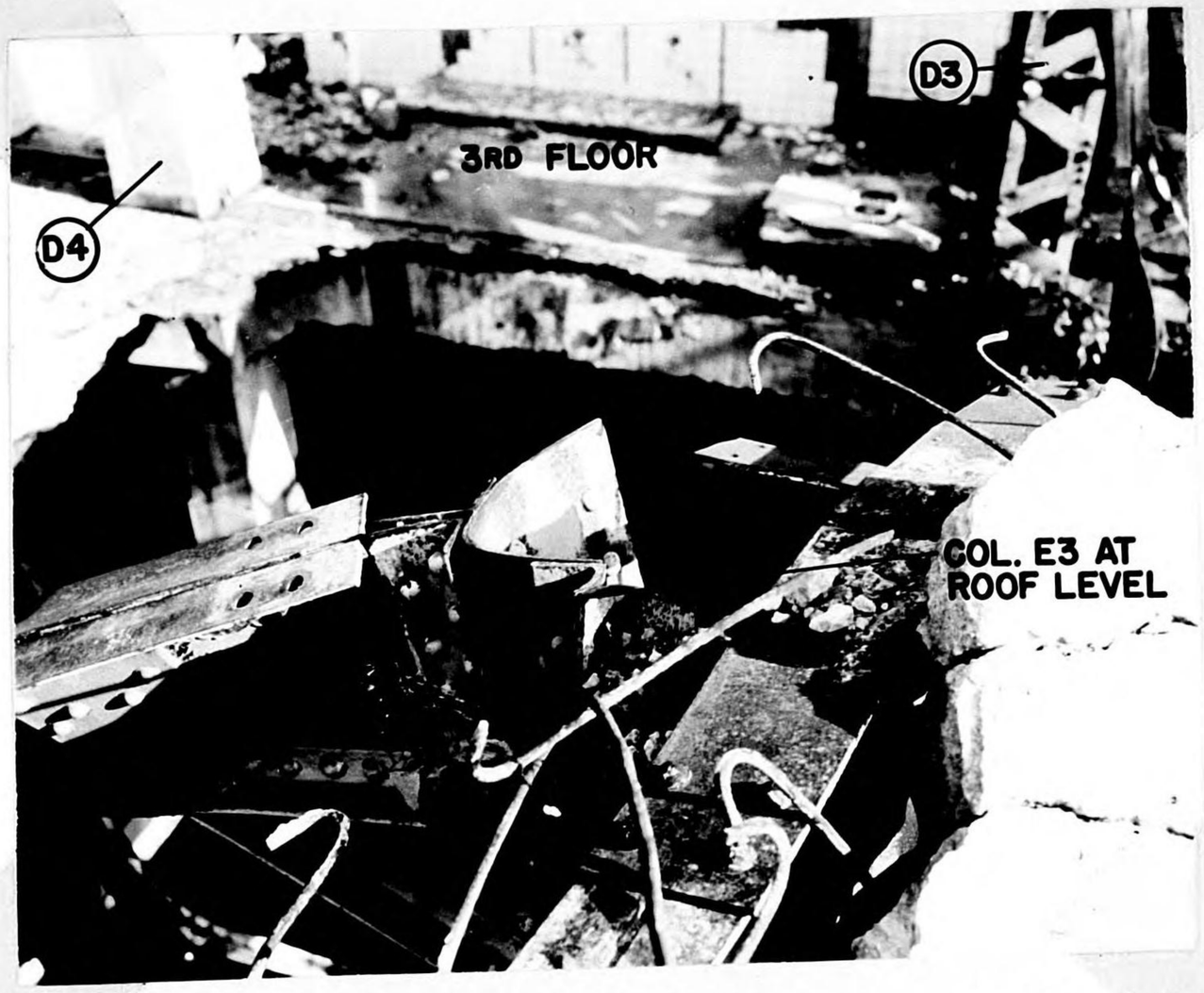


Photo 28/ Bldg. 25 / Failure of beam connection to Column E3 at roof level. Caused by Bomb 16 strike.

Photo 29/ Bldg. 25 / Distorted beam connection to Column D1 at roof level adjacent to Bomb 16 strike.

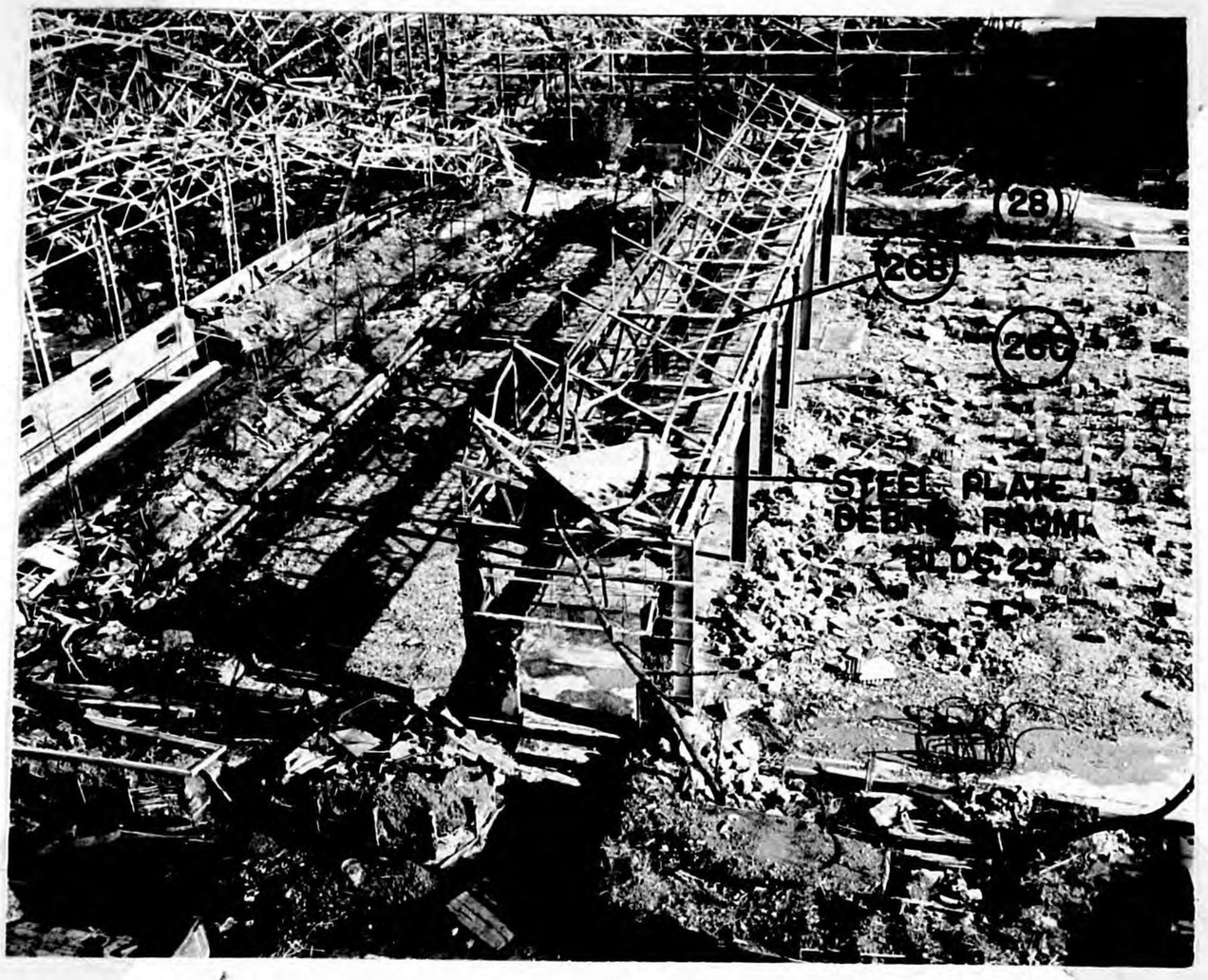


Photo 30. Bldg. 26 - Looking ESE from roof of Bldg. 25.

Photo 31. Bldg 27 - Looking NW. Damage caused by Bombs 17 and 19.

Photo 32. Bldg. 29 / SE corner looking NNW.

Photo 33. Bldg. 29 - SW corner.

480

Photo 34/ Bldg. 29 - Part South elevation - looking NE.

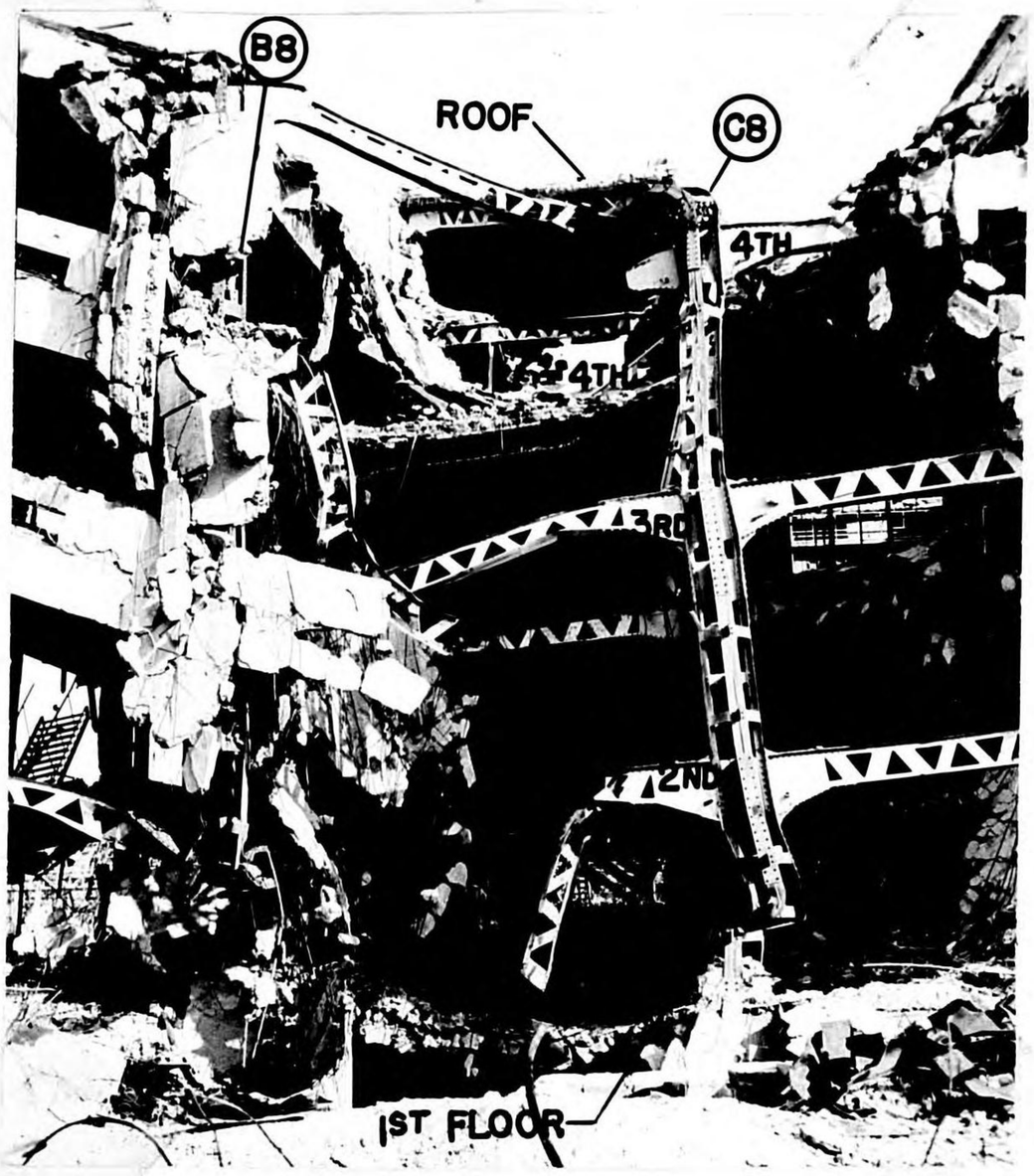


Photo 35/ Bldg. 29 / South elevation - damage caused by Bombs 18 and 19.

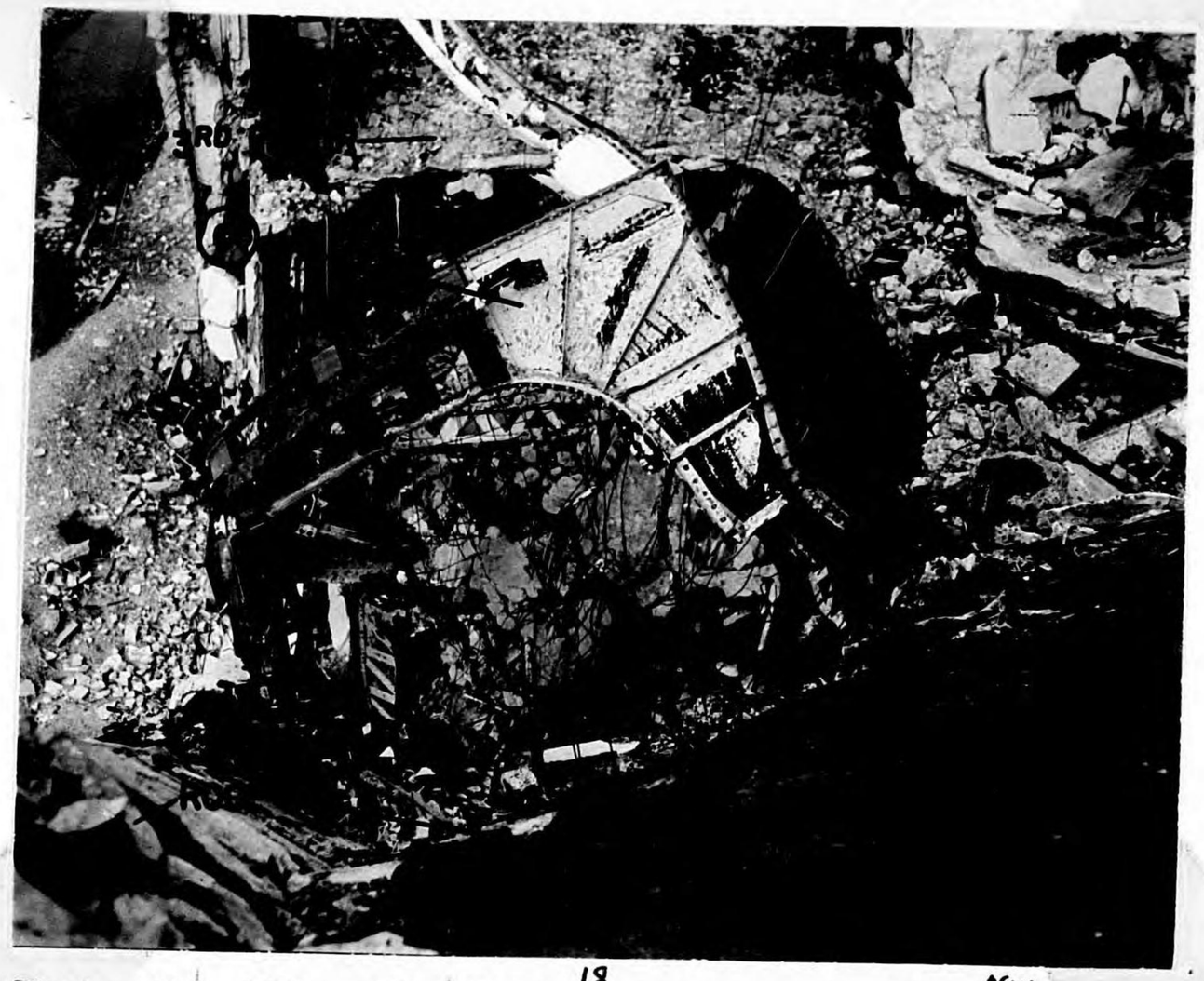


Photo 36. Bldg. 29 - Bomb ~~18~~ 18 strike - Looking ~~NE~~ NW and down from roof level.

Photo 37. Bldg. 29 - Looking NNW toward Bomb 15 strike at roof level.

Photo 38/ Bldg. 29 - Roof and (3rd) floor damage looking NE toward Bomb 15 strike.

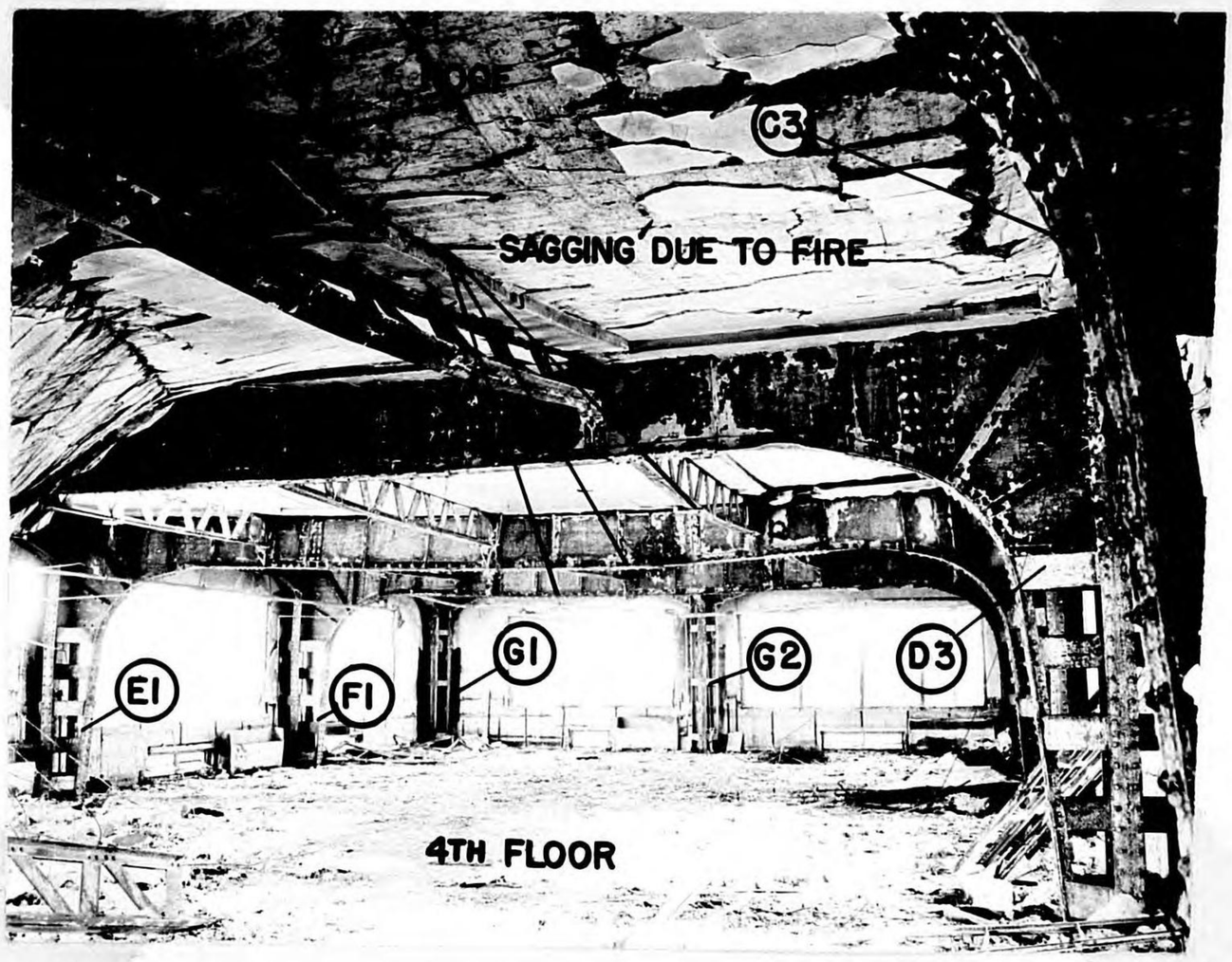


Photo 39/ Bldg. 29 - HE and fire damage to roof adjacent to Bomb 15 strike.

Photo 40. Bldg. 29 - North bay at 4th floor looking toward Bomb 18 strike. Sagging of roof framing shown.

Photo 41. Bldg. 29 - Column and roof framing adjacent to Bomb 18 strike.

Photo 42/ Bldg. 29 - Column and roof framing detail at interior column.

Photo 43/ Bldg. 29 - (3rd) floor damage adjacent to Bomb 18 strike.

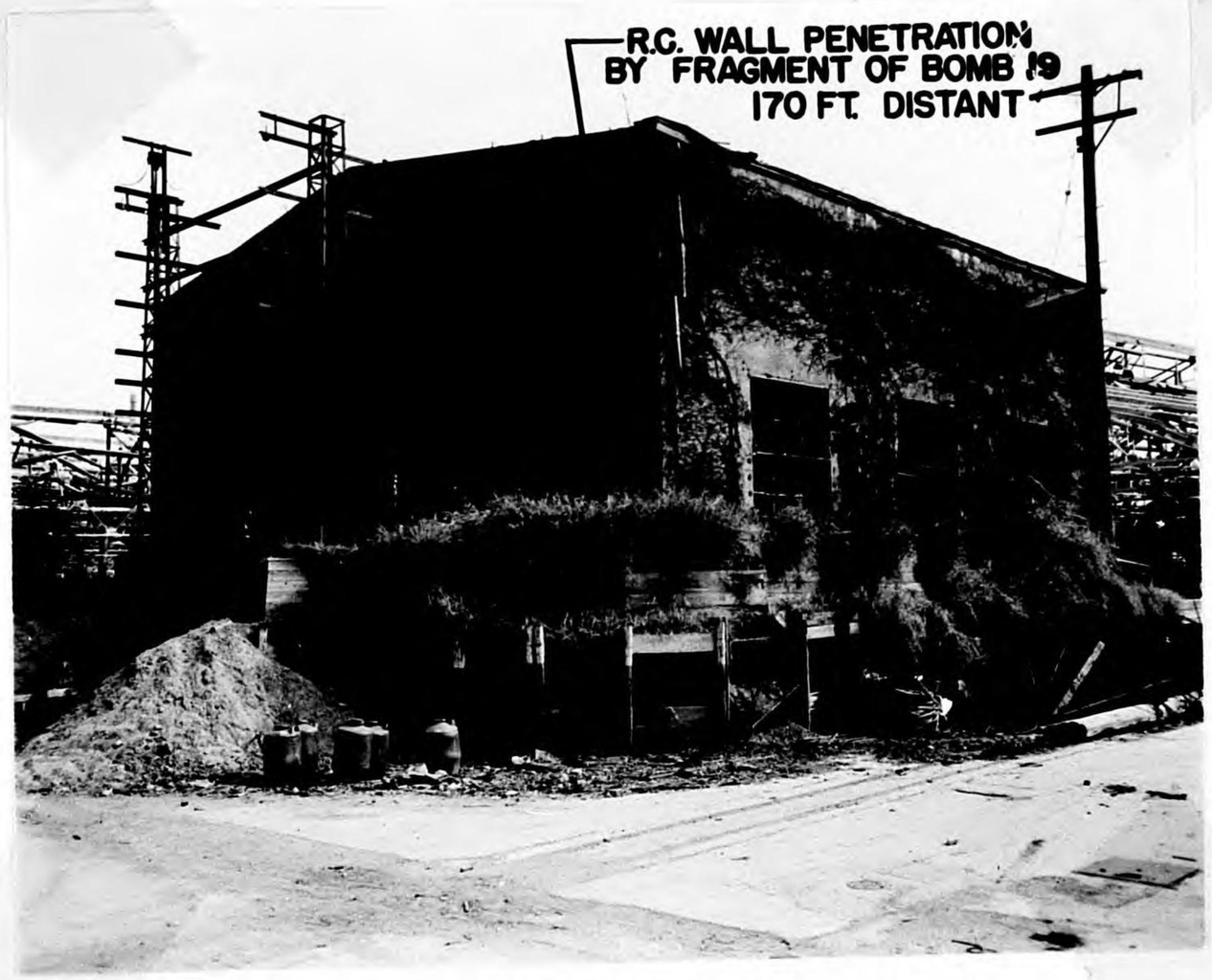


Photo 44. Bldg. 30 - SW corner looking NE.

Photo 45. Bldg. 37a - Looking NNE from interior toward damaged north end.

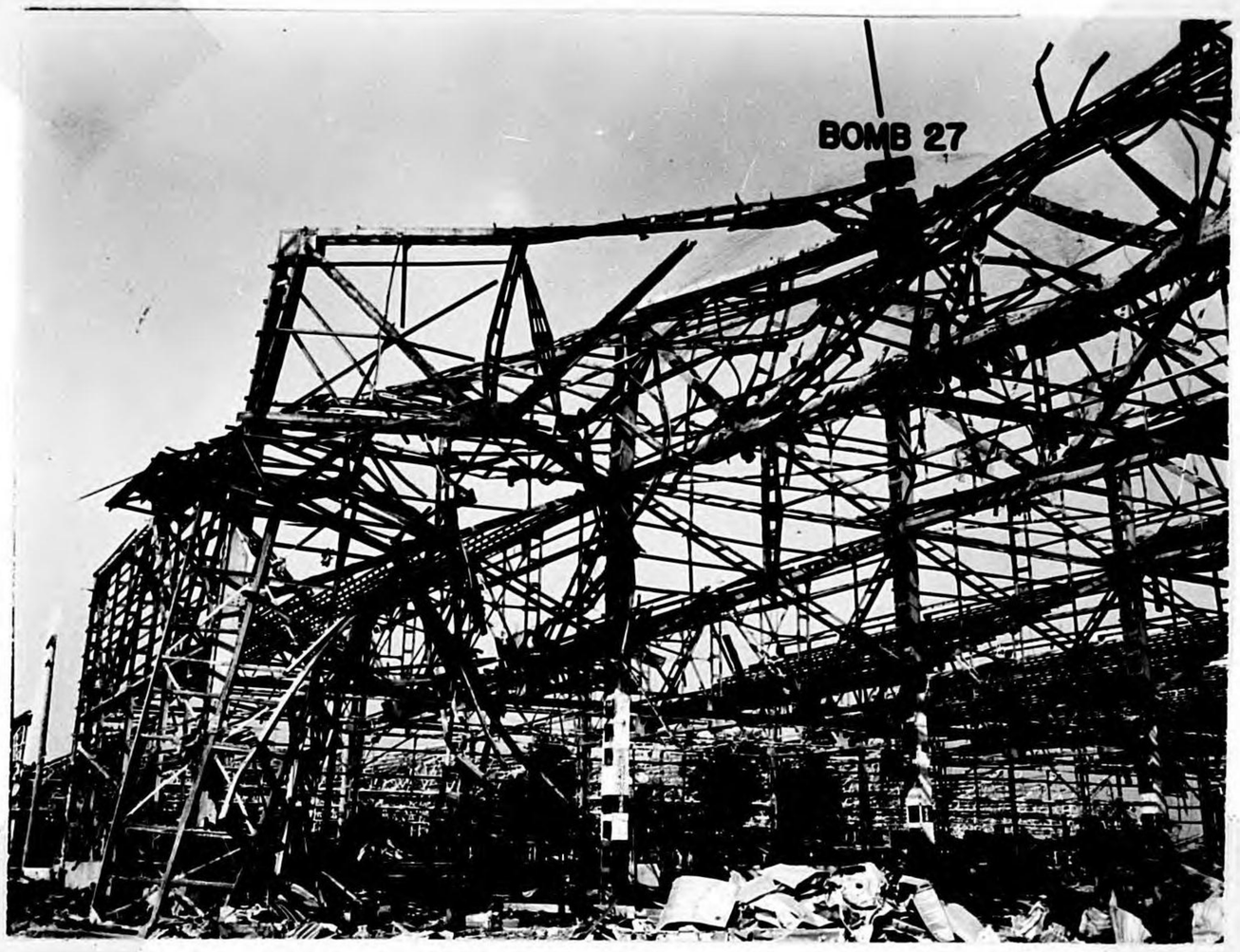


Photo 46/ Bldg. 37b - Damage to south end looking WNW.

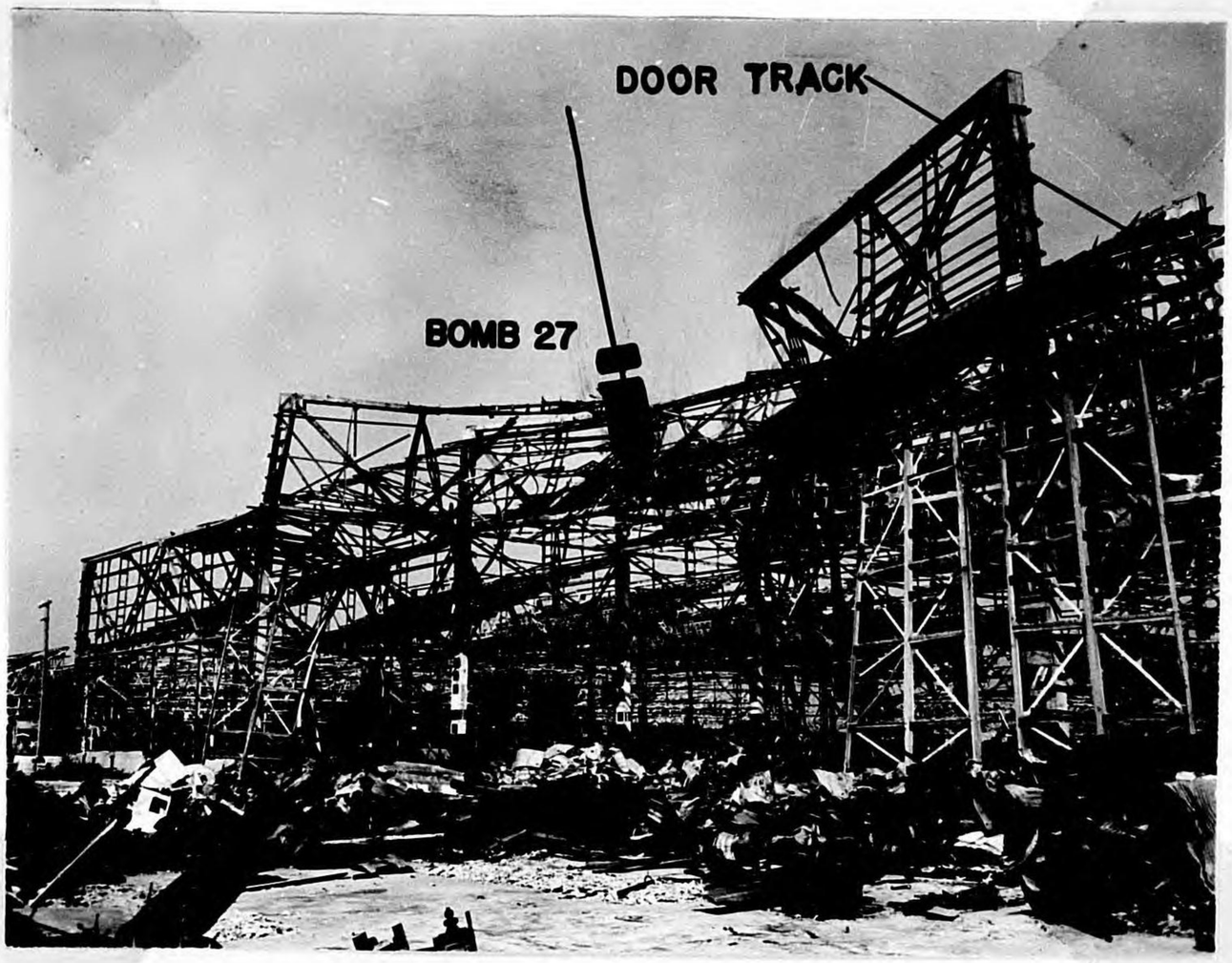


Photo 47/ Bldg. 37b - Damage to south end looking NW.

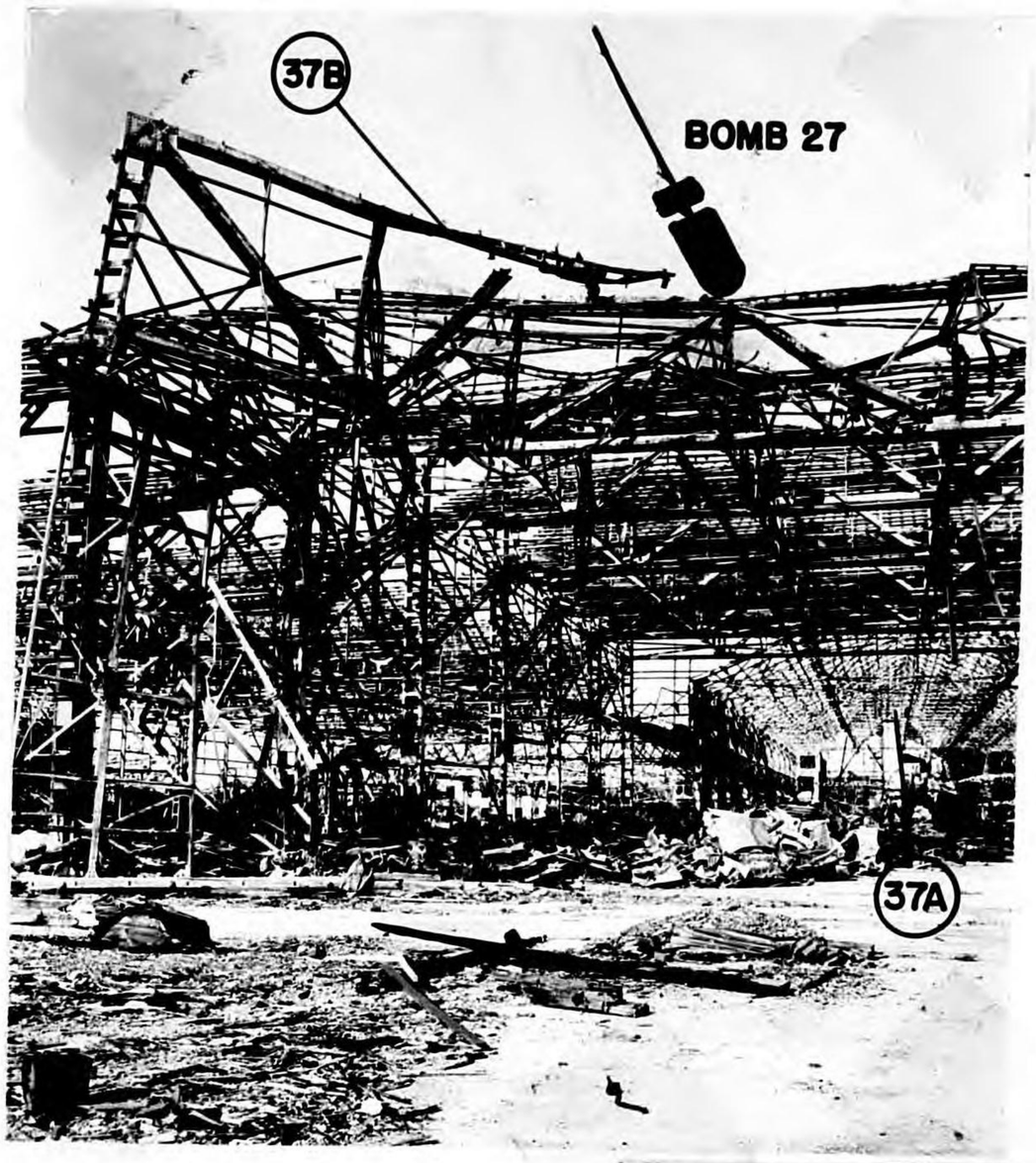


Photo 48. Bldg. 37b - Damage to South end - looking N.

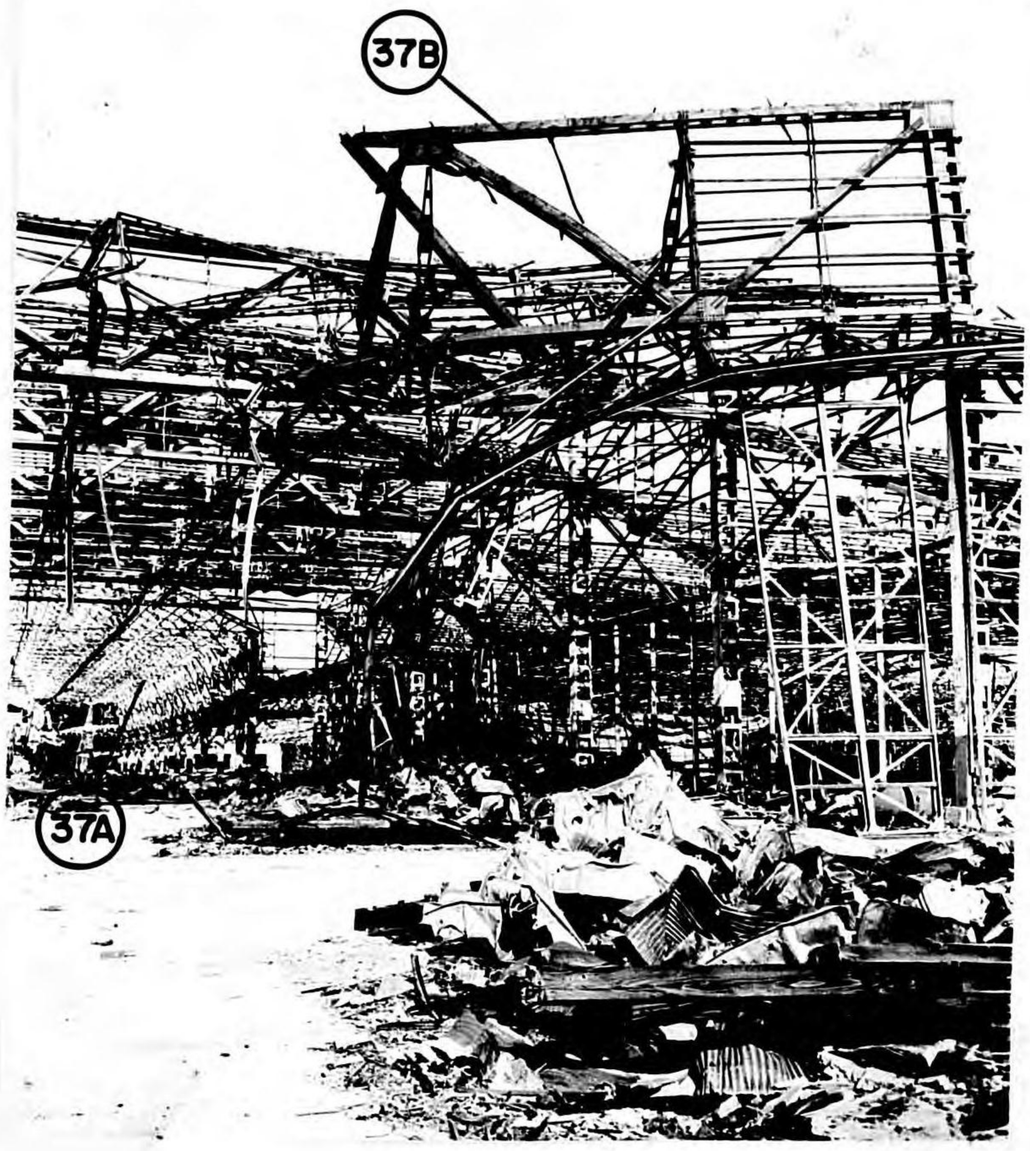


Photo 49. Bldg. 37b - Damage to South end - looking NE.

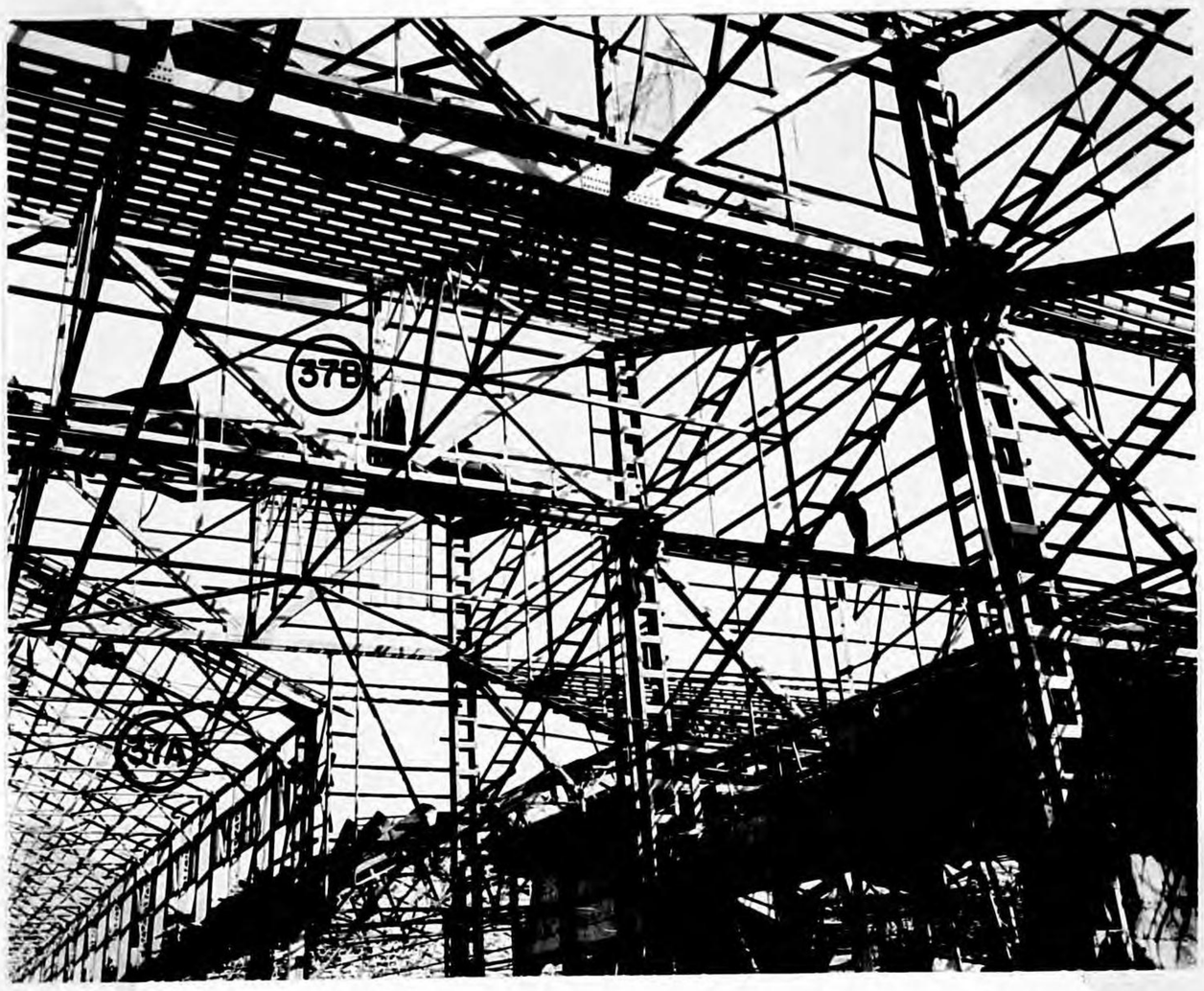


Photo 50/ Bldg. 37b - Roof framing details - Main assembly bay looking NE.

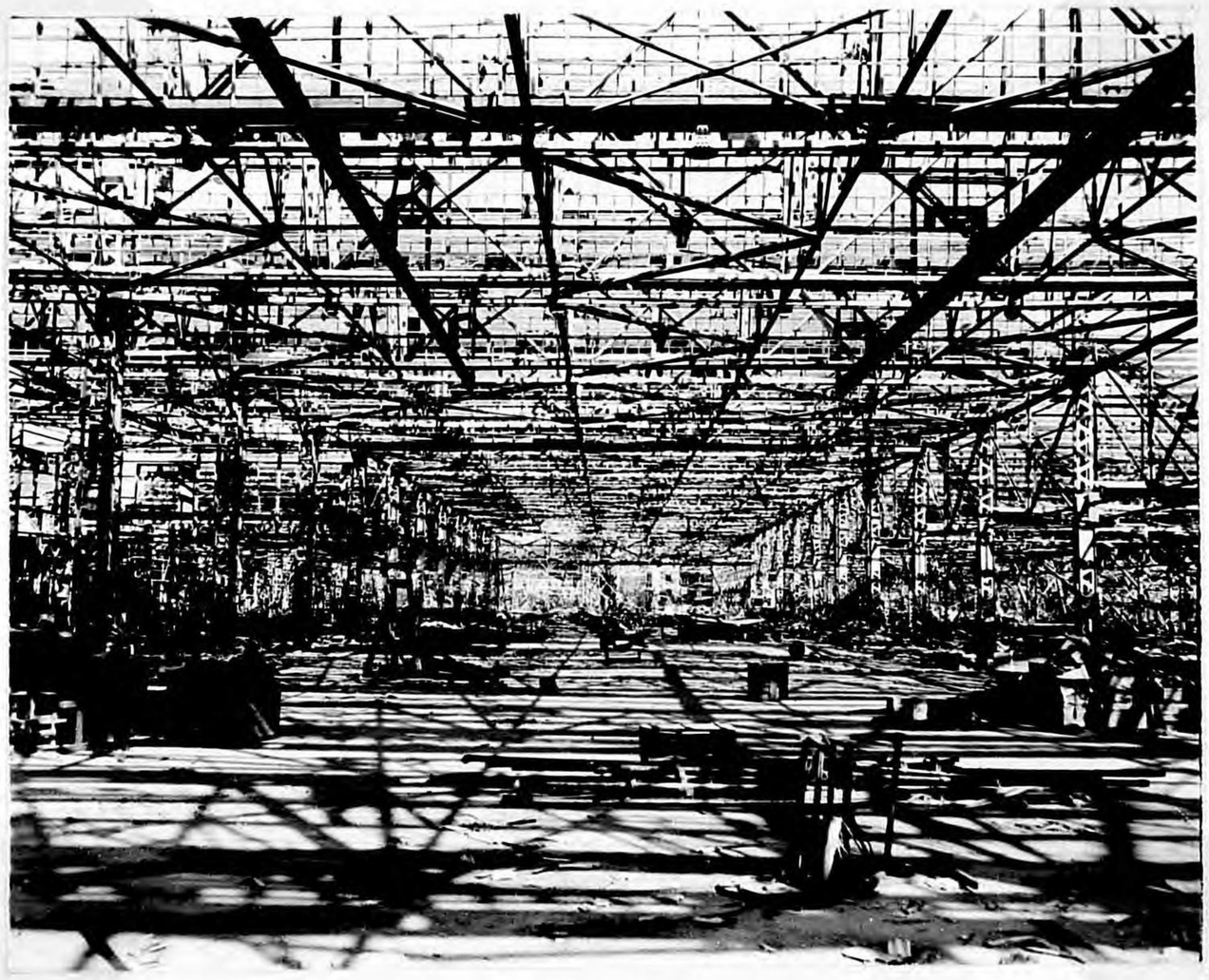


Photo 51./ Bldg. 39a - Assembly bay looking NNE.

4 87

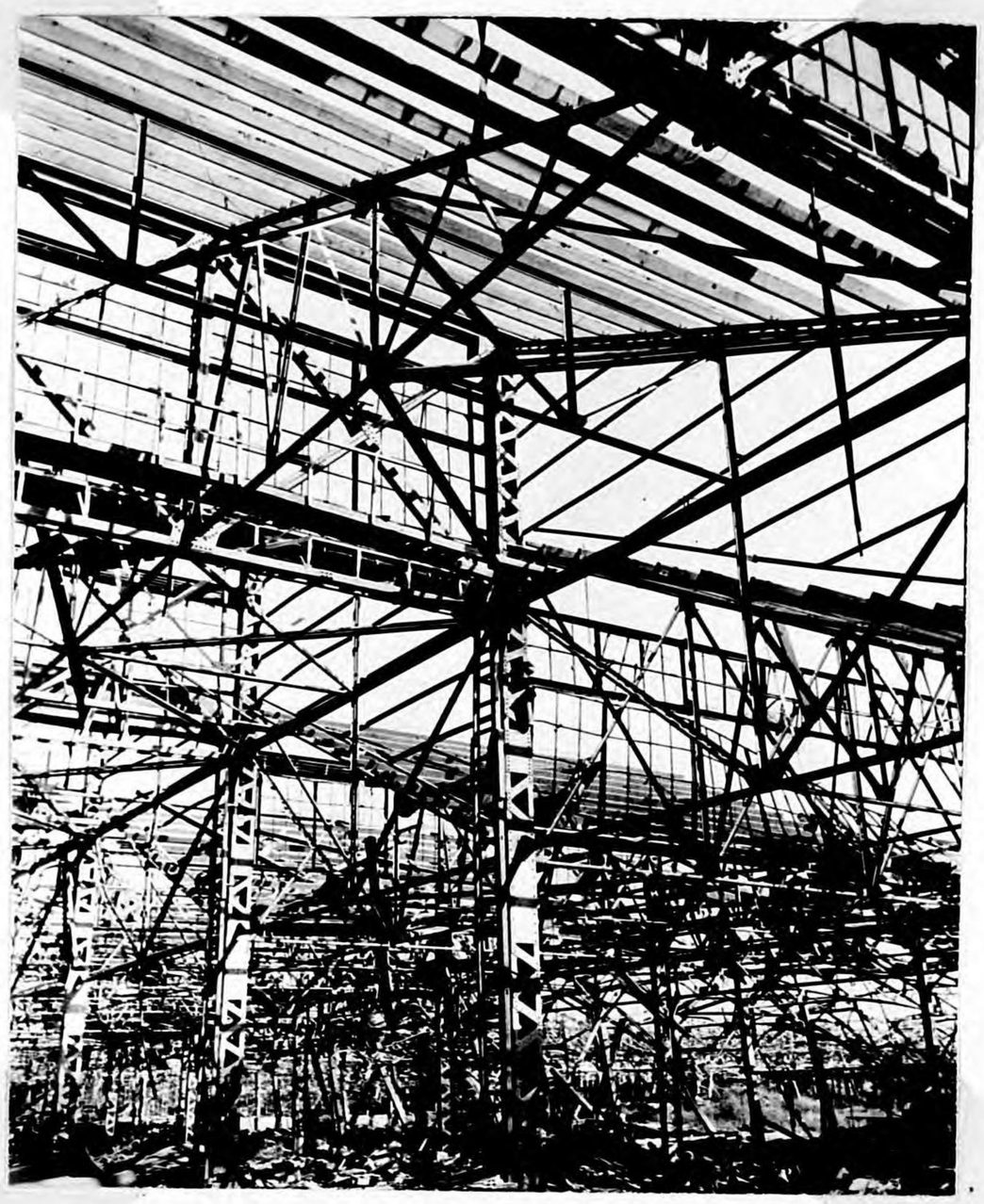


Photo 52/ Bldg. 39a / Interior looking ENE indicating typical roof framing.

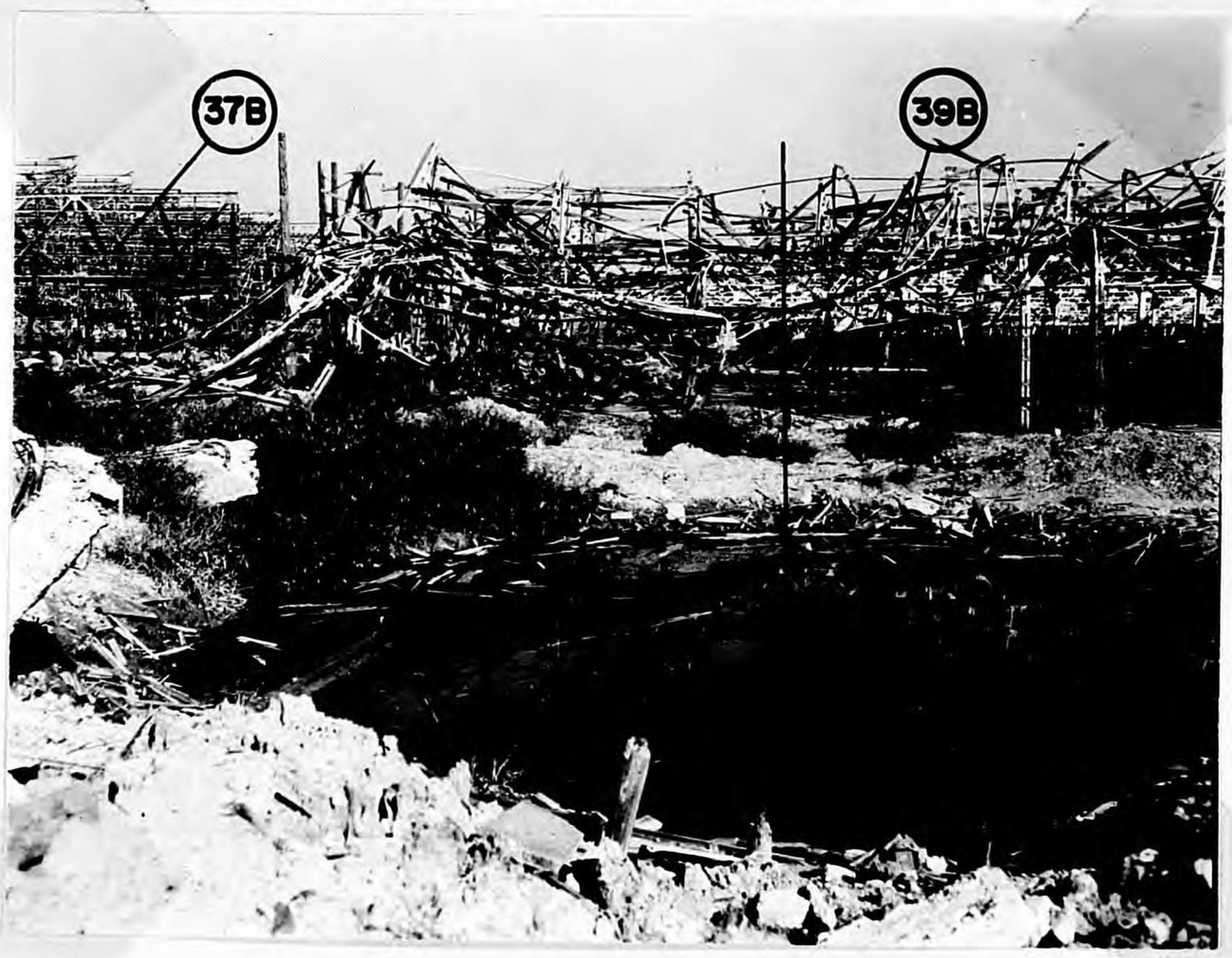


Photo 53./ Bldg. 39b / Damage looking NNE across Bomb 28 crater.

Photo 54. Bldg. 39b - Damage looking NE from Bomb 28 crater.

Photo 55. Bldg. 39b - Interior of east wing looking NNE toward Bomb 28 strike.

Photo 56. Bldg. 39b - Looking ESE toward Bomb 28 strike.

Photo 57. Bldg. 39b - East side of west wing looking NNW toward Bomb 29 strike.

Photo 58/ Bldg. 39b - Interior of west wing looking NNW.

Photo 59/ Bldg. 39b - Interior of west wing showing typical roof framing.

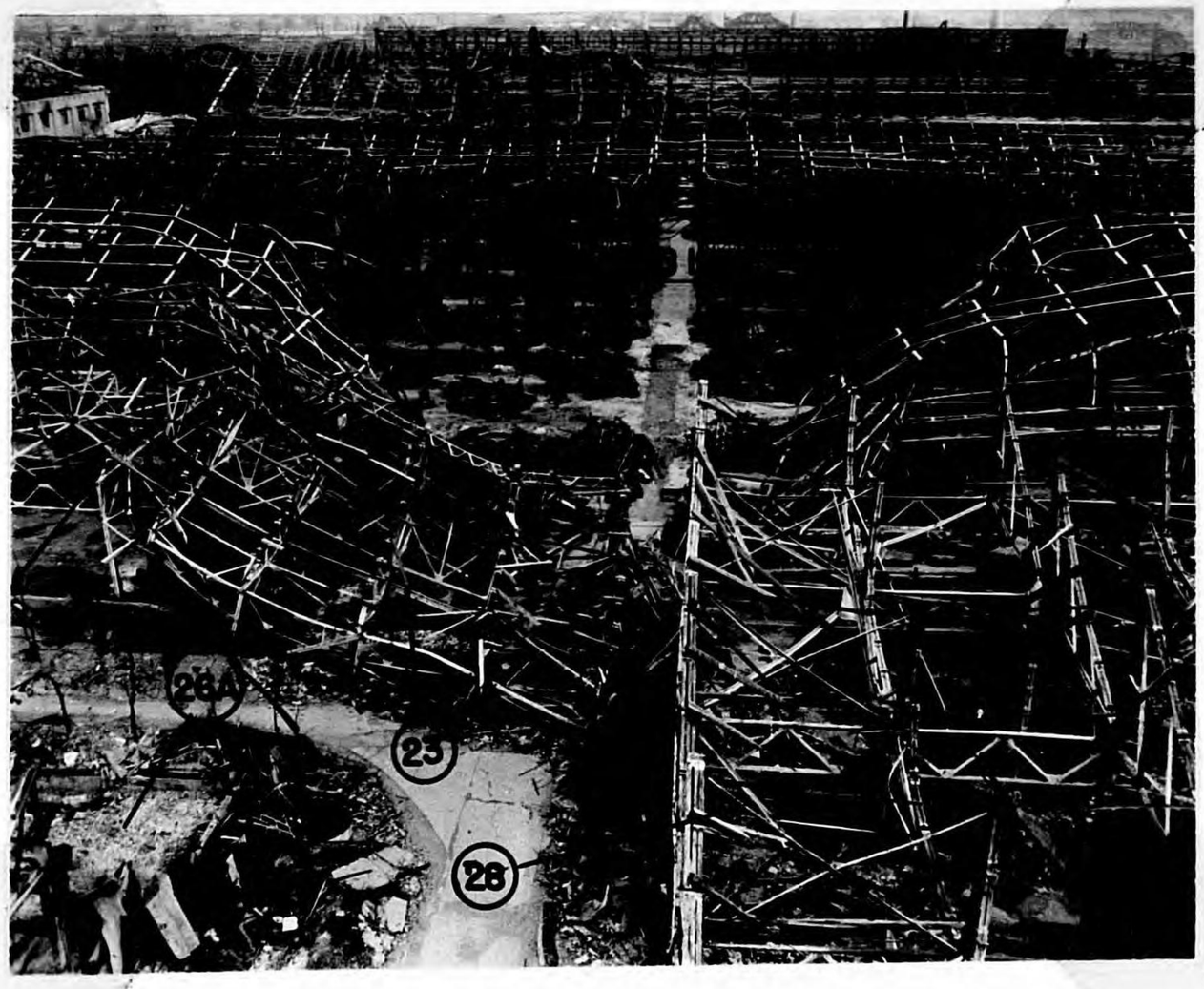


Photo 60. General view / Looking N from Bldg. 29.

Photo 61/ General view / Looking NNE from Bldg. 29./

Photo 62. General view - Looking WSW from Bldg. 29.

Photo 63. General view - Looking W from Bldg. 29.

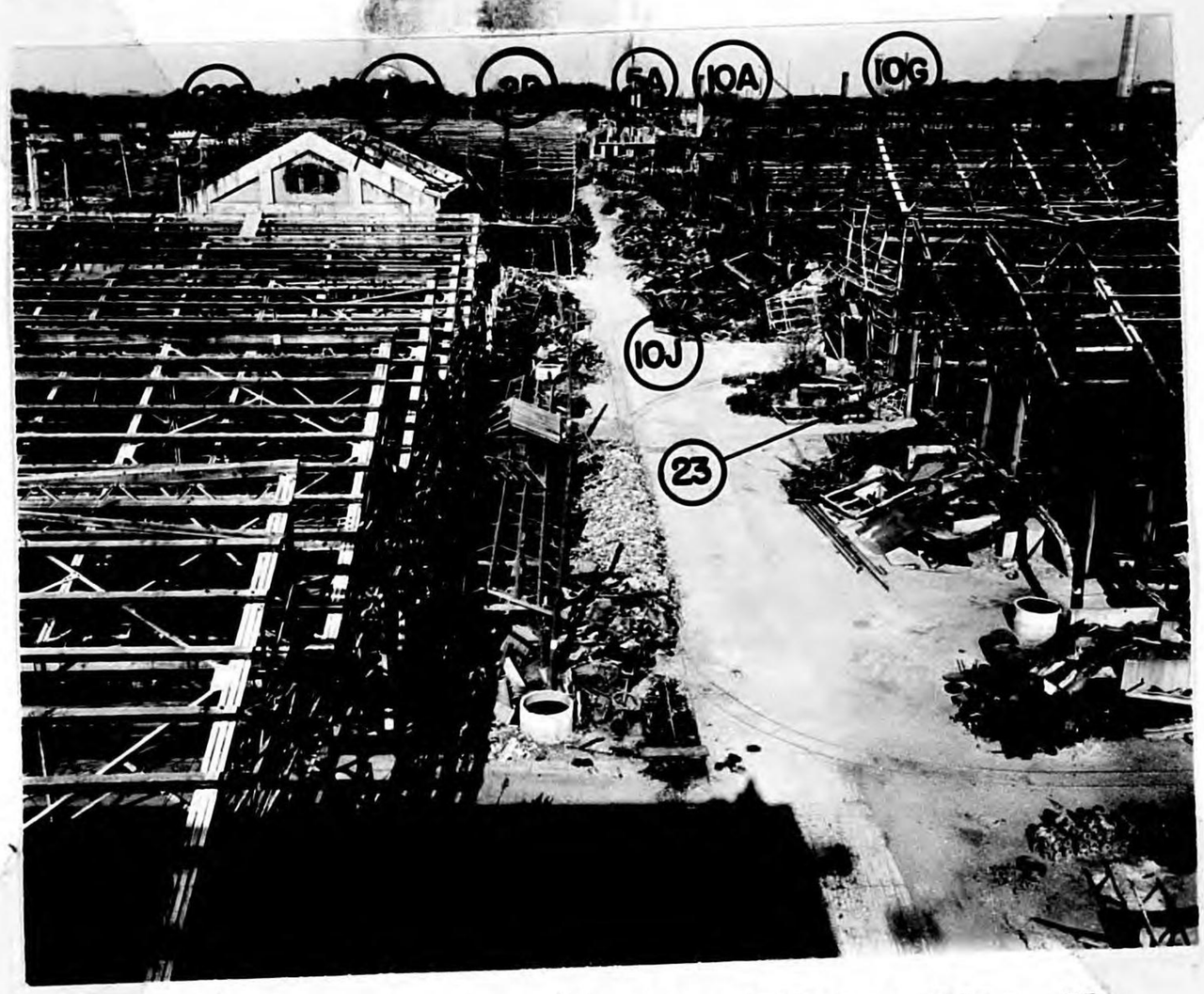


Photo 64. General view - Looking NNE from Bldg. 25.

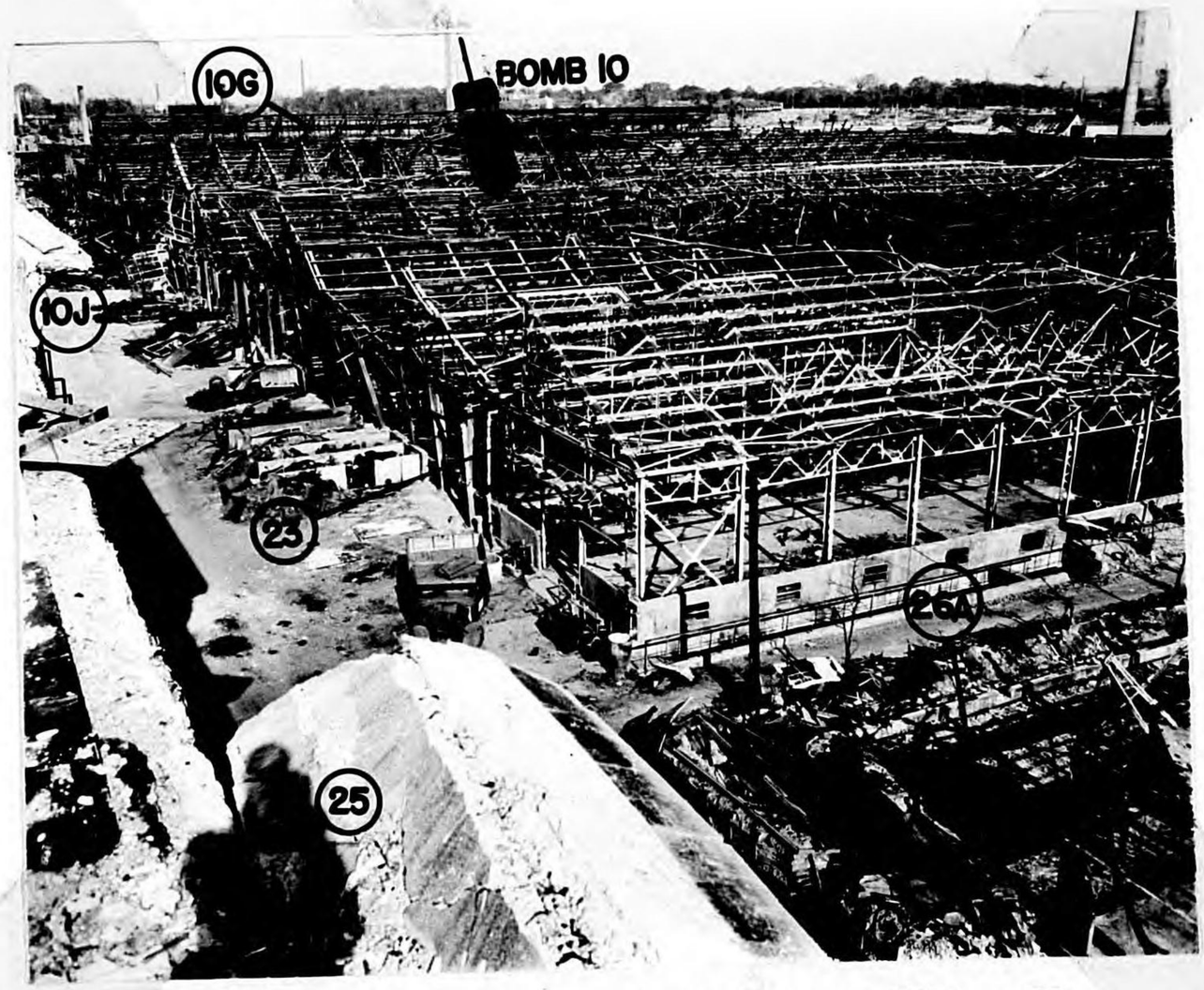


Photo 65. General view - Looking NE from Bldg. 25.

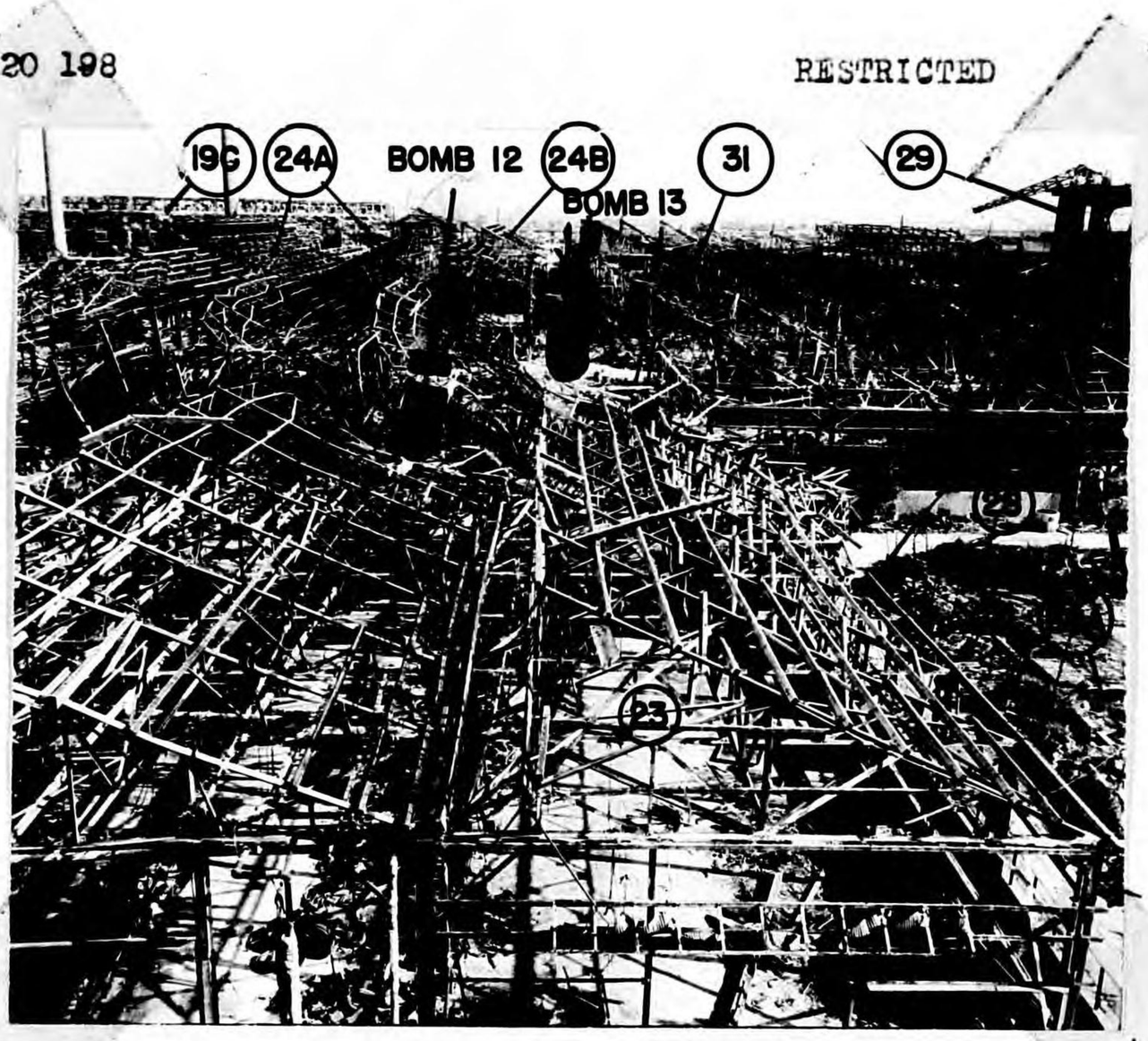


Photo 66. General view - Looking E from Bldg. 25.

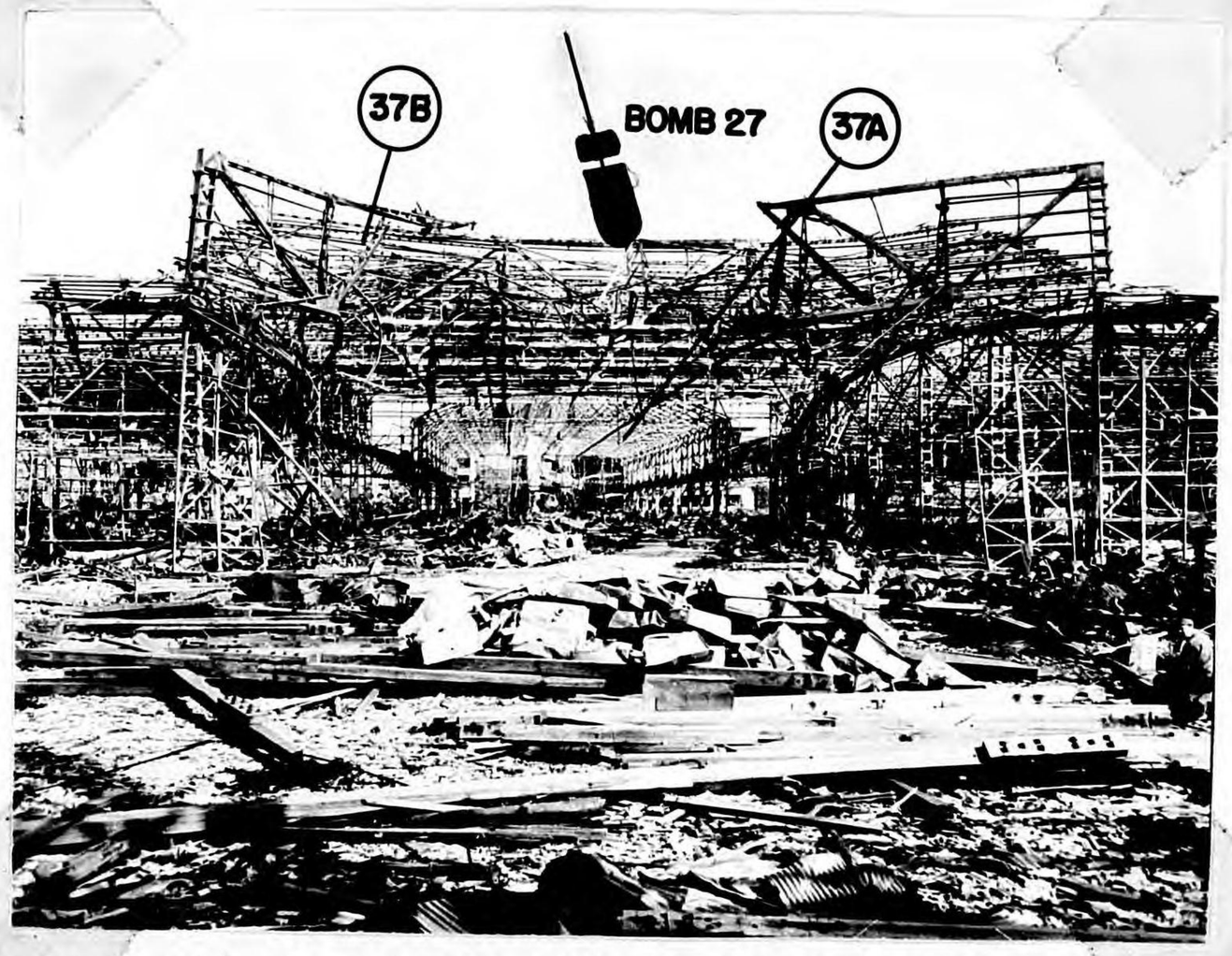


Photo 67. General view - South end of Bldg 37 looking NNE

By HR-M NARA, Date 3/5/91

TARGET NAME AND IDENTIFICATION: AICHI AIRCRAFT CO (FUNAKATA PLANT) AICHI CLOCK & ELECTRIC CO, LTD TARGET 90;20 - 198

APPENDIX 1

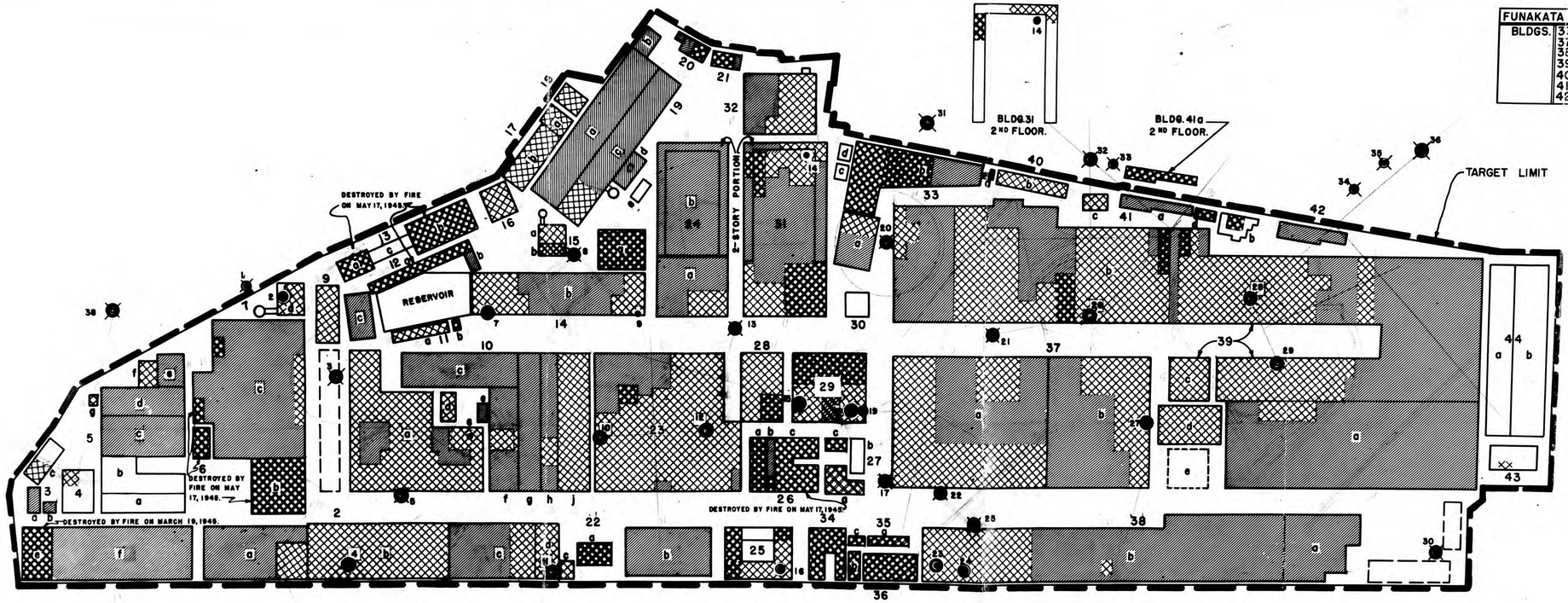
SUMMARY OF PHYSICAL DAMAGE

Note: ONE TON = 2,000 POUNDS.

TARGET AREA (acres)	BOMB DENSITY ON TARGET AREA (tons/acre)	WEAPONS SIZE TYPE	WEAPONS FUZING (sec)	DATE OF ATTACK AND DESCRIPTION OF STRUCTURES AND OCCUPANCY.	DAMAGE TO BUILDINGS (A) of built up area	DAMAGE TO MACHINE TOOLS & EQUIPMENT (B)	WEAPON EFFECTIVENESS Structural damage- acres/ton	PRINCIPAL CAUSE OF DAMAGE
42.3	NA	IBs Type NA		**ATTACK OF 19 MARCH 1945** **ATTACK OF 17 MAY 1945** Damaged buildings were predominately single-story wood and steel framed, both double pitched and sawtooth roofs, corrugated asbestos or corrugated iron roofing and siding on sheathing or fastened directly to framing. The occupancy was machine shops, warehouses and offices	* 3.2	Nil	NA	Fire
42.3	1.19	4000-lb LC) 2000-lb GP) 1000-lb GP	Inst Nose ND-Tail 0.01 Nose ND-Tail	**ATTACK OF 9 JUNE 1945** Damaged buildings were predominately single-story, steel framed building, double pitched and sawtooth roofs with roofing and siding of corrugated asbestos. Also included were well constructed steel framed, fire resistive multi-story buildings and single and two story wood framed buildings. Buildings were used for machine shops, forge and heat treatment shops, aircraft assembly, warehouses, woodworking shops and offices.	** 46.8	∓44.4	** 0.178	Blast, fire and debris

* Includes structural roof damage only.
** Includes structural roof and structural floor damage.
∓ Based on Japanese insurance claims.
ND - Non-delay.
NA - Information not available.

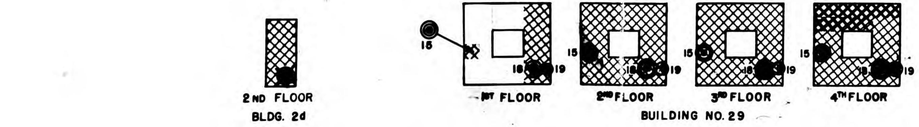
APPENDIX 1

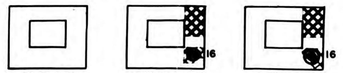


FUNAKATA PLANT	
BLDGS.	33 a, b
	37 a, b
	38 a, b
	39 a, b, c, d, e
	40c
	41 a, b, c, d
	42

AICHI CLOCK & ELECTRIC CO. LTD.		
BLDGS.	2 a, b, c, d, e, f.	21
	3 a, b, c.	22 a, b, c.
	4	23
	5 a, b, c, d, e, f, g.	24 a, b.
	6	25
	7 a, b, c.	26 a, b, c.
	9	27 a, b, c.
	10 a, b, c, d, e, f, g, h, j.	28
	11 a, b.	29
	12 a, b.	30
	13 a, b, c.	31
	14 a, b.	32
	15 a, b.	34
	16	35 a, b, c.
	17 a, b.	36
	18	40 a, b.
	19 a, b, c, d.	43
	20	44 a, b.

H.E. STRUCTURAL DAMAGE.
SUPERFICIAL DAMAGE.
FIRE STRUCTURAL DAMAGE.
H.E. PLUS FIRE DAMAGE.
1,000 LB. G.P. BOMB
2,000 LB. G.P. BOMB
4,000 LB. L.C. BOMB.
DESIGNATES CRATERING BOMB.
OUTLINE OF TARGET AREA.
DISMANTLED PRIOR TO JUNE 9, 1945.

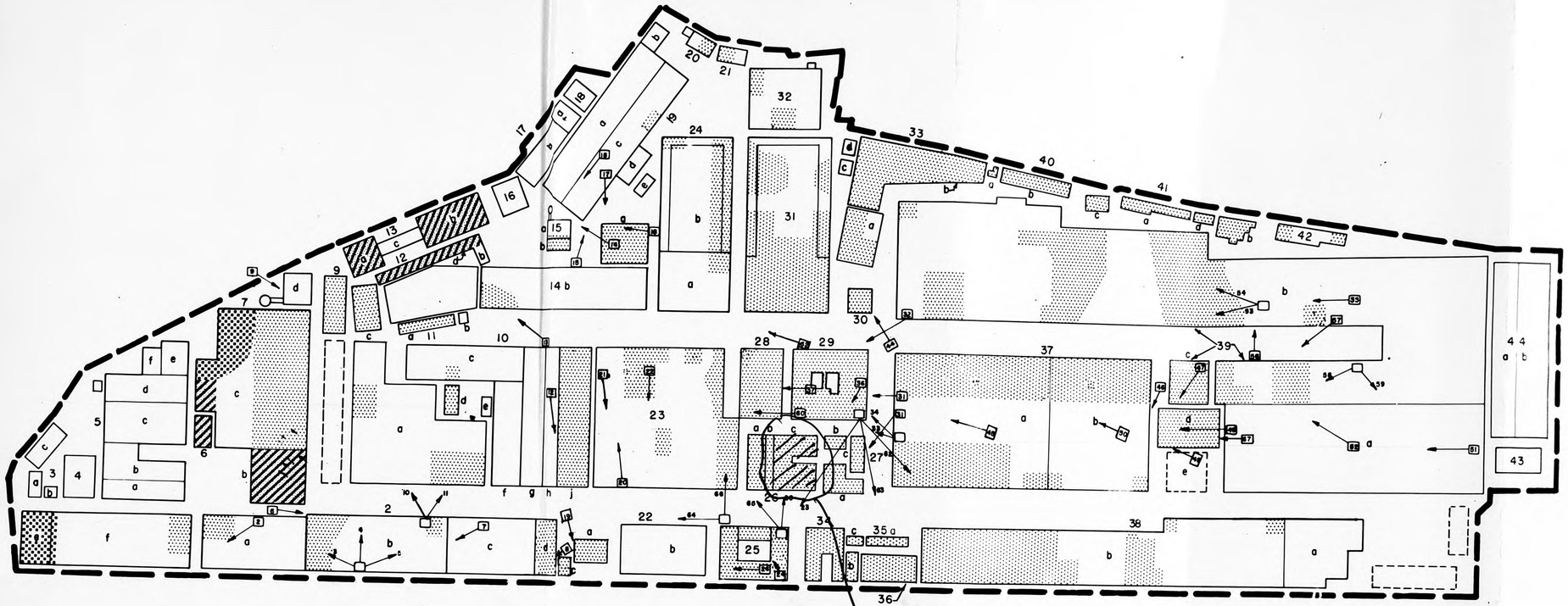




100 50 0 100 200 300 400
GRAPHIC SCALE IN FEET.

TARGET AREA 42.3 ACRES.

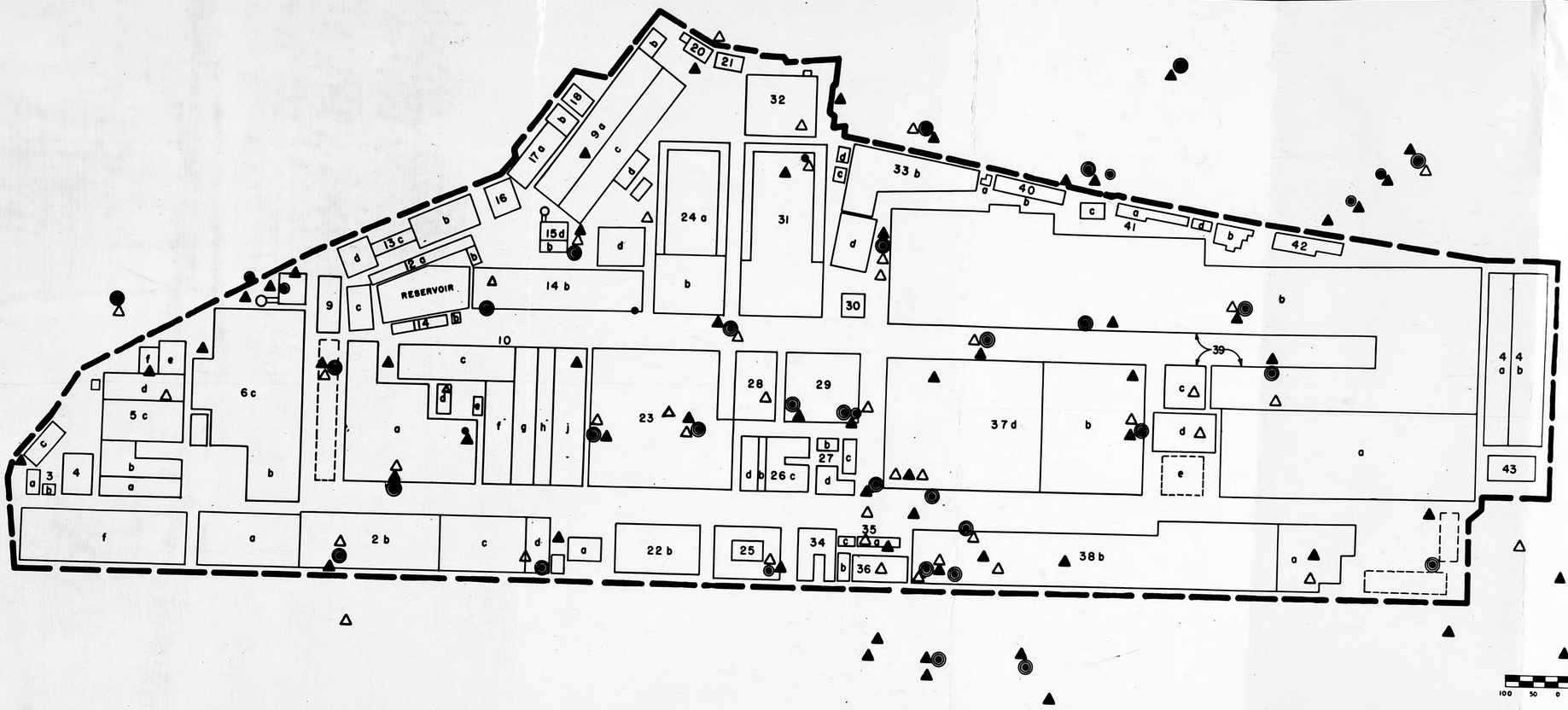
U.S. STRATEGIC BOMBING SURVEY
BOMB & DAMAGE PLOT
AICHI AIRCRAFT CO. FUNAKATA PLANT
AICHI CLOCK & ELECTRIC CO. LTD.
NAGOYA, JAPAN
ATTACK OF 9 JUNE, 1945
EXHIBIT A.



U.S. STRATEGIC BOMBING SURVEY
PHOTO PLOT & AREAS OF FIRE
AICHI AIRCRAFT CO. FUNAKATA PLANT
AICHI CLOCK & ELECTRIC CO. LTD.
NAGOYA, JAPAN
ALL ATTACKS
EXHIBIT B

500

By HR-A NARA Date 3/3/77



U.S. STRATEGIC BOMBING SURVEY
BOMB FALL
AERIAL PHOTO INTERPRETATIONS
VERSUS FIELD SURVEY
AICHI AIRCRAFT CO. FUNAKATA PLANT
AICHI CLOCK & ELECTRIC CO. LTD.
NAGOYA, JAPAN
ATTACK OF 9 JUNE 1945
EXHIBIT C

94

94

RESTRICTED

THE UNITED STATES
STRATEGIC BOMBING SURVEY

THE EFFECTS OF THE FOUR-THOUSAND-POUND BOMB ON JAPANESE TARGETS

A REPORT ON FIVE INCIDENTS

REGRADED UNCLASSIFIED
ORDER SEC ARMY BY TAG PER 10351 4

Physical Damage Division
May 1947

RESTRICTED

RESTRICTED

THE UNITED STATES
STRATEGIC BOMBING SURVEY

THE EFFECTS OF THE FOUR-THOUSAND-POUND BOMB ON JAPANESE TARGETS

A REPORT ON FIVE INCIDENTS

REGRADED UNCLASSIFIED
ORDER SEC ARMY BY TAG PER 103514

Physical Damage Division
Dates of Survey:
19 October–16 November 1945
Date of Publication:
May 1947

RESTRICTED

This report was written primarily for the use of the United States Strategic Bombing Survey in the preparation of further reports of a more comprehensive nature. Any conclusions or opinions expressed in this report must be considered as limited to the specific material covered and as subject to further interpretation in the light of further studies conducted by the Survey.

FOREWORD

The United States Strategic Bombing Survey was established by the Secretary of War on 3 November 1944, pursuant to a directive from the late President Roosevelt. Its mission was to conduct an impartial and expert study of the effects of our aerial attack on Germany, to be used in connection with air attacks on Japan, and to establish a basis for evaluating the importance and potentialities of air power as an instrument of military strategy, for planning the future development of the United States armed forces, and for determining future economic policies with respect to the national defense. A summary report and some 200 supporting reports containing the findings of the Survey in Germany have been published.

On 15 August 1945, President Truman requested that the Survey conduct a similar study of the effects of all types of air attack in the war against Japan, submitting reports in duplicate to the Secretary of War and to the Secretary of the Navy. The officers of the Survey during its Japanese phase were:

Franklin D'Olier, *Chairman.*
Paul H. Nitze,
Henry C. Alexander, *Vice Chairmen.*
Harry L. Bowman,
J. Kenneth Galbraith,
Rensis Likert,
Frank A. McNamee, Jr.,
Fred Searls, Jr.,
Monroe E. Spaght,
Dr. Lewis R. Thompson,
Theodore P. Wright, *Directors.*
Walter Wilds, *Secretary.*

The Survey's complement provided for 300 civilians, 350 officers, and 500 enlisted men. The military segment of the organization was drawn from the Army to the extent of 60 percent, and from the Navy to the extent of 40 percent. Both the Army and the Navy gave the Survey all possible assistance in furnishing men, supplies, transport, and information. The Survey operated from headquarters established in Tokyo early in September 1945, with subheadquarters in Nagoya, Osaka, Hiroshima, and Nagasaki, and with mobile teams operating in other parts of Japan, the islands of the Pacific, and the Asiatic mainland.

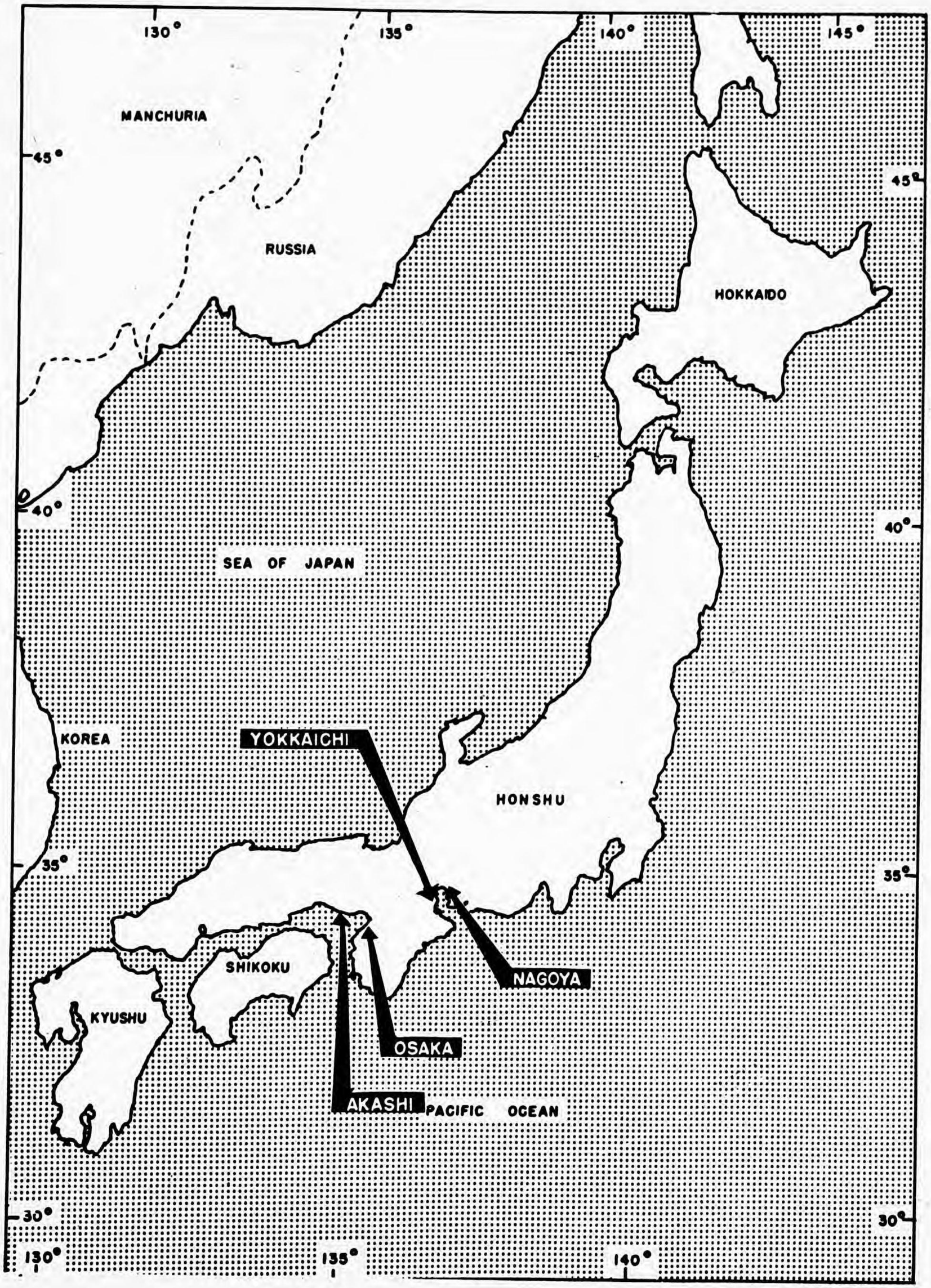
It was possible to reconstruct much of wartime Japanese military planning and execution, engagement by engagement, and campaign by campaign, and to secure reasonably accurate statistics on Japan's economy and war production, plant by plant, and industry by industry. In addition, studies were conducted on Japan's over-all stratcgic plans and the background of her entry into the war, the internal discussions and negotiations leading to her acceptance of unconditional surrender, the course of health and morale among the civilian population, the effectiveness of the Japanese civilian defense organization, and the effects of the atomic bombs. Separate reports will be issued covering each phase of the study.

The Survey interrogated more than 700 Japanese military, government, and industrial officials. It also recovered and translated many documents which not only have been useful to the Survey, but also will furnish data valuable for other studies. Arrangements have been made to turn over the Survey's files to the Central Intelligence Group, through which they will be available for further examination and distribution.

TABLE OF CONTENTS

	Page
MAP	VI
I. INTRODUCTION	1
II. SUMMARY	2
III. REFERENCE TABLES	3
IV. INCIDENT REPORTS	5
Part 1. Kawasaki Aircraft Co., Akashi, Japan	5
Part 2. Sumitomo Light Metals Industry, Ltd., Osaka, Japan	33
Part 3. Aichi-Atsuta Engine Plant, Nagoya, Japan	95
Part 4. Second Naval Fuel Depot (Utsube River Oil Refinery) Yokkaichi, Honshu, Japan	133
Part 5. Aichi Aircraft Co. (Funakata Plant) and the Aichi Clock and Electric Co., Ltd., Nagoya, Japan	199

NOTE.—A table of contents for each part is provided in the front thereof


130°
135°
140°
145°
MANCHURIA
45°
RUSSIA
HOKKAIDO
45°
40°
SEA OF JAPAN
40°
KOREA
YOKKAICHI
HONSHU
35°
35°
SHIKOKU
NAGOYA
KYUSHU
OSAKA
AKASHI
PACIFIC OCEAN
30°
30°
130°
135°
140°

Section I. INTRODUCTION

1. *The weapon.*—This report comprises studies on the use and effectiveness against Japanese industrial targets of the M56 4,000-pound, light-case, high-explosive bomb, equipped with instantaneous-nose and nondelay-tail fuzes.

2. *The targets.*—The targets selected for study, all of which had been subjected to attacks by this weapon, consisted of aircraft engine and assembly plants, a light-metals plant, an oil refinery and fuel depot and a combined aircraft and munitions plant.

3. *Types of structures.*—Structures in the target areas varied according to plant type and use. In general, they were light, steel-frame buildings with corrugated-asbestos or sheet-iron walls and roofs; or heavy, steel-frame, mill-type structures, some of which had overhead-crane runways forming integral parts of the construction; or steel and reinforced-concrete buildings, including a few of earthquake-resistant design; and a comparatively small number of wooden structures used as offices and auxiliary buildings. Each of the incident reports lists the buildings affected by the attacks, describes their construction, and classifies the high-explosive and fire vulnerability of each.

4. *Other installations.*—Other installations are discussed in this report, such as steel tanks, stacks, refinery structures, boiler houses, and plant utilities.

5. *Other attacks.*—Each of the targets was subjected to attacks by weapons other than the 4,000-pound bomb, but those strikes resulted in relatively minor damage. No effort has been made to discuss their effect in detail; such information that is included is to permit a general comparison of effects and to provide an explanation of the presence of damage not caused by 4,000-pound bombs.

6. *Photo interpretation.*—*a.* In some parts of this report, results of photo interpretation are compared with the findings of the field team. Discrepancies between the two were accounted for, in some instances, by the discovery of hidden damage in the target area, such as damage to sidewalls and interiors, which would not have been visible on aerial photographs.

b. Plant production was often overestimated by photo interpreters who apparently based their findings on the possible capacity of plant installations indicated by size and construction, whereas actual production was affected by many factors which could not have been visibly judged.

Section II. SUMMARY

1. *Steel-frame buildings.*—The 4,000-pound bomb was especially effective in producing large-scale damage to steel-frame, mill-type buildings. The cutting, knocking out, or displacing of interior columns resulted in collapse of supporting beams and connected framing, which, in turn, aided in spreading damage and distortion throughout wide areas. Buildings with long-span trusses were subjected to widespread structural damage because of column removal. Near misses caused distortion of columns, damage to roof steel and superficial damage, such as wall and roof stripping, over extensive areas. Explosions in roof steel generally created wider damage than floor bursts which occurred usually in the absence of roof covering as a result of previous attacks.

2. *Reinforced-concrete buildings.*—This type of building suffered heavy damage to roof and floor slabs in the immediate vicinity of the bomb burst. At greater distances the blast effect damaged members and displaced slabs. Interior bursts blew out walls and exterior columns.

3. *Blast walls.*—Brick blast walls generally failed to withstand the blast of near-by detonations and became debris themselves often causing damage to contents, but in the cases where they were not demolished they did limit damage from fragmentation and flying debris.

4. *Fire.*—Fire damage to combustible structures and contents was usually a secondary result of 4,000-pound-bomb attacks, and was generally limited in scope, so that plant fire-fighting efforts were effective in preventing widespread damage. In one plant, however, fire affected practically all combustible buildings and contents in the attack area, and, in addition, contributed to the over-all structural damage of noncombustible structures by warping and distorting steel members.

5. *Plant utilities.*—Plant utilities were damaged to some degree or put out of service entirely in almost every instance. It was seldom, however, that such damage was sufficiently extensive to preclude prompt restoration of at least a part of the services for limited operations.

6. *Machine tools.*—Damage to machine tools resulted from blast, fragmentation, building collapse, falling debris, and, occasionally, from fire. In plants where salvage and repair operations had not been promptly initiated, or where protective coverings had not been provided, additional damage to tools and equipment occurred through exposure to the elements. Fragmentation was one of the most effective agents in producing damage to machinery. Falling structural members and debris accounted for some damage but material of this nature lacked sufficient force to produce heavy damage. It was generally observed that machines close to the point of detonation suffered heavy damage but the effects from any one burst were not widespread.

7. *Production.*—Products manufactured by the plants discussed in this report were critical items needed by Japan's hard-pressed war machine, and production suffered seriously as a result of the 4,000-pound-bomb attacks. In at least three of the five plants studied, production had been either drastically cut or virtually stopped as a result of high-explosive hits on vital areas, of fire damage, or of inability to utilize machines which, although undamaged, had been rendered inoperative by debris. In one instance, however, the reduction in production was also affected by earthquake damage which occurred prior to the attack, and by manufacturing difficulties.

8. *General.—a.* It is apparent that the 4,000-pound bomb was an excellent choice of weapon against the types of plants selected as targets. Its effectiveness against steel-frame buildings is graphically illustrated by the following text and accompanying photographs. The degree of its superiority over other types of demolition bombs becomes more conclusive as the weight of target construction increases.

b. Evaluation of the bomb's effects on machine tools and plant equipment, however, indicates that the over-all results were not particularly outstanding compared with its potential power. This type of damage was not sufficiently widespread, and the damage per ton of bomb was too low to consider the weapon to be an efficient agent in this respect.

c. Mean areas of effectiveness (MAE's) have been computed for the 4,000-pound bomb, and they will be found in PDD Report 76, the over-all report of this division. A comparison of the MAE's for this weapon with those of other bombs discussed will indicate its relative effectiveness.

Section III. REFERENCE TABLES

TYPES OF DAMAGE

Damage to buildings, industrial and domestic

a. Structural.—Damage to principal load-carrying members (trusses, beams, columns, load-bearing walls, floor slabs in multistory buildings) requiring replacement or external support during repairs. Light members such as purlins and rafters are not included.

b. Superficial.—Damage to purlins and other light members; stripping of roofing and non-load-bearing exterior walls. Damage to glass and interior partitions not included.

Damage to machinery, utilities, and equipment

a. Total.—Not worth repair.

b. Heavy.—Requiring repair beyond capacity of normal maintenance staff; usually returned to manufacturer.

c. Slight.—Requiring repair within capacity of normal maintenance staff.

Damage to contents other than machinery and equipment

a. Total.—Not usable.

b. Other.—Usable if reprocessed or repaired.

BUILDING TYPES OR CLASSIFICATIONS

(Tables A and B from Joint Target Group)

TABLE A

Group	Type symbol	Description
A. Single-story, no traveling cranes, spans generally less than 75 feet, heights at eaves generally less than 25 feet, area of 10,000 square feet or more:		
1. With saw-tooth roofs.	A1.1	All buildings of this group with saw-tooth roofs other than those included in types A1.2, A1.3, and A1.4.
	A1.2	Frame and roof slab of monolithic reinforced concrete.
	A1.3	Exposed top chords of trusses.
	A1.4	Stressed-skin type of reinforced concrete (e. g. Zeiss Dywidag).
2. Without saw-tooth roofs.	A2.1	Simple beam and column.
	A2.2	Arches and rigid frames.
	A2.3	Truss construction.
	A2.4	Frame and roof slab of monolithic reinforced concrete.
	A2.5	Stressed-skin type including concrete shell.

TABLE A—Continued

Group	Type symbol	Description
B. Single-story with traveling cranes; any length of span; area of 10,000 square feet or more:		
1. Buildings housing heavy cranes.	B1	Buildings containing runways for heavy cranes (capacity 25 tons or more); height at eaves generally more than 30 feet.
2. Buildings housing light cranes.	B2	All buildings in this group other than those in B1.
C. Single-story; no traveling crane runways; spans greater than 75 feet; height at eaves generally greater than 25 feet; area of 10,000 square feet or more:		
1. Main frame members in two directions.	C1.1	Roof trusses supported along 1 side of building by long-span trusses and along other side by columns. Permits large door along 1 side and at ends.
	C1.2	Continuous trusses in 1 or 2 directions; long span in 1 direction, supported by columns or exterior walls and by internal columns.
	C1.3	Exposed chord saw-tooth roof buildings; exposed chord trusses supporting major size trusses at 90°. One or both truss systems may be of long span.
	C1.4	Diamond mesh arch.
2. Main frame members in one direction only.	C2.1	Long-span arches, individually supported along sides of building. May be arranged in multiple spans joined alongside.
	C2.2	Long-span, triangular or bowstring trusses, individually supported by columns at sides of building. May be arranged in multiple spans joined alongside, using common columns. Roof pitch exceeds 2 in 10.
	C2.3	Long-span trusses, top cord of pitch 2 in 10 or less, including exposed cord saw-tooth roofs, individually supported by columns along sides of building. May be arranged in multiple spans using common columns or may be continuous over internal columns.
3. Shell-type construction.	C3	Stressed-skin including concrete shell construction.
D. All single-story buildings of less than 10,000 square feet plan area.	D	This type covers all single-story industrial buildings, regardless of type of construction if under 10,000 square feet in plan area.
E. Multistory frame buildings.	E1	Earthquake-resistant; extremely heavy steel or reinforced-concrete, multistory construction, designed to resist heavy lateral loads.
	E2	Structures in this group other than those in E1.
F. Multistory, wall-bearing buildings. (May have internal columns.).	F1	Earthquake-resistant, wall-bearing construction. (Walls of brick, reinforced concrete, or very massive masonry.)
	F2	Structures in this group other than those in F1.
S. Special structures	S	Coke ovens, test cells, fuel storage, boilers in power plants, etc.

HIGH-EXPLOSIVE VULNERABILITY CLASSES

TABLE B

High-explosive vulnerability class	Substructural groups (symbols refer to Table A)
V1	E1.
V2	B1, B2.
V3	E2, F1.
V3A	F2.
V4	A1.1, A1.2, A1.3, A2.1, A2.2, A2.3, A2.4, D.
V4A	C1.2, C1.3, C1.4, C2.3.
V5	A1.4, A2.5, C1.1, C2.1, C2.2, C3.

FIRE CLASSIFICATION—BUILDINGS AND CONTENTS

C—*Combustible.*—Buildings whose roofs and/or walls are constructed of combustible material. The floors (except the ground floor) are required to be of similar construction. Wood-frame buildings with noncombustible sheeting on roof and/or walls are also included in "combustible" class.

N—*Noncombustible.*—Buildings which have no significant amount of combustible material in the structure, but whose structure is susceptible to damage by fire in the contents. An example of this type is a building with exposed steel members which may be warped irreparably by the heat of a fire. Roofs of this type are: Corrugated asbestos, corrugated iron, pre-cast or pour-in-place cement or gypsum on exposed steel, and reinforced concrete 2½ inches thick or less.

R—*Fire-resistive.*—Buildings which have no significant amount of combustible material in the structure and which will withstand all but the most intense fire without structural damage. Roofs and floors (other than ground) should be of concrete more than 2½-inches thick, and the steel frame should be protected and not subject to ordinary fire damage.

C and N, N and R, or C and R used where above types are combined in a single fire division.

SECTION IV. INCIDENT REPORTS

(Parts 1 to 5, Inclusive)

PART 1

EFFECTS OF THE 4,000-POUND BOMBS DROPPED ON THE PLANT OF THE KAWASAKI AIRCRAFT CO., AKASHI, JAPAN

Target 90.25–1547

Dates of Survey: 19 October–3 November 1945

TABLE OF CONTENTS

	Page
I. OBJECT OF STUDY	6
II. SUMMARY	6
III. GENERAL INFORMATION	6
IV. THE TARGET	6
V. THE ATTACKS	9
VI. ANALYSIS OF DAMAGE	10
Photos 1 to 29, inclusive.	
Figures 1 to 6, inclusive.	
Tables A to J, inclusive.	

I. OBJECT OF STUDY

The object of this study was to determine the effect of 4,000-pound bombs (M56) on steel and reinforced-concrete buildings found at the Kawasaki Aircraft Co., Akashi, Japan.

II. SUMMARY

1. The Kawasaki Aircraft Co.'s plant at Akashi (34°39′ N., 134°57′ E.), Japan, consisted of 163 acres and was roughly rectangular in shape. Buildings (steel-frame, wooden, and reinforced-concrete) covered 69.8 acres or 43 percent of the total area. This installation produced aircraft engines of the liquid- and air-cooled types, as well as single- and two-seater-fighter fuselages. The company as a whole, with all plants considered, was responsible for 25 percent of the engines used in all Japanese Army combat aircraft. The Akashi plant, in addition to its production functions, performed tests on engines manufactured at all other Kawasaki holdings.

2. B–29 aircraft of the Twentieth Air Force attacked the Kawasaki (Akashi) plant four times as a primary target. The first attack on 19 January 1945 was accomplished with 500-pound, general-purpose AN–M64 bombs, fuzed 0.10-second nose and 0.025-second tail. (Only 4,000-pound, light-case bombs will be covered in detail by this report.) The second, third, and fourth strikes were made on 9, 22, and 26 June 1945, respectively, with 4,000-pound, light-case M56 bombs, fuzed instantaneous nose and nondelay tail. The three 4,000-pound attacks varied in release from 26,200 feet to 16,000 feet altitudes. As a result of these attacks, 46 bombs struck the target, of which 24 hit buildings and 22 exploded in the open. These 46 bombs totaled 92 tons (bomb plot, Fig. 5). Radar was used in the 9 June 1945 strike, visual sighting was utilized on 22 June, and both were used on 26 June.

3. Photo Intelligence estimated the 4,000-pound-bomb structural damage to five partly destroyed buildings at 237,500 square feet or 28.2 percent of the estimated 842,400 square feet of original roof area. Field survey showed that of the 779,200 square feet original roof area of those five buildings, 202,600 square feet or 26 percent were demaged. For details of Photo Intelligence data refer to Table H. All structures within the plant were superficially damaged.

III. GENERAL INFORMATION

1. The study of the Kawasaki Aircraft Co., Akashi, Japan, was begun on 19 October 1945 and completed on 3 November 1945.

2. Composition of Field Team 3: Maj. H. W. McCord, team chief; Maj. W. N. Dillin, ordnance officer; Maj. R. B. Wilson, structural engineer; Capt. P. Elliott, structural engineer; Lt. J. E. Bennett, USNR, structural engineer; Lt. P. Casamajor, USNR, photo interpreter; First Lt. F. A. Bellucci, ordnance officer; Mr. C. K. Parker, interpreter; Sgt. M. Calvin, photographer; BM1c J. B. Daniels, USNR, draftsman; Y3c H. Albrecht, USNR, clerk; S2c C. L. Hirrel, Jr., USNR, draftsman.

3. Data were obtained from Twentieth Air Force operational reports, plant records, personal interviews, and visual observation.

4. Bomb plots furnished by plant officials were inaccurate and resulted in preparation of new plots by the ordnance members of this team.

5. The target area had not been disturbed and was under United States military guard.

IV. THE TARGET

1. *Official personnel.*—Mr. Shugira was technical director of the company and held the retired rank of lieutenant general in the Japanese Army. Mr. Komoda, the architectural engineer for the firm, was a graduate of Tokyo University and had traveled in the United States for several months during 1929. All engineering data on buildings, such as live loads, wind loads, and working stresses, were furnished by Mr. Komoda, while Mr. Shugira supplied general information and production and operation details.

2. *Location.*—Target 90.25–1547 was about 2 miles west of the city of Akashi and consisted of the Akashi aircraft engine plant (Akashi Hatsudaki Kojo) and the Akashi (airplane) fuselage plant (Akashi Kitai Kojo). Both plants were holdings of the Kawasaki Aircraft Co. (Kawasaki Kokuki Kabushiki, Kaisha) and a consolidation of the two was begun in September 1940. At that time the aircraft engine plant was moved from Kobe to Akashi, and in November 1940 the (airplane) fuselage plant was moved from Gifu City to Akashi. By the end of 1940 the consolidation had been completed and production was under way:

3. *Building data.*—Prior to the 4,000-pound-

bomb air attacks, buildings covered 69.8 of the total 163 acres or 43 percent of the plant which was roughly in the shape of a rectangle (general layout and photo plot, Fig. 6).

a. The structures at this target were of three types: Wooden, steel-frame, and reinforced concrete. In general, concrete buildings were used for administration and storage; steel buildings for subassembly, assembly, and workshops; wooden buildings for living quarters, bathhouses, and other needs connected with the housing and care of personnel. The steel-frame and reinforced-concrete buildings were adequate in design although the quality of material and construction in the reinforced-concrete buildings was poor. Material and construction of wooden buildings were also poor. Figures 3 and 4 show construction of typical steel and concrete buildings.

b. In conversations with plant officials it was learned that all large structures were constructed to withstand earthquake shocks.[1] In addition, the following general design criteria were furnished:

(1) Live load on roofs—6.15 pounds per square foot.

(2) Live load on office-building floors—61.5 pounds per square foot.

(3) Wind load, vertical surfaces—20.4 pounds per square foot.

(4) Tensile and compressive working stress of structural steel—17,000 pounds per square inch.

(5) Ultimate tensile stress of structural steel—52,700 pounds per square inch.

(6) Design compressive strength of concrete—640 pounds per square inch.

(7) Ultimate compressive strength of concrete after 28 days—1,422 pounds to 2,148 pounds per square inch.

(8) Unit cost of steel erected—560 yen per ton (yen at 23.8 cents).

(9) Unit cost of reinforced concrete in place—256 yen per cubic yard.

4. *Capital.*—The Kawasaki Aircraft Co., a joint stock company with a nominal capital of 300,000,000 yen, was incorporated in 1937. It had a paid-up capital of 150,000,000 yen, based on the prewar value for the yen of 23.8 cents.

5. *Products.*—This plant manufactured aircraft engines, both liquid- and air-cooled, and aircraft fuselages of the two-seater, Nick-fighter (Ki–45) and single-seater, Randy-night-fighter (Ki–102) types. The highest monthly production of engines was 450 in November 1944 (Table A), and dropped to 410 just prior to the first United States air assault on this plant in early January 1945. Fuselage production went from a high of 119 in August 1944 to a pre-attack low of 50 in December 1944 (Table B).

a. The Akashi plant, most important of Kawasaki factories, together with other plants, turned out 25 percent of the engines used in all Japanese Army combat aircraft. This was indicative of its importance as a military target.

b. Engines used in the two types of fighter fuselages produced at Akashi came from the Mitsubishi plant in Nagoya.

c. Production for both engines and fuselages was considerably decreased during the year of 1945 as indicated in Table C. A primary function of the Akashi plant was to test engines produced in all Kawasaki plants, as well as to manufacture parts for engines which were assembled at Akashi and other company installations. Typical of this procedure were the 128 engines produced during the month of July 1945 of which two-thirds were air-cooled and were assembled at the Kawasaki Futami plant. The remaining one-third was liquid-cooled engines of which 60 percent were assembled at the Takatsuki plant and 40 percent at the Akashi plant. All of the 128 engines were, however, tested at Akashi.

6. *Air attacks reported by plant officials.*—The following air attacks were reported by officials of the Kawasaki Aircraft Co., Akashi plant. (For reference to actual attacks which took place, see Sec. V, Air attacks.)

19 January—High-explosive attack.
22 June—High-explosive attack.
26 June—High-explosive attack.
7 July—Incendiary attack.
28 July—High-explosive attack.
30 July—High-explosive attack.

7. *Financial loss.*—Attack on 19 January 1945.—

Buildings	¥43, 268, 000
Machinery, tools	9, 904, 000
Stock	9, 847, 000
Semifinished products	62, 895, 000
Miscellaneous	4, 148, 000
	130, 062, 000

The above total was recognized and paid by the insurance company.

[1] Earthquake formula:

$$K=\frac{F}{W}=\frac{a}{g}=0.1$$

Where W is the weight of any part F ($=KW$) is the horizontal force assumed acting on the part due to the earthquake; a is the acceleration due to the force of the earthquake; g is the acceleration due to gravity.

(The attack of 19 January 1945 was made with 500-pound bombs, fuzed 0.10-second nose and 0.025-second tail, but as this study deals with 4,000-pound bombs, this information is given only as a matter of record.)

TABLE A.—*Engine production, November 1944*

(All Kawasaki plants)

Type	Production	Type plane in which used	American code name
HA-115	257	(*a*) Ki-48 (light bomber)	Lily 1.
		(*b*) Nakajima fighter	Oscar 2.
HA-40	172	Ki-61 (fighter)	Tony 1.
HA-140	21	Ki-61 (modified fighter)	Do.
Total	450		

TABLE B.—*Fuselage production, 1944 (both types)*

(All Kawasaki plants)

January	February	March	April	May	June	July	August	September	October	November	December
76	78	86	88	62	70	111	119	109	97	51	50

TABLE C.—*Engine and fuselage production, 1945*

(All Kawasaki plants)

	January	February	March	April	May	June	July	August
Engines assembled at Akashi and other Kawasaki plants and tested at Akashi	158	69	50	292	285	195	128	None
Fuselage	14	34	24	44	18	18	14	None

8. *Employees.*—Prior to the 19 January 1945 attack approximately 25,000 workers were employed at the Kawasaki (Akashi) plant. After that attack a gradual dispersal of workers took place. By the time of the attack of 22 June 1945 only 15,000 workers remained.

9. *Dispersal of tools and parts.*—On 1 January 1945 2,171 machines (presses, machine tools, and the like) were listed at the target. When the 22 June 1945 strike occurred only 324 machines remained. Of these, 228 in the engine section were classified as "mostly tools," while 96 remaining in the fuselage plant were classified as "mostly presses." Dispersal which took place between February and April 1945 consisted chiefly of tools and parts as indicated in Table D.

TABLE D.—*Dispersal of tools (Akashi plant), February through April 1945* [1]

Month	Tools and parts	Moved to—	Number moved
February to April	Crank shafts, rods and camshafts of liquid-cooled engines.	Ibaragi plant of Osaka Seisa Co.	194
March	Cutters	Otsu branch	90
April	Trial parts, jigs, and fixtures.	Nishinomiya branch	222
	Jigs and fixtures	Yashiro branch	141

[1] Japanese source.

10. *Unexploded bombs.*—The Japanese reported that in all air attacks there were 32 unexploded bombs as indicated in Table E. Upon visual inspection of the target no unexploded bombs or low-order detonations were in evidence.

TABLE E.—*Unexploded bombs* [1]

	Attack				
	19 Jan. 45	22 June 45	26 June 45	28 July 45	30 July 45
Number	30	None	None	2	None
Disposal time	3 weeks	None	None	Not given	None

[1] Japanese source.

11. *Casualties from air attacks.*—Dead and injured as a result of air attacks are listed in table F.

TABLE F.—*Casualties* [1]

	Date of attack					
	19 Jan. 45	22 June 45	26 June 45	7 July 45	28 July 45	30 July 45
Dead	268	5	5	None	None	None
Injured	99	7	19	1	None	None

[1] Japanese source.

12. *Damage to buildings from air attacks.*—Japanese officials of the Kawasaki Co. recorded damage to buildings, possibility of repair, and repairs completed. A summary of this information follows in Table G.

TABLE G.—*Estimated damage to buildings*

Date of attack	Percentage of damage	Percentage of damage repairable	Percentage actually repaired
19 Jan. 45	40	30	15
22 June 45	15	7	None
26 June 45	10	5	None
28 July 45	Slight	2	None
30 July 45	Slight	1	None

V. THE ATTACKS

1. The Kawasaki (Akashi) plant was bombed four times as a primary target. One attack was with 500-pound bombs, the other three attacks with 4,000-pound bombs. Damage resulting from 4,000-pound bombs will be discussed under Section VI, Analysis of damage. In Section IV, Paragraph 6, is a table of Japanese origin listing air attacks. This table may be compared with the following résumé. Further detailed attack data may be found in Table I.

a. 19 January 1945.—Sixty-two aircraft of the Twentieth Air Force attacked the Kawasaki (Akashi) plant with 500-pound bombs. Bombing altitudes ranged from a high of 27,400 feet to a low of 25,100 feet and all aircraft bombed visually.

b. 9 June 1945.—On this date 24 aircraft, each carrying three 4,000-pound bombs, attacked the Kawasaki (Akashi) plant as their primary target.

(1) Eight-tenths to ten-tenths overcast obscured the target and radar was used. Results were unobserved.

(2) Bombing altitudes ranged between 17,400 feet and 16,700 feet.

c. 22 June 1945.—The plant was attacked by one group of the 313th Wing in a daylight effort. The target was designated as primary for visual and radar. Bombing altitude was 18,000 feet base for the lead squadron with the second and third air squadrons in trail stacked at intervals of 500 feet above the lead squadron.

(1) Twenty-five aircraft bombed the primary target. An average of 6.5 tons of 4,000-pound, light-case M56 bombs was carried by each aircraft.

(2) Due to haze encountered over the target the lead bombardiers had difficulty in identifying the aiming point and as a result the axis of attack for the formations varied.

d. 26 June 1945.—The plant was again attacked by one group of the 313th Wing in a daylight strike and was designated as the primary visual and radar target.

(1) With extreme overcast weather conditions and broken clouds at the assembly point, aircraft were unable to assemble and bomb in formation. Only three aircraft succeeded in bombing in formation. All other aircraft bombed individually. Ice which formed on the bombardier's compartments and the almost solid overcast made bombing by radar necessary.

(2) Bombing altitudes varied from 15,000 to 25,000 feet. Each aircraft carried three 4,000-pound bombs.

e. 7 July 1945.—Aircraft of the Twentieth Air Force bombed the Akashi urban area with incendiary bombs on this date. Many of the incendiary bombs of the M69 type fell on the property of the Kawasaki Aircraft Co.

f. 28 and 29 July 1945.—On these dates naval carrier-based aircraft dropped a number of 500-pound bombs on the airfield of the Kawasaki aircraft plant. Bombs which spilled over on the plant proper caused only slight damage.

2. On visual inspection it was found that a total of forty-six 4,000-pound bombs struck the target. Table I shows distribution of hits; bomb plot, Figure 5, shows location of each hit; and annex to bomb plot, directly following Figure 5, gives points of detonation of all 4,000-pound bombs. No unexploded bombs or low-order detonations were in evidence.

3. Table H contains Photo Intelligence estimates and field survey measurements and shows only the five buildings that were partly destroyed by 4,000-pound bombs and covered by both sources. These buildings comprised about 25 percent of the building area.

TABLE H.—*Comparison of damage due to 4,000-pound bombs estimated by photographic intelligence and by field survey*

Photo Intelligence [1]				Field survey			
JTG building No.	Building roof area	Structural damage	Percentage	PDD building No.	Building roof area	Structural damage	Percentage
	Acres	*Acres*			*Acres*	*Acres*	
66	132.3	30.2	22.8	1 and 2	113.0	46.6	41.2
67	84.0	11.6	13.8	3	86.0	15.0	17.4
68	75.6	32.2	42.6	4	62.5	39.2	62.7
38	427.0	40.0	9.4	19	412.2	22.0	5.3
86	123.5	123.5	100.0	22	106.0	79.8	75.3
Total	842.4	237.5	28.2	Total	779.2	202.6	26.0

[1] Based on central interpretation unit XXI bomber command damage assessment reports 104 of 28 June 1945 and 120 of 8 July 1945.

TABLE I

	Date of attack				
	19 Jan. 1945	9 June 1945	22 June 1945	26 June 1945	Totals for 4,000-pound attacks
Weapon:					
Weight	500-pound	4,000-pound	4,000-pound [1]	4,000-pound	
Type	Bomb GP	Bomb LC	Bomb LC	Bomb LC	
Model	AN-M64	M56	M56	M56	
Fuzing:					
Nose	0.10 second	Instantaneous	Instantaneous	Instantaneous	
Tail	0.025 second	Nondelay	Nondelay	Nondelay	
Aircraft bombing:					
Visual	62	0	25	9	34
Radar	0	24	0	22	46
	—	—	—	—	—
Total	62	24	25	31	80
Number bombs dropped	610	72	74	92	238.
Tons released over target	152.5	144.0	148.0	184.0	476.0.
Mean point of impact	Southeast corner building 19.	Approximate center of northeast side of building 16.	Southwest corner building 11.	Approximate southwest corner building 1.	
Axis of attack	291° T	102° T	36½° T	35½° T	
Altitude of release:					
Highest (feet)	27,400	17,400	19,600	26,200	
Lowest (feet)	25,100	16,700	18,000	16,000	
Unexploded bombs on visual inspection	None	None	None	None	None.
Low-order detonations on visual inspection	None	None	None	None	None.

Total 4,000-pound bomb hits: On buildings, 24; in open, 22; total, 46. Further details on bomb plot, Fig. 5.

[1] One aircraft carried 1 AN-M66 2,000-pound, general-purpose bomb in addition to three 4,000-pound bombs normally carried.

VI. ANALYSIS OF DAMAGE

1. Following is an analysis of structural damage representative of the effect of 4,000-pound bombs. Figure 5 contains location of buildings and plot of damaged areas. Superficial damage which was 100 percent throughout this target will not be discussed in detail. No assessment of damage due to incendiary-bomb attacks was made and the major damaging factor was blast unless otherwise specified.

a. Buildings 1 and 2.—Building 1 was a structural-steel, one-story building used as an assembly shop, and building 2 was attached to it although the framing was not carried through to connect them rigidly. Bomb 22 struck Building 1 as indicated on bomb plot, Figure 5, and Photos 1 and 2. The effect of the bomb was to knock over two interior columns and to cut the roof steel so badly that, aided by the impetus imparted by the blast, the building began to collapse. The two nearest exterior columns were distorted by blast and, since the steel between was severed, they fell under the weight of the collapsing steel (Photo 1). Further, the removal of the two interior columns allowed the collapse to create distortion over a widespread area. The distortion carried over into Building 2 and was localized there because the connection to Building 1 was insufficiently strong to transmit heavy loads.

b. Building 3, a structural-steel, one-story building, was damaged by the effect of a near miss (Bomb 25) approximately 35 feet from the northwest end (Photo 3). No columns were knocked down, but several were badly distorted, and the roof steel was severely damaged.

c. Building 4, also a structural-steel, one-story building, was struck by Bomb 29 (Photos 4 and 5 present general views of damage from this hit) which knocked down several columns. Photos 6 and 7 show the two interior columns which were displaced, and Photos 8 and 9 show exterior columns. The destruction of these columns and the immediate area of roof steel (Photos 4, 5, 7) resulted in widespread collapse and distortion. There were two near-misses (Bombs 30 and 31) approximately 50 feet distant from the southwest side of the building. It could not be determined whether any structural damage resulted from these near-misses as the positive damage caused by Bomb 29 was very heavy and extended to and covered any area that would have been affected by Bombs 30 and 31.

d. Building 8, a three-story, reinforced-concrete office building, was struck by two 4,000-pound bombs. Photo 10 presents general aspects of the building (the collapse of the penthouse and the damage at extreme right of this photo were the results of 500-pound strikes and are not covered by this report). Bomb 45 exploded in the east wing of the building (Photo 11). (Photo intelligence indicates that a 500-pound bomb struck in approximately the same place as the 4,000-pound bomb. Extent of damage attributable to the 500-pound bomb could not be determined and is, of necessity, included in this survey.) The roof and the third-story slab were destroyed for one bay, and one third-story exterior column was completely removed by the explosion. In addition, the exterior walls of the second and third floors were blown out for two bays. The interior slabs and beams suffered in the areas indicated as damaged in Figure 1. One of the more severely damaged columns is shown in Photo 12. Bomb 46 exploded in the extreme north corner of the building as shown in Photo 10. The third-story exterior walls and the included column were blown down and outward for two bays on the northwest face (Photo 12), and one bay on the northeast face. The roof collapsed, leaving the corner column standing (Photo 12). The interior structure was damaged as shown on Figure 1. Bomb 44 was a near-miss which detonated approximately 50 feet southeast of the building and damaged first-story exterior walls and second-floor exterior beams of the adjacent five bays.

e. Building 12, a two-story, reinforced-concrete ffice building, was hit with two 4,000-pound mbs, 14 and 15. Bomb 15 exploded at the itheast end and Bomb 14 exploded at approxitely the northwest end. Collapse was noted hin three bays of each bomb. Examination the portion still standing indicated that all of ıe beams, except those in one bay at the northvest end, had been damaged at the haunches as a result of shock. The building was 95 percent structurally damaged.

f. Building 23, a one-story, structural-steel building, was also damaged by the blast from Bomb 15 which struck in Building 12. The damage extended for two bays from the eastern edge of the building (Photo 13). The blast had the effect of buckling the bottom chord members of the truss and bending the exterior columns inward. Photo 14 shows the damage caused by Bomb 15 and Photo 15 the damage caused by bomb 14.

g. Building 16 was a one-story, structural-steel building with saw-tooth roof. Photo 16 shows the damage caused by one bomb bursting in the roof. This damage was confined to a small area as the bomb burst about 15 feet from the east side of the building and 30 feet from the north end, causing a large portion of the blast to be expended outside of the structure. This area had previously suffered damage from a 500-pound hit, but the area damaged by the 4,000-pound bomb was much larger than, and included, the area damaged by the former.

h. Building 19, a one-story, structural-steel building with saw-tooth roof, was hit and damaged by one 4,000-pound bomb. Damage assessment plot, Figure 5, shows area damaged by Bomb 2.

(1) This building had been hit previously in the 500-pound-bomb attack, but no bombs fell within the damage area of the 4,000-pound bomb being discussed.

(2) Bomb 2 hit in the roof steel approximately 10 feet inside the west wall. There was no crater in the concrete floor and very few fragmentation marks were observed.

(3) The column in the foreground of Photo 17 was, from all indications, directly in line with the blast, and the built-up flange which faced the explosion received the greatest part of the blast. Before the column was knocked over, the force of the explosion was transmitted through the bottom chord of the adjacent saw-tooth truss to the next column. The process of transmitting the load through the bottom chord which acted as a strut continued for five bays, in each case buckling the bottom chord of the truss and putting the column out of line at the truss connection. The sixth and seventh bays in the same line were slightly distorted but not enough to justify classification as structural damage. Damage extended over an approximately circular area having a radius of four bays from the point of detonation. The structure would have to be replaced for at least two and one-half bays in radial distance from the bomb. The rest of the area could have been repaired without replacing a large percentage of the steel.

(4) Blast was the only cause of damage to this building. Photo 18 taken about 100 feet from the west side of the building gives a general view of the damage.

i. Building 22, a one-story, structural-steel building with saw-tooth roof, approximately 320 feet long and 280 feet wide, was used as a flight preparation shop. The trusses running perpendicular to the saw-tooth trusses and supporting them had a span of 140 feet. The height of the bottom chord above the floor level was 32 feet. This structure received one hit and several near misses. Bomb 3 burst near one of the interior columns supporting the long-span trusses. The blast from the bomb collapsed the column (Photo 19), which pulled down the heavy trusses it was supporting. The trusses, which had been tied into the rest of the structure by the saw-tooth trusses, in turn pulled down and distorted trusses and framework for three more bays on one side of the hit, and two on the other side. Photos 20 and 21 show this collapse. Figure 2 indicates the position of Bomb 3 in relation to surrounding framing. Photo 19 shows in its final position the column which had collapsed. Photo 22, taken from outside the western end of the building, shows how five of the exterior columns were pulled over by the collapse of the interior column. A bomb cratered 30 feet south of this structure, knocked down the hangar doors, and wrecked the southern part of this building. The widespread damage in this building as the result of the collapse of one column was due to the doubling of the span of the truss, together with the higher dead load inherent in the design of long spans.

j. Building 27 was a one-story, steel building used as a plating shop. It was divided in two by an 8-inch reinforced-concrete wall running parallel to the roof trusses and as high as the bottom chord of the truss. Bomb 12 cratered 30 feet south of the south side of the building. Photo 23 indicates the effect of the blast from this bomb which pushed the south side of the building in and caused the roof to collapse. No damage occurred on the far side of the concrete wall which acted as a blast wall.

k. Building 132 was a structural-steel boiler-house. Photo 24 presents general aspects and over-all damage. The one bomb affecting this structure blew over the boiler (Photo 25) and cut the corner column, blowing the end of the building inward (Photos 26, 27, and 24). Photo 28 shows the construction and how the failure took place in the side of the building away from the stack. The reinforced-concrete stack was damaged, the concrete being knocked out over an area approximately 15 feet high by 4 feet wide (Photos 26 and 27). The foundation of the stack was apparently undisturbed and the stack appeared to be in plumb.

TABLE J

TARGET NO. 1547 NAME OF PLANT KAWASAKI AIRCRAFT COMPANY , AKASHI, JAPAN

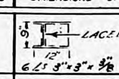
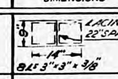
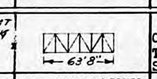
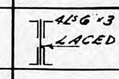
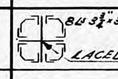
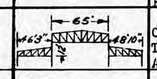
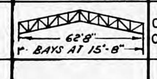
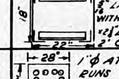
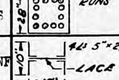
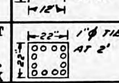
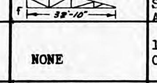
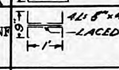
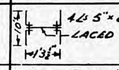
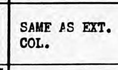
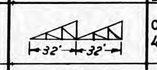
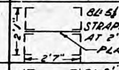
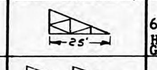
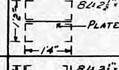
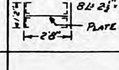
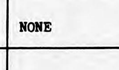
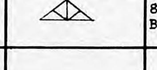
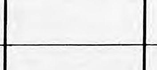
NO. OF BLDG.	NAME OF BLDG.	GROUND AREA OF BUILDING IN SQ FT	NO. STORIES	FLR. AREA IF MORE THAN ONE STORY IN SQ FT	HT. OF EAVES IN FT	DESCRIPTION OF STRUCTURE A JTG Classification	VULNERABILITY FIRE RESISTIVE	VULNERABILITY NON COMBUSTIBLE	VULNERABILITY COMBUSTIBLE	FLOORS TYPE & THICKNESS	EXTERIOR COLUMNS & DIMENSIONS C.C.	INTERIOR COLUMNS & DIMENSIONS	TRUSSES TYPE - SPAN	EXTERIOR WALLS BEARING, CURTAIN - THICKNESS	INTERIOR WALLS BEARING, CURTAIN THICKNESS	ROOF	STRUCTURAL DAMAGE TO BLDG. SQ. FT. FLOOR AREA	REMARKS
1 & 2	HEAT TREATING SHOP	113,000	1		21	STEEL FRAME, SAW TOOTH ROOF - SOUTH EAST LIGHT B2		X		REINF CONC				CURTAIN-6" REINF CONC. TO 5'-WOOD TO EAVES ON STEEL GIRTS	CURTAIN - STEEL SASH & GLASS - CORRUGATED 1 RON	CORR. CEMENT ASBESTOS ON WOOD PURLINS IN DAMAGED PORTION OF BLDG.	46,600	SUPERFICIAL DAMAGE 100%
3	ACCESSORY SHOP	86,000	1		21	STEEL FRAME, SAW TOOTH ROOF B2		X		REINF CONC	SAME AS BUILDING 1 AND 2	SAME AS BUILDING 1 AND 2		CURTAIN-REINFORCED CONCRETE TO 5' WOOD TO EAVES ON STEEL GIRTS	NONE	CORR. CEMENT ASBESTOS ON WOOD PURLINS	15,000	SUPERFICIAL DAMAGE 100%
4	BUILDING UNDER CONSTRUCTION	62,500	1		21	STEEL FRAME B2		X		REINF CONC				CURTAIN-CONCRETE WALL TO 2' 6"-WOOD SHEATHING ABOVE	NONE	CORR. CEMENT ASBESTOS ON WOOD PURLINS	39,200	SUPERFICIAL DAMAGE 100%
132	BOILER HOUSE	6,500	1		30	STEEL FRAME A2.3		X		REINF CONC		NONE		CURTAIN WALL CORR. IRON OVER STEEL GIRTS	NONE	CORR. CEMENT ASBESTOS OVER WOOD PURLINS AND WOOD SHEATHING	3,600	SUPERFICIAL DAMAGE 100%
												NONE						
8	OFFICE	16,800	3	50,400	30	REINFORCED CONCRETE B2	X			8"CONC REIN AT 12"CNTRS WITH ½"		SAME AS EXT. COL.	NONE	12" CURTAIN WALL REINF. CONCRETE FIRST STORY. 10" REINF. CONCRETE FOR TWO TOP STORIES	8" REINFORCED CONCRETE CURTAIN	REINF. CONCRETE ROOF, ASPHALT FELT ROOFING COVERED WITH TILE	15,900	ROOF AREA STRUCTURALLY DAMAGED - 9,600 SQ FT SUPERFICIAL DAMAGE 100%
11	TRIAL SHOP	70,000	1		22	STEEL FRAME B2		X		8" REINF CONC		SAME AS EXT. COL.		CONCRETE CURTAIN WALL 6" THICK 4' HIGH STEEL SASH AND GLASS TO ROOF AND EAVES	NONE	WOOD SHEATHING ON WOOD PURLINS AND ROOFING FELT	7,900	SUPERFICIAL DAMAGE 100%
12	MATERIAL INSPECTION DEPARTMENT	10,800	2	21,600	24	REINFORCED CONCRETE B2	X			CONC,1ST FL. 8" 2ND FL. 5" THICK		SAME AS EXT. COL.	NONE	12" REINFORCED CONCRETE CURTAIN WALL	8" CONCRETE REINFORCED CURTAIN WALL	REINF. CONCRETE ROOF, ASPHALT FELT ROOFING COVERED WITH TILE	20,520	ROOF AREA STRUCTURALLY DAMAGED - 10,260 SQ FT SUPERFICIAL DAMAGE 100%
16	ASSEMBLY BUILDING	380,000	1		31	STEEL FRAME B2		X		6" REINF CONC				CURTAIN WALL REINFORCED CONCRETE TO 4', STEEL SASH AND GLASS TO EAVES	NONE	WOOD SHEATHING ON WOOD PURLINS AND ROOFING FELT	12,100	SUPERFICIAL DAMAGE 100%
19	ENGINE PARTS	411,700	1		15	STEEL FRAME, SAW TOOTH ROOF - SAW TOOTH RUNS TRANSVERSE B2		X		CONC		SAME AS EXT. COL.		CURTAIN-6" CONCRETE TO 4' STEEL SASH TO EAVES AND GLASS	NONE	CORRUGATED CEMENT ASBESTOS ROOFING ON WOOD PURLINS	22,000	SUPERFICIAL DAMAGE 100%
22	FLIGHT PREP. SHOP	106,000	1		31	STEEL FRAME, SAW TOOTH TRUSS RUNNING TRANSVERSE GLASS - STEEL SASH THROUGHOUT B2		X		CONC		SAME AS EXT. COL.		6" CONCRETE CURTAIN WALL TO SILL STEEL SASH TO EAVES	BAMBOO BLAST WALL FILLED WITH SAND	CORRUGATED ASBESTOS ON WOOD PURLINS	79,800	SUPERFICIAL DAMAGE 100%
23	RESEARCH BUILDING	40,800	1		22	STEEL FRAME B2		X		CONC		SAME AS EXT. COL.		6" CONCRETE WALLS 4'0" HIGH STEEL SASH AND GLASS TO EAVES	6" REINFORCED CONCRETE	STEEL TRUSS WOOD PURLINS WOOD SHEATHING ASPHALT FELT	5,200	SUPERFICIAL DAMAGE 100%
26	HEAT TREATMENT	63,000	1		22	STEEL FRAME B2		X		CONC		SAME AS EXT. COL.		6" CONCRETE WALLS 4'0" HIGH, STEEL SASH AND GLASS ABOVE TO THE EAVES	NONE	CORRUGATED IRON ON STEEL PURLINS	34,800	SUPERFICIAL DAMAGE 100%
27	HEAT TREATING SHOP	17,500	1		21	STEEL FRAME B2		X		CONC		SAME AS EXT. COL.		6" CONCRETE WALLS 4'0" HIGH, STEEL SASH AND GLASS ABOVE TO THE EAVES	8" THICK CONCRETE WALL 22'0" HIGH DIVIDING BUILDING IN HALF	CORRUGATED IRON ON STEEL PURLINS	8,500	SUPERFICIAL DAMAGE 100%
58	OIL STORAGE SHOP	6,000	1		10	SMALL CONCRETE BUILDING WITH STEEL ROOF O	X			CONC	NONE	NONE		8" REINFORCED CONCRETE BEARING WALL	NONE	STEEL PURLINS CORR. CEMENT ASBESTOS	6,000	SUPERFICIAL DAMAGE 100%

TABLE J

TARGET NO. 1547 NAME OF PLANT KAWASAKI AIRCRAFT COMPANY, AKASHI, JAPAN

NO. OF BLDG.	NAME OF BLDG.	GROUND AREA OF BUILDING	NO. STORIES	FLR. AREA IF MORE THAN ONE STORY	HT OF EAVES	DESCRIPTION OF STRUCTURE	VULNERABILITY: FIRE RESISTIVE	VULNERABILITY: NON COMBUSTIBLE	VULNERABILITY: COMBUSTIBLE	FLOORS TYPE & THICKNESS	EXTERIOR COLUMNS & DIMENSIONS C.C.	INTERIOR COLUMNS & DIMENSIONS	TRUSSES TYPE - SPAN	EXTERIOR WALLS BEARING, CURTAIN - THICKNESS	INTERIOR WALLS BEARING, CURTAIN THICKNESS	ROOF	STRUCTURAL DAMAGE TO BLDG. SQ FT FLOOR AREA	REMARKS
106	UNKNOWN	2,400	NO INFORMATION, BLDGS. DESTROYED BY FIRE			WOODEN STRUCTURE			X		NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	2,400	NONE
107	UNKNOWN	2,400	"	"	"	WOODEN STRUCTURE			X								2,400	
108	UNKNOWN	3,100	"	"	"	WOODEN STRUCTURE			X								3,100	
116	PURCHASE INSP. SHOPS	5,100	"	"	"	WOODEN STRUCTURE			X								5,100	
117	PURCHASE INSP. SHOPS	4,400	"	"	"	WOODEN STRUCTURE			X								4,400	
118	PURCHASE INSP. SHOPS	4,400	"	"	"	WOODEN STRUCTURE			X								4,400	
119	PURCHASE INSP. SHOPS	4,400	"	"	"	WOODEN STRUCTURE			X								4,400	
122	PATTERN SHOP	10,800	"	"	"	WOODEN STRUCTURE			X								6,500	
123	MATERIAL TESTING SHOP	2,200	"	"	"	WOODEN STRUCTURE			X								2,200	
124	MATERIAL TESTING SHOP	900	"	"	"	WOODEN STRUCTURE			X								900	
125	MATERIAL TESTING SHOP	900	"	"	"	WOODEN STRUCTURE			X								900	
126	MATERIAL TESTING SHOP	900	"	"	"	WOODEN STRUCTURE			X								900	
127	MATERIAL TESTING SHOP	900	"	"	"	WOODEN STRUCTURE			X								900	
128	REPAIR SHOP	17,500	"	"	"	WOODEN STRUCTURE			X								17,500	
129	CASTING SHOP	23,500	"	"	"	WOODEN STRUCTURE			X								23,500	
133	DINING ROOM	6,500	"	"	"	WOODEN STRUCTURE			X								6,500	
134	DINING ROOM	6,500	"	"	"	WOODEN STRUCTURE			X								6,500	
135	DINING ROOM	6,500	"	"	"	WOODEN STRUCTURE			X								6,500	
136	DINING ROOM	6,500	"	"	"	WOODEN STRUCTURE			X								6,500	

TABLE J

TARGET NO. 1547 NAME OF PLANT KAWASAKI AIRCRAFT COMPANY, AKASHI, JAPAN

NO. OF BLDG.	NAME OF BLDG.	GROUND AREA OF BUILDING IN SQ FT	NO. STORIES	FLR. AREA IF MORE THAN ONE STORY IN SQ FT	HT. OF EAVES IN FT	DESCRIPTION OF STRUCTURE	VULNERABILITY: FIRE RESISTIVE	VULNERABILITY: NON COMBUSTIBLE	VULNERABILITY: COMBUSTIBLE	FLOORS TYPE & THICKNESS	EXTERIOR COLUMNS & DIMENSIONS C.C.	INTERIOR COLUMNS & DIMENSIONS	TRUSSES TYPE - SPAN	EXTERIOR WALLS BEARING, CURTAIN - THICKNESS	INTERIOR WALLS BEARING, CURTAIN THICKNESS	ROOF	STRUCTURAL DAMAGE TO BLDG. SQ FT FLOOR AREA	REMARKS
68	UNKNOWN	3,000	NO INFORMATION, BLDGS DESTROYED BY FIRE			WOODEN STRUCTURE			X		NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	3,000	
69	TRANSFORMER HOUSE	1,000	"	"	"	WOODEN STRUCTURE			X								1,000	
70	UNKNOWN	2,400	"	"	"	WOODEN STRUCTURE			X								2,400	
71	UNKNOWN	1,800	"	"	"	WOODEN STRUCTURE			X								1,800	
121	WOODWORKING SHOP	28,200	"	"	"	WOODEN STRUCTURE			X								28,200	
130	JIG ASSEMBLY SHOP	8,100	"	"	"	WOODEN STRUCTURE			X								8,100	
131	JIG ASSEMBLY SHOP	3,500	"	"	"	WOODEN STRUCTURE			X								3,500	
137	DINING ROOM	1,500	"	"	"	WOODEN STRUCTURE			X								1,500	
138	DINING ROOM	1,500	"	"	"	WOODEN STRUCTURE			X								1,500	
140	DORMITORY	38,800	"	"	"	WOODEN STRUCTURE			X								29,900	

Photo 1—Buildings 1 and 2, Bomb 22.

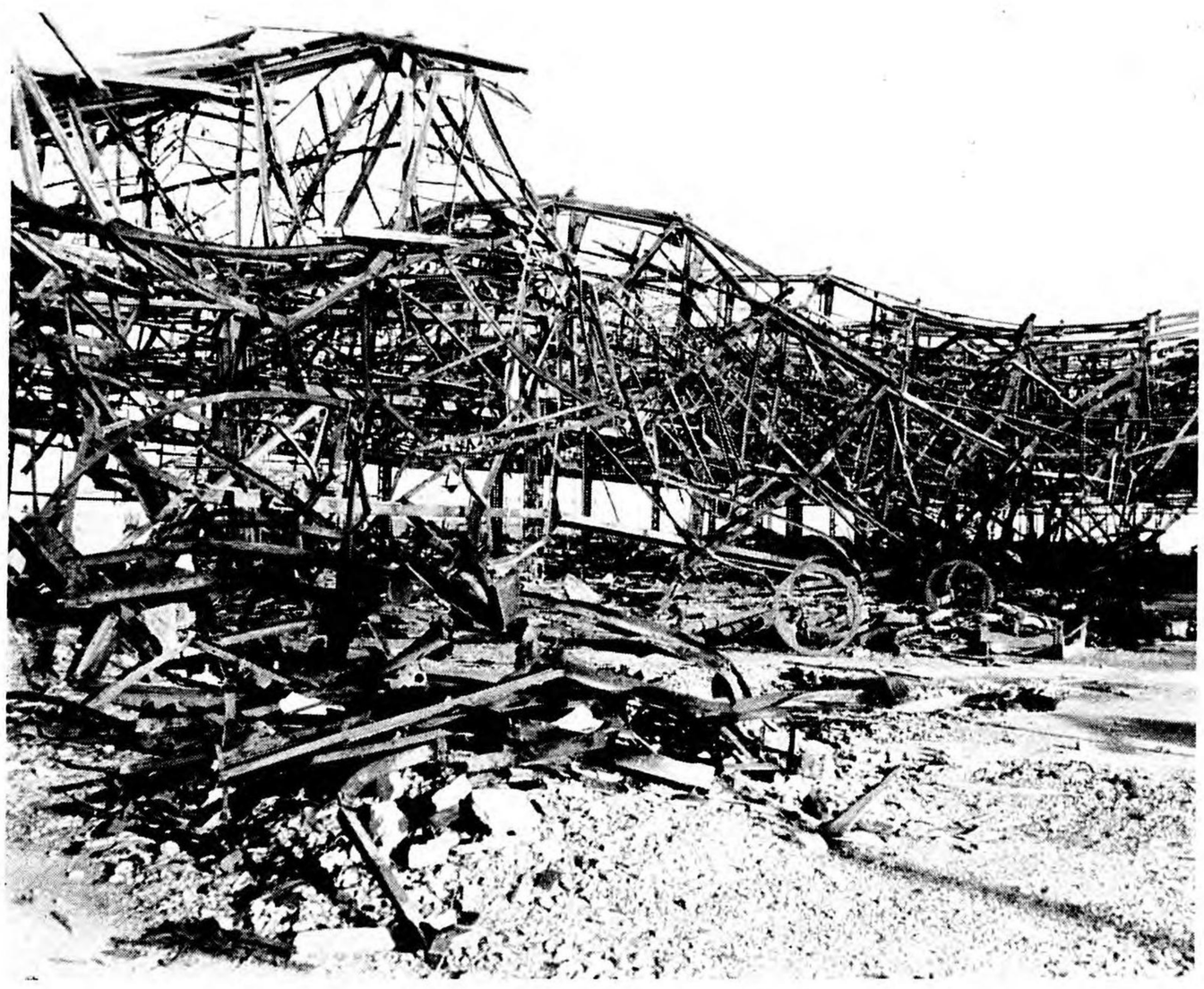


Photo 2—Building 1, Bomb 22.

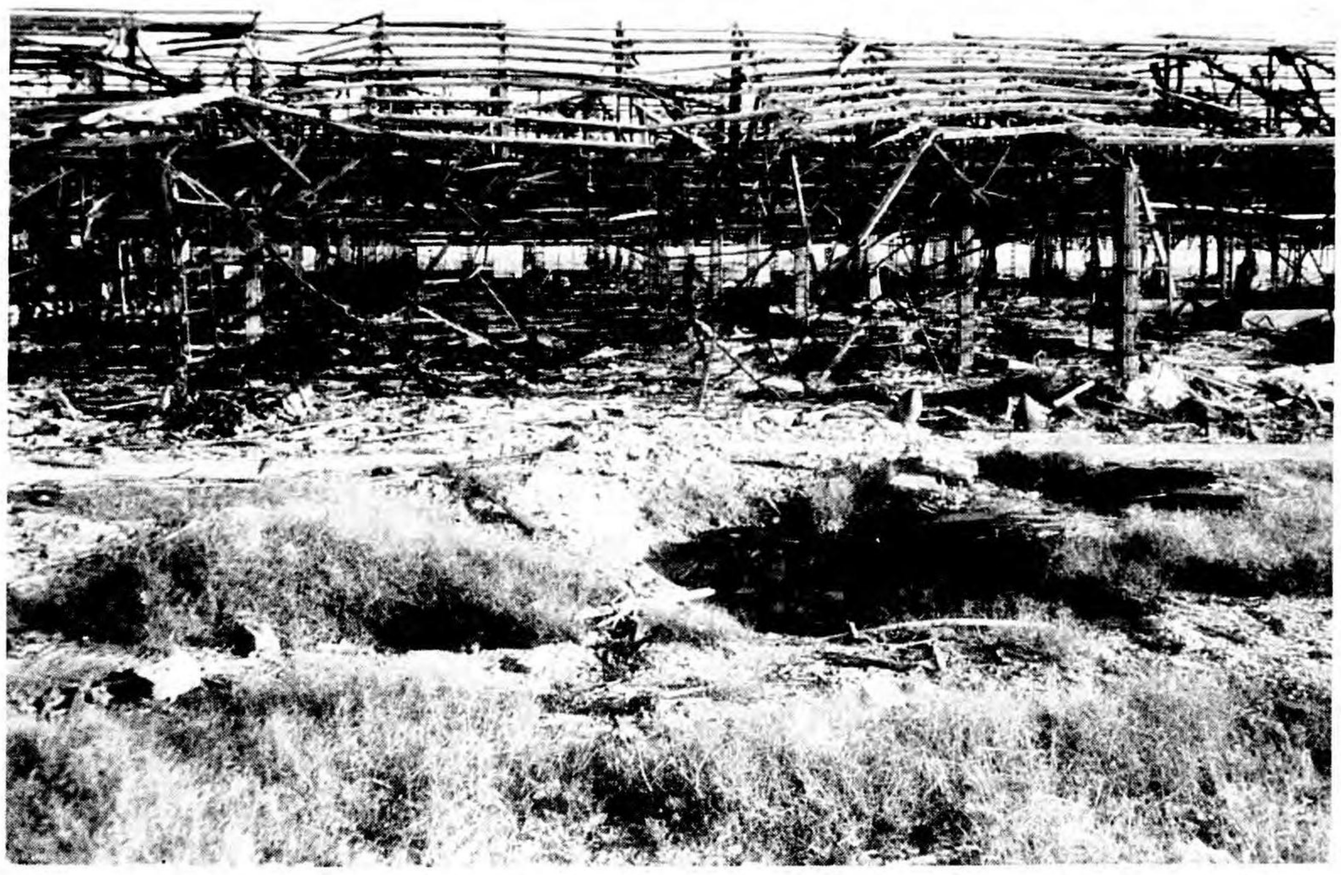


Photo 3--Building 3, Bomb 25. (Crater in foreground), near-miss 35 feet from building.

Photo 4—Building 4, Bomb 29. General view.

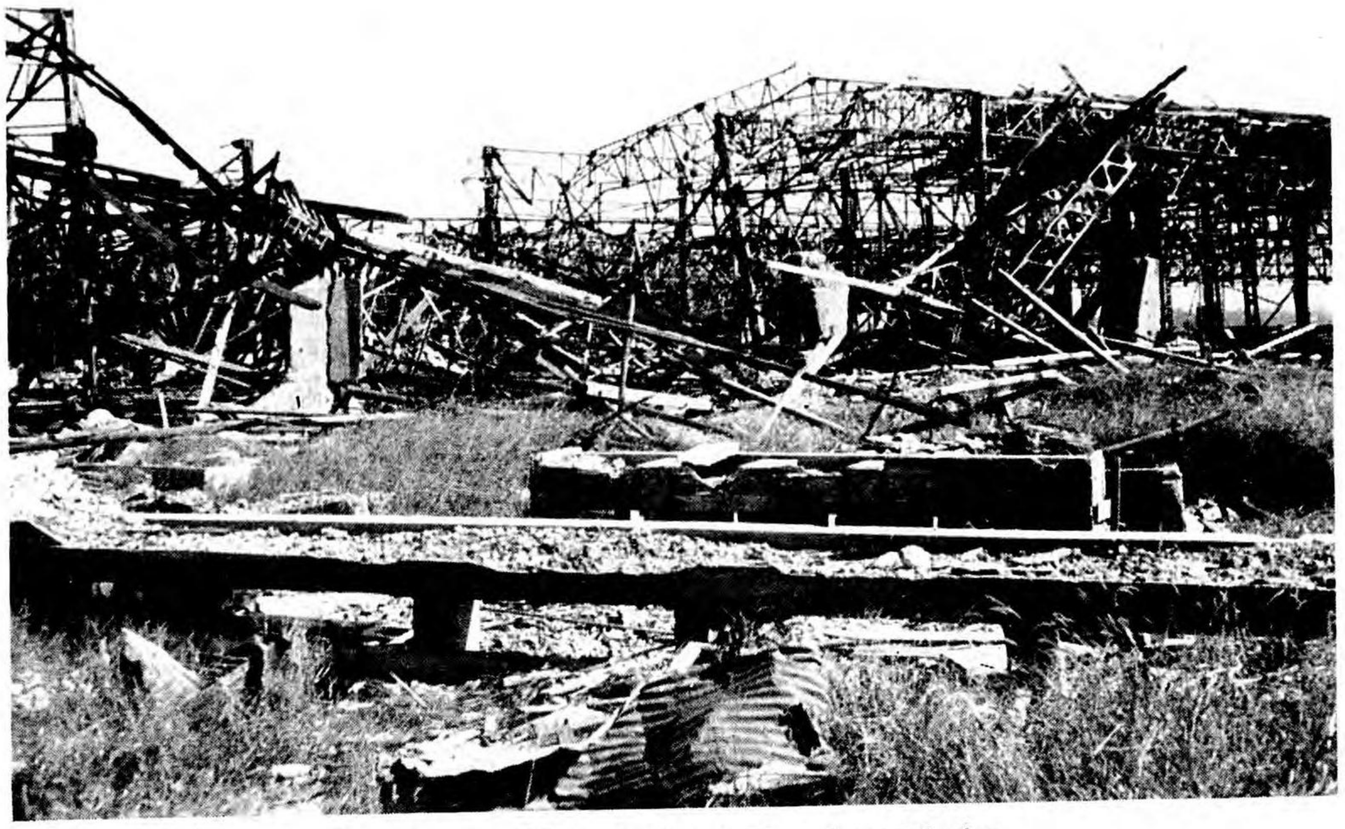


Photo 5—Building 4, Bomb 29. General view.

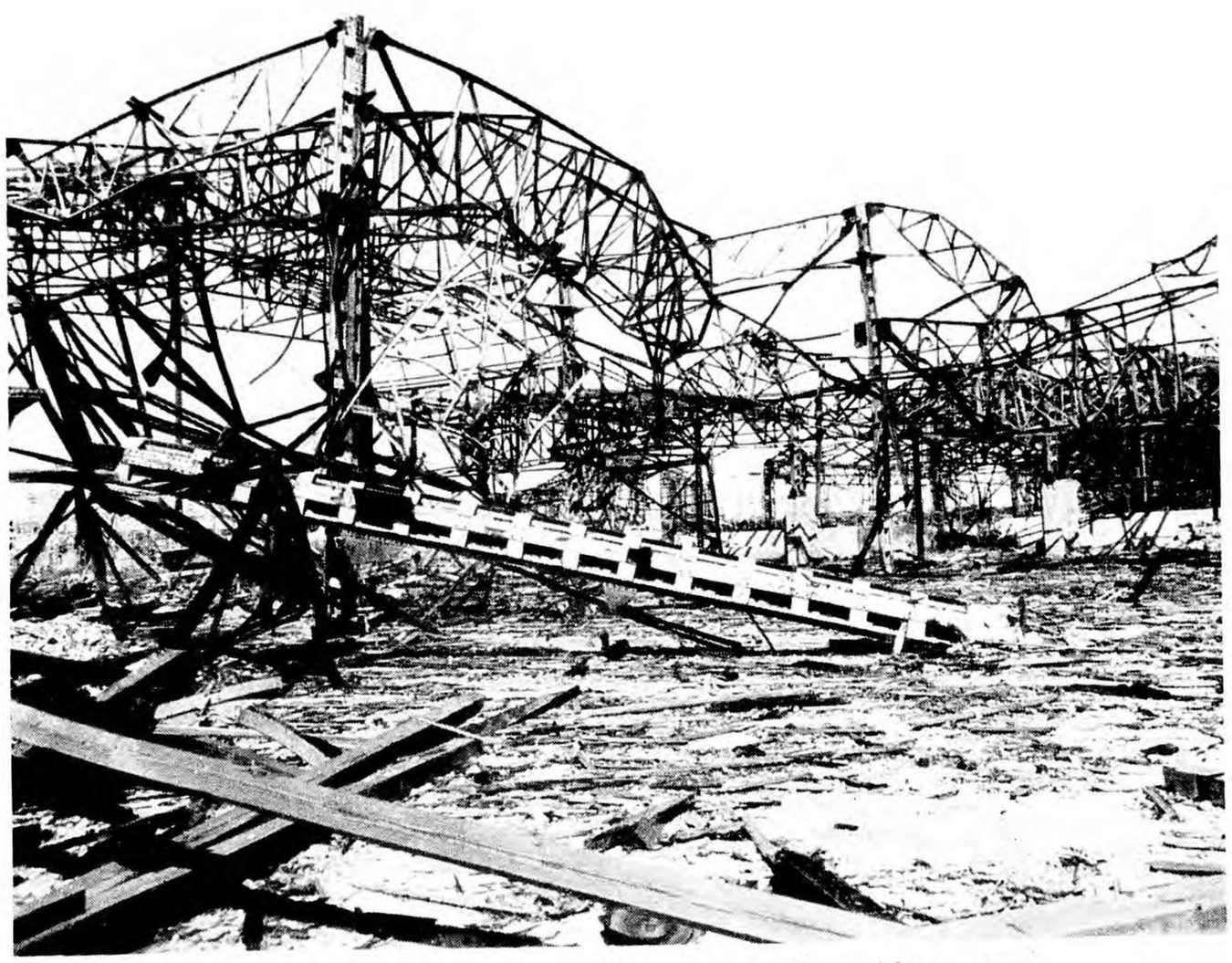


Photo 6—Building 4, Bomb 29. Interior column blown over.

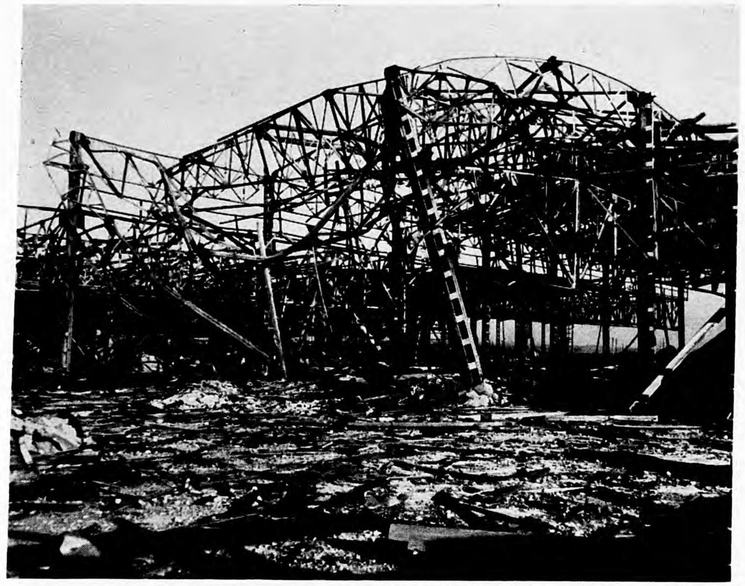


Photo 7—Building 4, Bomb 29. Interior column displaced.

Photo 8—Building 4, Bomb 29. Exterior column.

Photo 9—Building 4, Bomb 29. Exterior column blown over.

Photo 10—Building 8, Bombs 45 and 46.

Photo 11—Building 8, Bomb 45.

Photo 12—Building 8. Third floor slab and column.

Photo 13—Showing damage to building 23 and Building 12 by bomb 15.

Photo 14—Building 12, Bomb 15.

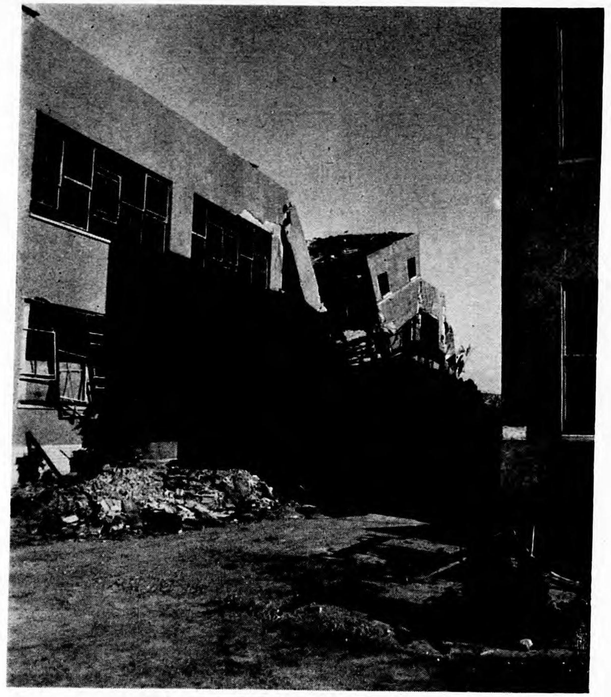


Photo 15—Building 12, Bomb 14.

Photo 16—Building 16, Bomb 9.

Photo 17—Building 19, Bomb 2. Point of detonation in right foreground.

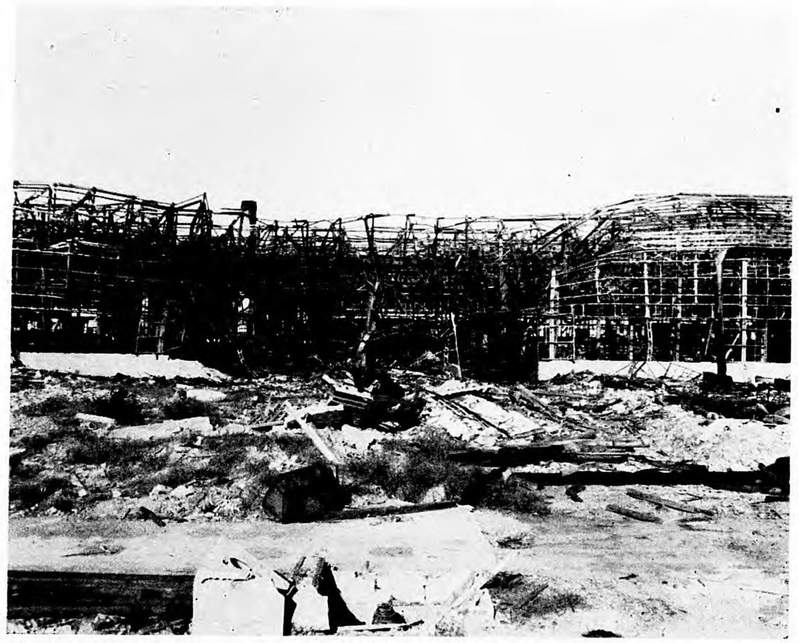


Photo 18—Building 19, Bomb 2.

Photo 19—Building 22, Bomb 3. Column in left foreground caused initial collapse.

Photo 20—Building 22, bomb 3. Column with arrow caused initial collapse.

Photo 21—Building 22, Bomb 3. General view of collapse.

Photo 22—Side view of Building 22, Bomb 3.

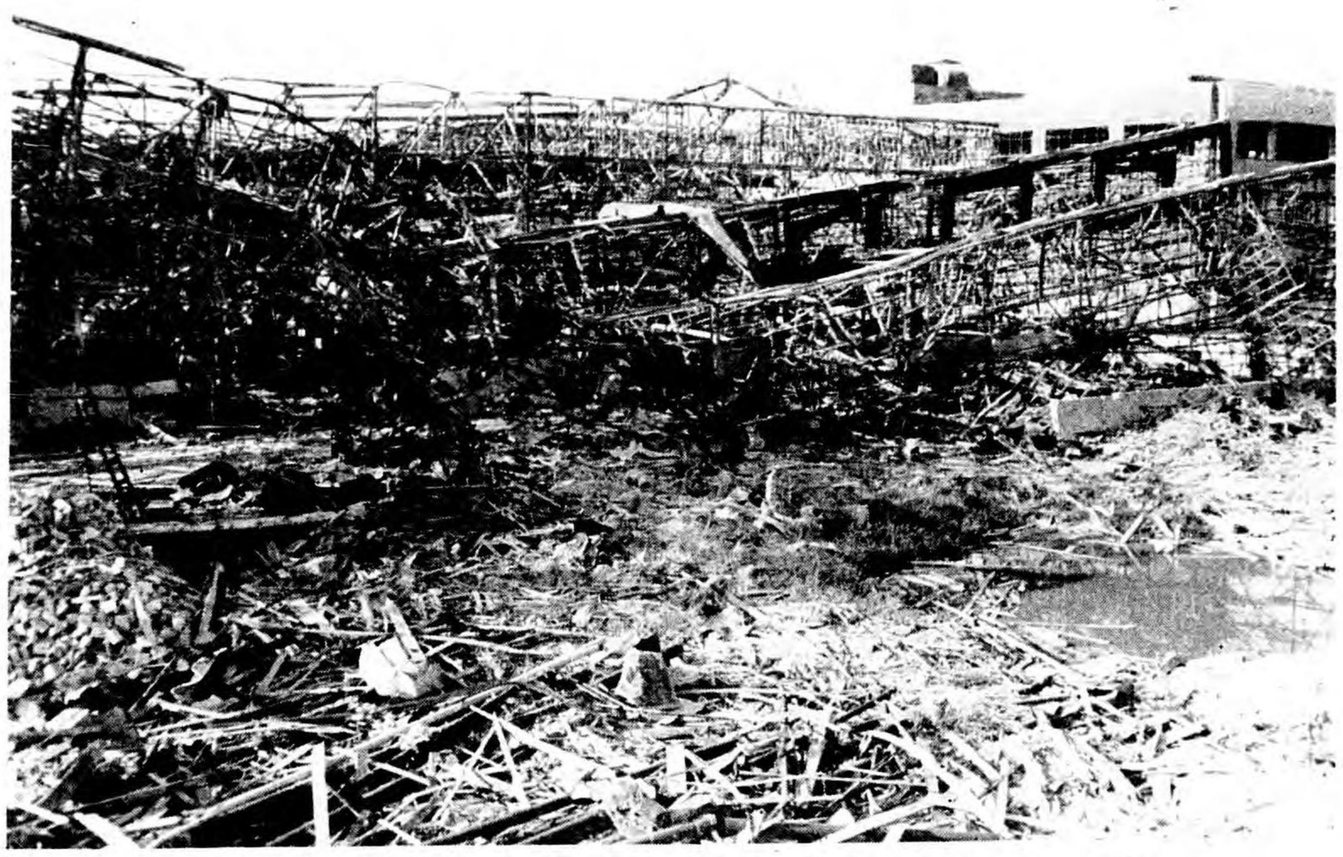


Photo 23—Building 27, Bomb 12. Damage caused by near miss.

Photo 24—Building 132, Bomb 23. General view.

Photo 25—Building 132, Bomb 23. Boiler blown over.

Photo 26—Building 132, Bomb 23.

Photo 27—Building 132, Bomb 23. Damaged stack and column.

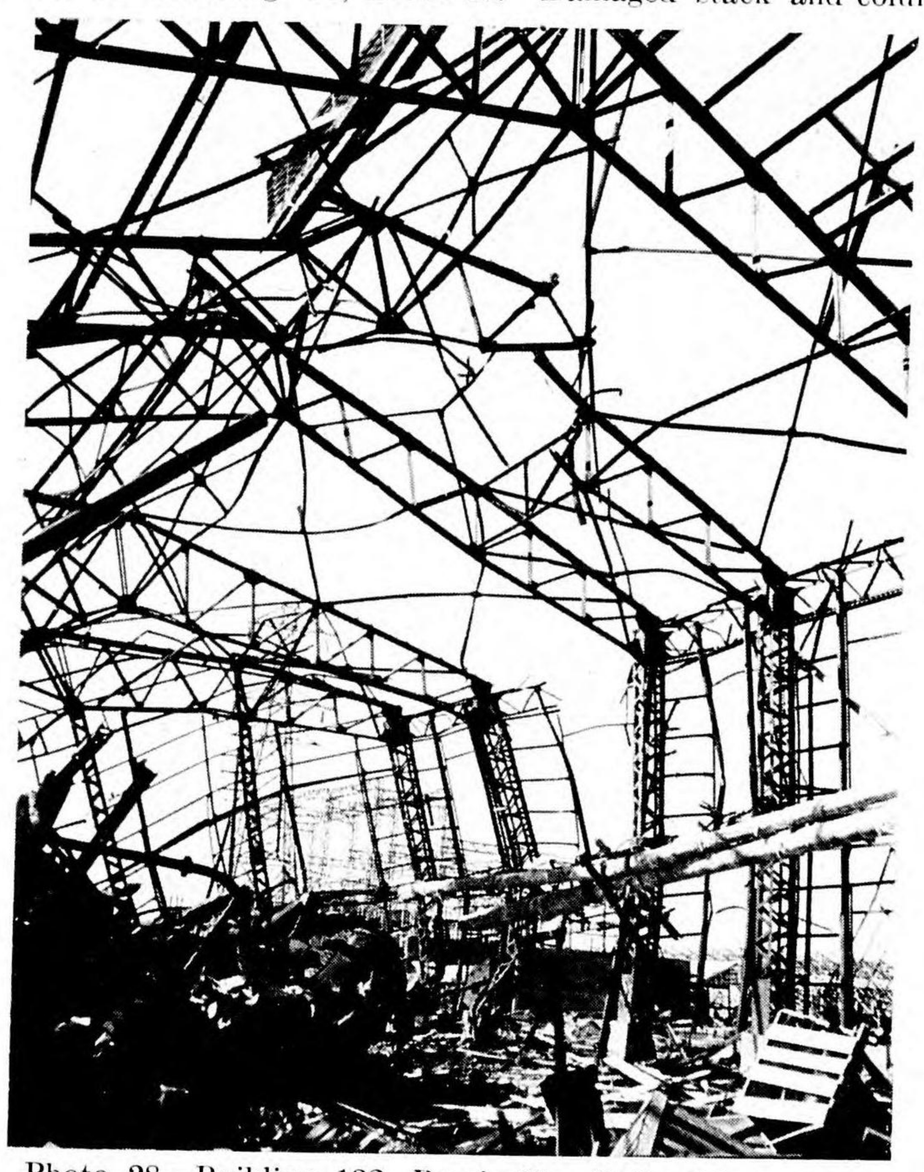
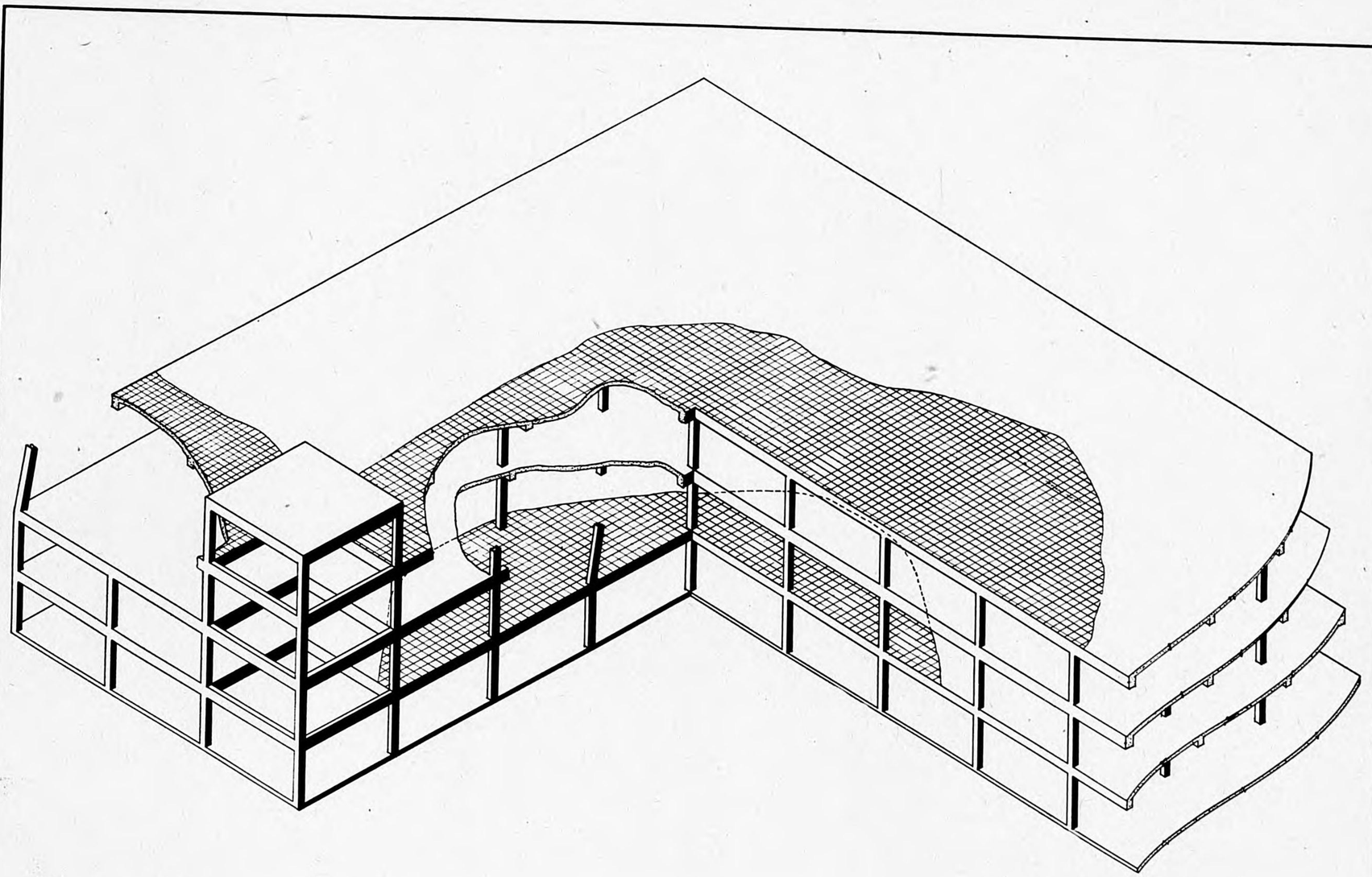


Photo 28—Building 132, Bomb 23. Boiler blown over.

Photo 29—Over-all view of fire damage caused by several 4,000-pound bombs.



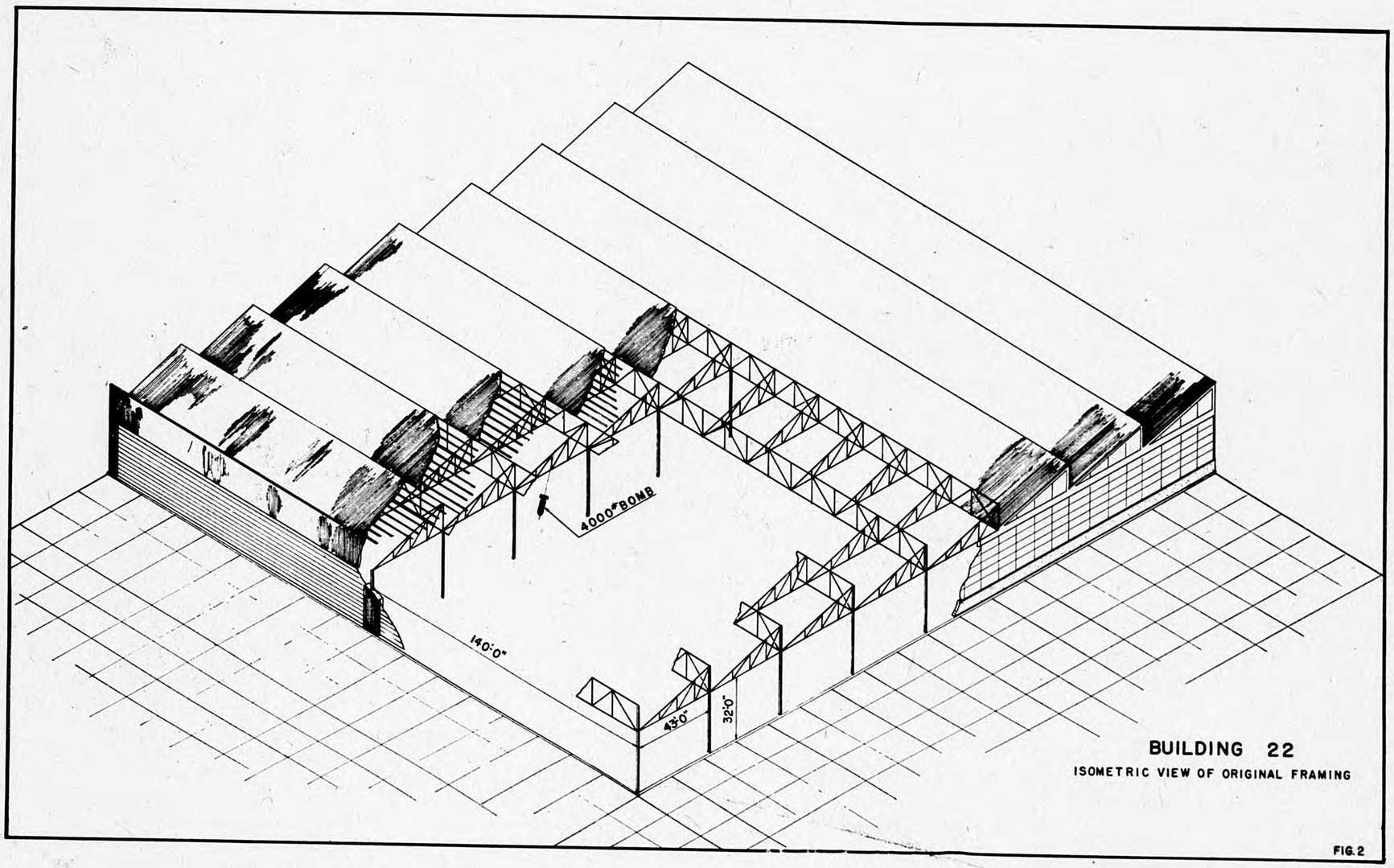
NOTE:

▨ = DENOTES AREAS IN WHICH STRUCTURAL MEMBERS WERE DAMAGED.
COLLAPSED PORTIONS REMOVED
ON THIS DRAWING
DAMAGED AREA ON 2ND FLOOR CONTINUES
AS OUTLINED BY DOTTED LINE

BUILDING 8

DAMAGED AREAS-4000 LB BOMBS

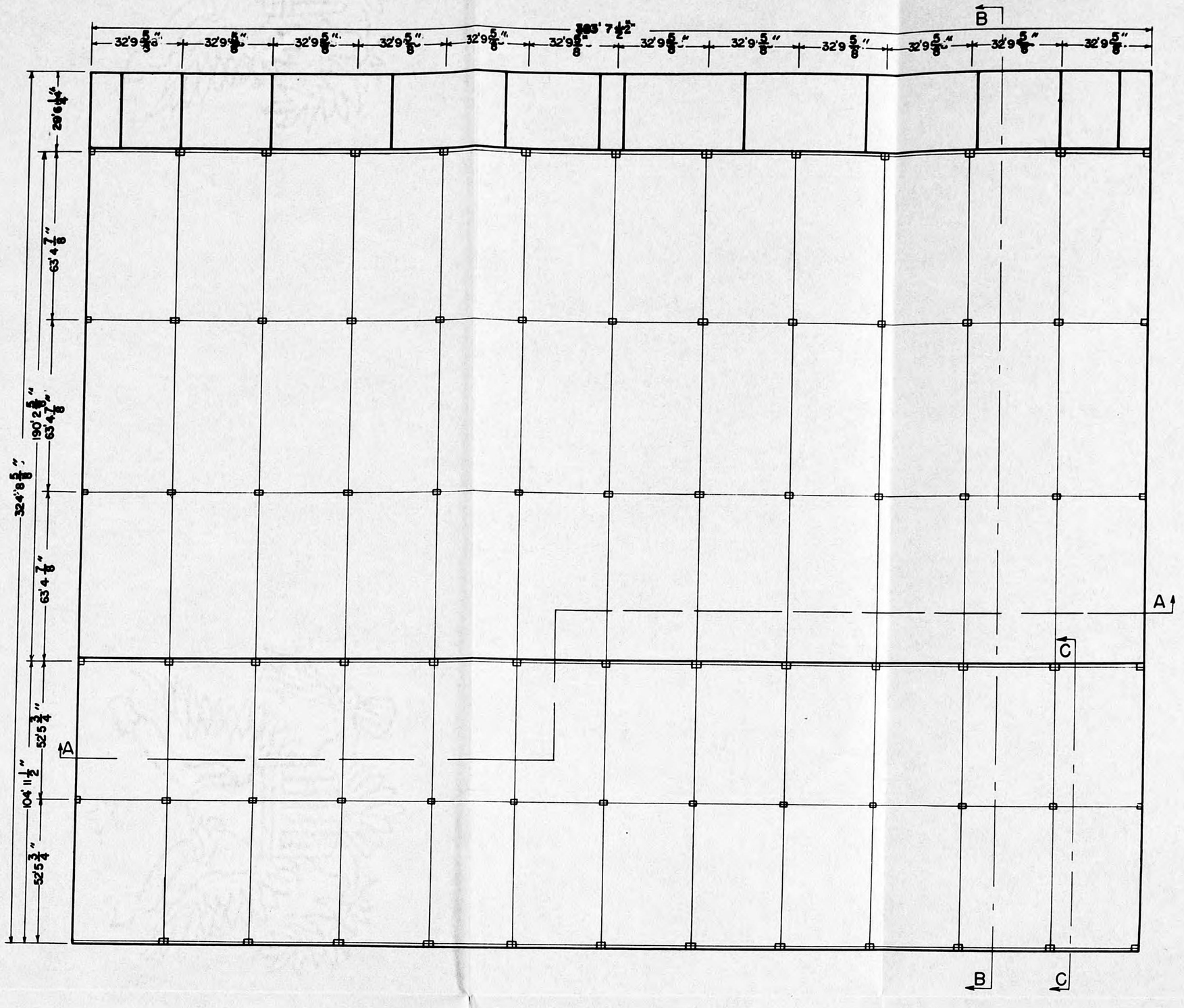
FIG. 1



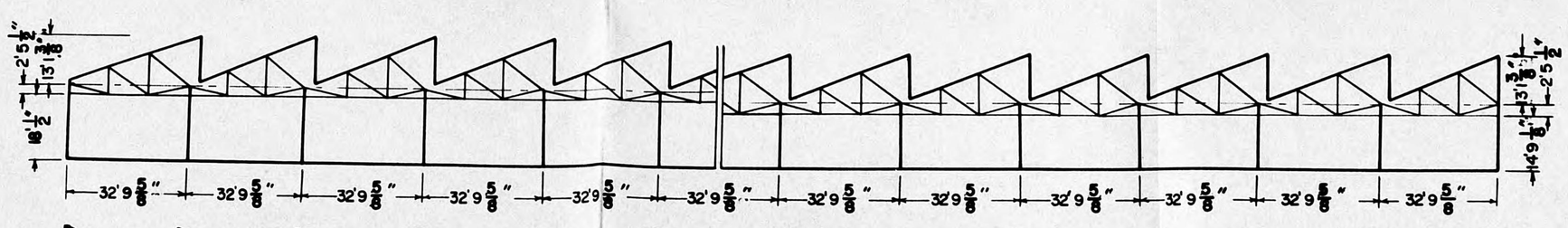
BUILDING 22

ISOMETRIC VIEW OF ORIGINAL FRAMING

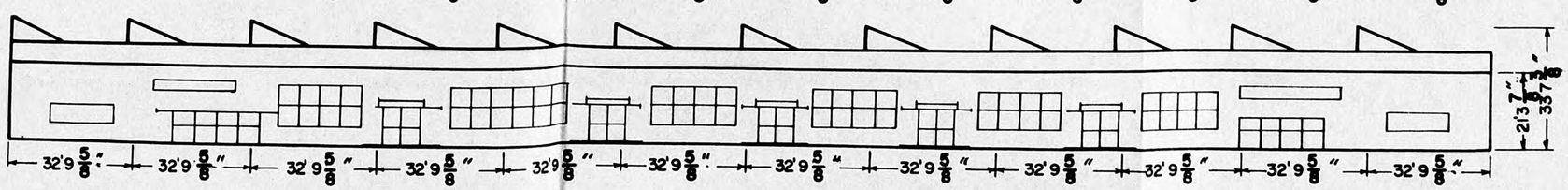
FIG. 2



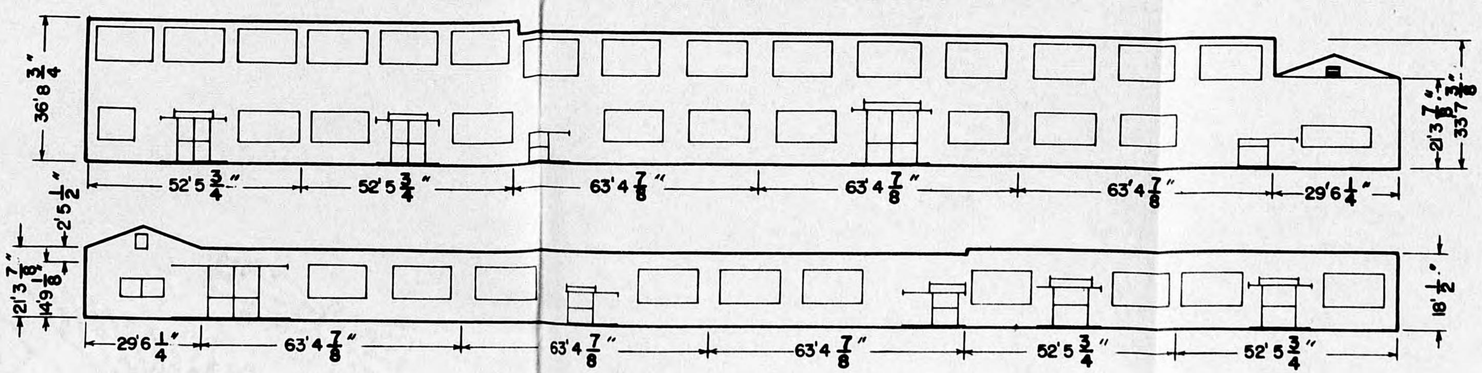
SECTION A-A



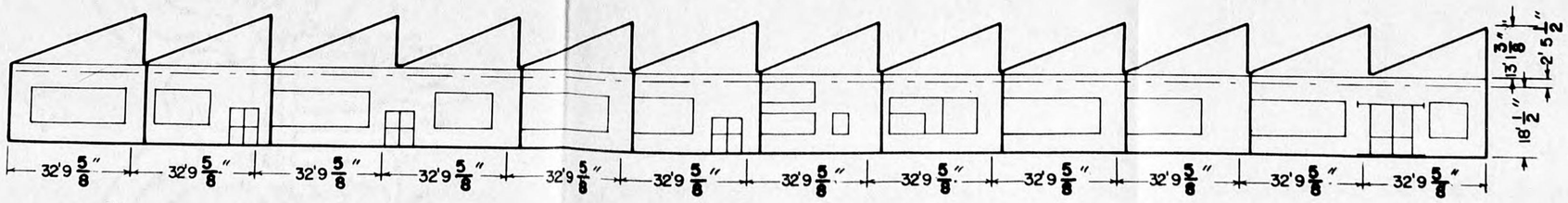
ELEVATION N-E SIDE



ELEVATION S-E SIDE

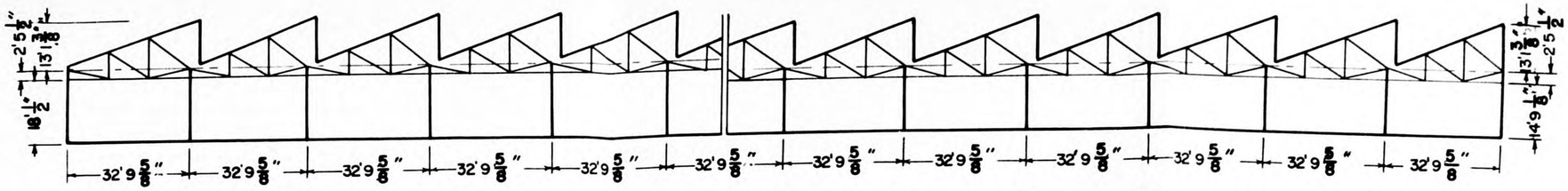


ELEVATION N-W SIDE

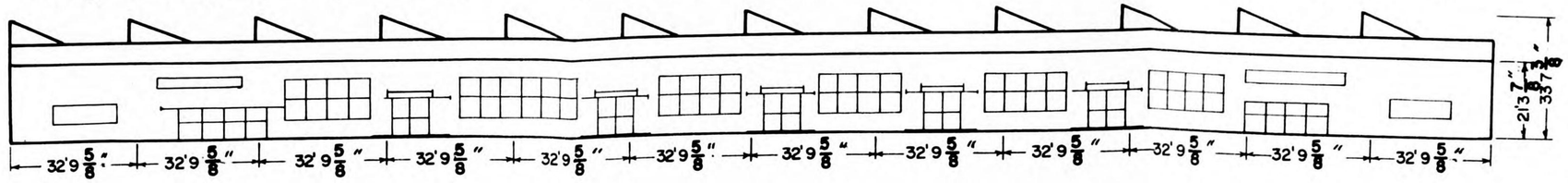


ELEVATION S-W SIDE

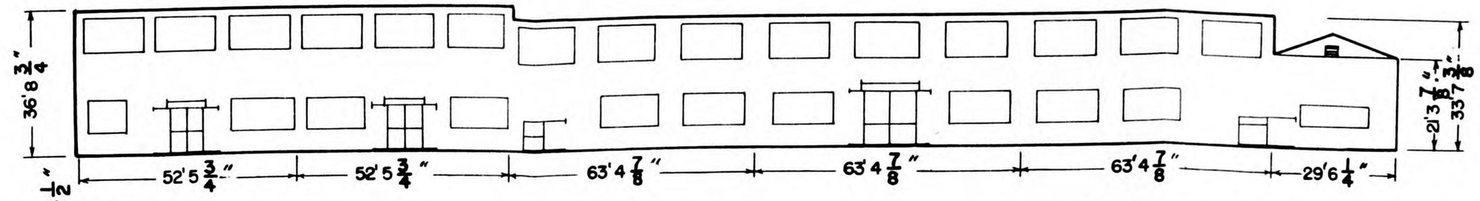
SECTION A-A



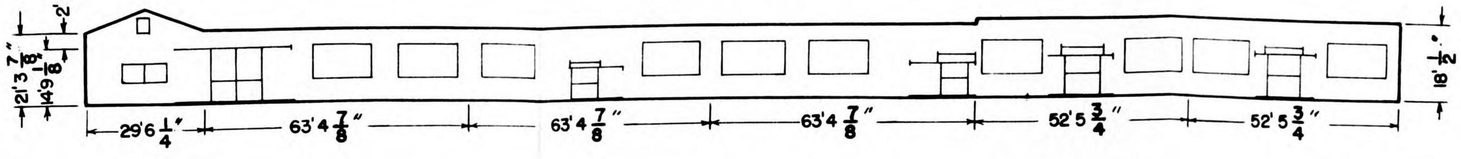
ELEVATION N-E SIDE



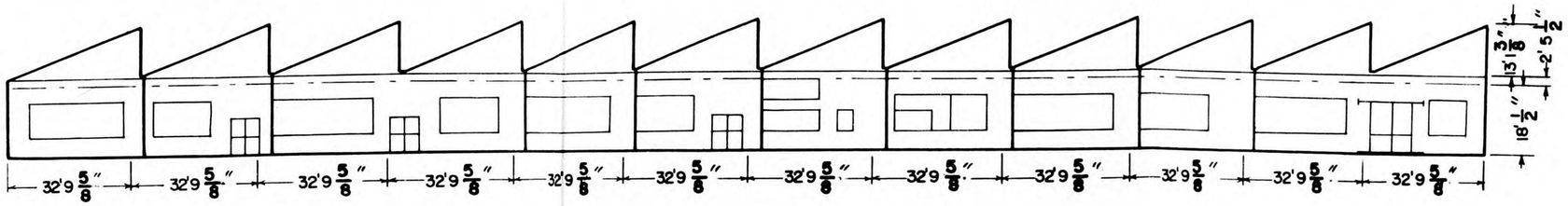
ELEVATION S-E SIDE



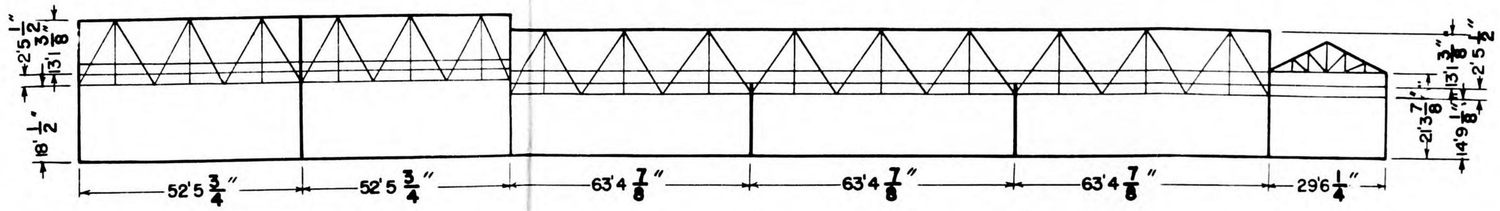
ELEVATION N-W SIDE



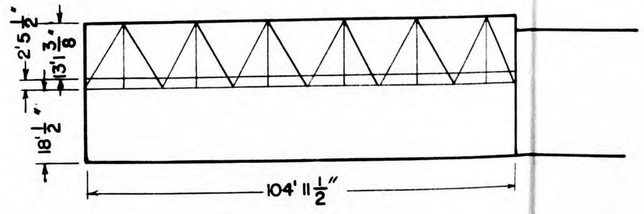
ELEVATION S-W SIDE



SECTION B-B



SECTION C-C



PLAN, ELEVATIONS, & SECTIONS,
OF BLDGS. 1 & 2

US STRATEGIC BOMBING SURVEY

KAWASAKI AIRCRAFT INDUSTRIES
AKASHI PLANT
BLDGS. 1 & 2 FIG. 3.

713273 O - 47 (Face p. 30) No. 1

295' 1 7/8"

19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8"

137' 8 7/8"

19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8" | 19' 8 1/8"

59' 0 3/8"

3RD FLOOR

59' 0 3/8"

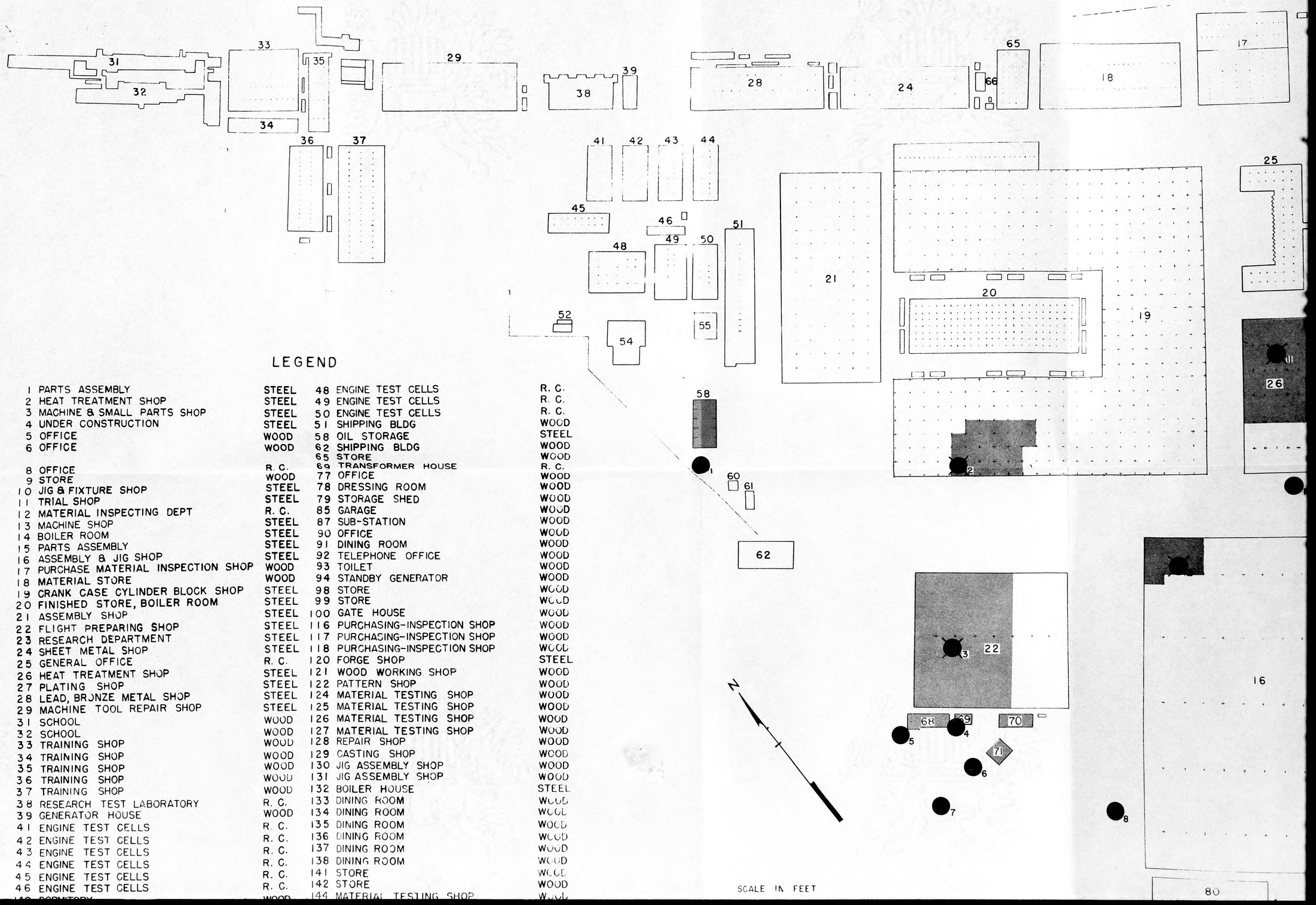
2ND FLOOR

1ST FLOOR

PLAN BLDG. 25

U.S. STRATEGIC BOMBING SURVEY	
KAWASAKI AIRCRAFT INDUSTRIES AKASHI PLANT	
BLDG. 25	FIG. 4.

713273 O - 47 (Face p. 30) No. 2



LEGEND

1	PARTS ASSEMBLY	STEEL	48	ENGINE TEST CELLS	R. C.
2	HEAT TREATMENT SHOP	STEEL	49	ENGINE TEST CELLS	R. C.
3	MACHINE & SMALL PARTS SHOP	STEEL	50	ENGINE TEST CELLS	R. C.
4	UNDER CONSTRUCTION	STEEL	51	SHIPPING BLDG	WOOD
5	OFFICE	WOOD	58	OIL STORAGE	STEEL
6	OFFICE	WOOD	62	SHIPPING BLDG	WOOD
			65	STORE	WOOD
8	OFFICE	R. C.	69	TRANSFORMER HOUSE	R. C.
9	STORE	WOOD	77	OFFICE	WOOD
10	JIG & FIXTURE SHOP	STEEL	78	DRESSING ROOM	WOOD
11	TRIAL SHOP	STEEL	79	STORAGE SHED	WOOD
12	MATERIAL INSPECTING DEPT	R. C.	85	GARAGE	WOOD
13	MACHINE SHOP	STEEL	87	SUB-STATION	WOOD
14	BOILER ROOM	STEEL	90	OFFICE	WOOD
15	PARTS ASSEMBLY	STEEL	91	DINING ROOM	WOOD
16	ASSEMBLY & JIG SHOP	STEEL	92	TELEPHONE OFFICE	WOOD
17	PURCHASE MATERIAL INSPECTION SHOP	WOOD	93	TOILET	WOOD
18	MATERIAL STORE	WOOD	94	STANDBY GENERATOR	WOOD
19	CRANK CASE CYLINDER BLOCK SHOP	STEEL	98	STORE	WOOD
20	FINISHED STORE, BOILER ROOM	STEEL	99	STORE	WOOD
21	ASSEMBLY SHOP	STEEL	100	GATE HOUSE	WOOD
22	FLIGHT PREPARING SHOP	STEEL	116	PURCHASING-INSPECTION SHOP	WOOD
23	RESEARCH DEPARTMENT	STEEL	117	PURCHASING-INSPECTION SHOP	WOOD
24	SHEET METAL SHOP	STEEL	118	PURCHASING-INSPECTION SHOP	WOOD
25	GENERAL OFFICE	R. C.	120	FORGE SHOP	STEEL
26	HEAT TREATMENT SHOP	STEEL	121	WOOD WORKING SHOP	WOOD
27	PLATING SHOP	STEEL	122	PATTERN SHOP	WOOD
28	LEAD, BRONZE METAL SHOP	STEEL	124	MATERIAL TESTING SHOP	WOOD
29	MACHINE TOOL REPAIR SHOP	STEEL	125	MATERIAL TESTING SHOP	WOOD
31	SCHOOL	WOOD	126	MATERIAL TESTING SHOP	WOOD
32	SCHOOL	WOOD	127	MATERIAL TESTING SHOP	WOOD
33	TRAINING SHOP	WOOD	128	REPAIR SHOP	WOOD
34	TRAINING SHOP	WOOD	129	CASTING SHOP	WOOD
35	TRAINING SHOP	WOOD	130	JIG ASSEMBLY SHOP	WOOD
36	TRAINING SHOP	WOOD	131	JIG ASSEMBLY SHOP	WOOD
37	TRAINING SHOP	WOOD	132	BOILER HOUSE	STEEL
38	RESEARCH TEST LABORATORY	R. C.	133	DINING ROOM	WOOD
39	GENERATOR HOUSE	WOOD	134	DINING ROOM	WOOD
41	ENGINE TEST CELLS	R. C.	135	DINING ROOM	WOOD
42	ENGINE TEST CELLS	R. C.	136	DINING ROOM	WOOD
43	ENGINE TEST CELLS	R. C.	137	DINING ROOM	WOOD
44	ENGINE TEST CELLS	R. C.	138	DINING ROOM	WOOD
45	ENGINE TEST CELLS	R. C.	141	STORE	WOOD
46	ENGINE TEST CELLS	R. C.	142	STORE	WOOD
	DORMITORY	WOOD	144	MATERIAL TESTING SHOP	WOOD

AIRBURST *
CRATER
ATTACK OF 26 JUNE 1945

AIRBURST
CRATER
ATTACK OF 22 JUNE 1945

POINT OF IMPACT OF BOMB REPORTED BY JAPANESE WHICH COULD NOT BE CONFIRMED BY VISUAL INSPECTION BECAUSE THEY MADE NO CRATERS AND THE WOODEN BUILDINGS AT THESE POINTS HAD BEEN BURNED.

* BOMBS WHICH WERE ACTIVATED BY ROOFS OR OTHER CONCRETE OBJECTS ABOVE GROUND LEVEL AND WHICH DETONATED BEFORE CONTACT WITH THE GROUND.

NOTE: DAMAGE FROM BOMBS 8 & 10 NOT ASSESSED

NOTE:

PLAN AS OF 21 JUNE 1945

IN FEET

9	STORE	WOOD	77 OFFICE
10	JIG & FIXTURE SHOP	STEEL	78 DRESSING ROOM
11	TRIAL SHOP	STEEL	79 STORAGE SHED
12	MATERIAL INSPECTING DEPT	R. C.	85 GARAGE
13	MACHINE SHOP	STEEL	87 SUB-STATION
14	BOILER ROOM	STEEL	90 OFFICE
15	PARTS ASSEMBLY	STEEL	91 DINING ROOM
16	ASSEMBLY & JIG SHOP	STEEL	92 TELEPHONE OFFICE
17	PURCHASE MATERIAL INSPECTION SHOP	WOOD	93 TOILET
18	MATERIAL STORE	WOOD	94 STANDBY GENERATOR
19	CRANK CASE CYLINDER BLOCK SHOP	STEEL	98 STORE
20	FINISHED STORE, BOILER ROOM	STEEL	99 STORE
21	ASSEMBLY SHOP	STEEL	100 GATE HOUSE
22	FLIGHT PREPARING SHOP	STEEL	116 PURCHASING-INSPECTION SHOP
23	RESEARCH DEPARTMENT	STEEL	117 PURCHASING-INSPECTION SHOP
24	SHEET METAL SHOP	STEEL	118 PURCHASING-INSPECTION SHOP
25	GENERAL OFFICE	R. C.	120 FORGE SHOP
26	HEAT TREATMENT SHOP	STEEL	121 WOOD WORKING SHOP
27	PLATING SHOP	STEEL	122 PATTERN SHOP
28	LEAD, BRONZE METAL SHOP	STEEL	124 MATERIAL TESTING SHOP
29	MACHINE TOOL REPAIR SHOP	STEEL	125 MATERIAL TESTING SHOP
31	SCHOOL	WOOD	126 MATERIAL TESTING SHOP
32	SCHOOL	WOOD	127 MATERIAL TESTING SHOP
33	TRAINING SHOP	WOOD	128 REPAIR SHOP
34	TRAINING SHOP	WOOD	129 CASTING SHOP
35	TRAINING SHOP	WOOD	130 JIG ASSEMBLY SHOP
36	TRAINING SHOP	WOOD	131 JIG ASSEMBLY SHOP
37	TRAINING SHOP	WOOD	132 BOILER HOUSE
38	RESEARCH TEST LABORATORY	R. C.	133 DINING ROOM
39	GENERATOR HOUSE	WOOD	134 DINING ROOM
41	ENGINE TEST CELLS	R. C.	135 DINING ROOM
42	ENGINE TEST CELLS	R. C.	136 DINING ROOM
43	ENGINE TEST CELLS	R. C.	137 DINING ROOM
44	ENGINE TEST CELLS	R. C.	138 DINING ROOM
45	ENGINE TEST CELLS	R. C.	141 STORE
46	ENGINE TEST CELLS	R. C.	142 STORE
140	DORMITORY	WOOD	144 MATERIAL TESTING SHOP

NOTE: MISCELLANEOUS UTILITY BUILDINGS AND BUILDINGS DESTROYED PREVIOUS TO 21 JUNE 1945 NOT SHOWN ON THIS DRAWING.

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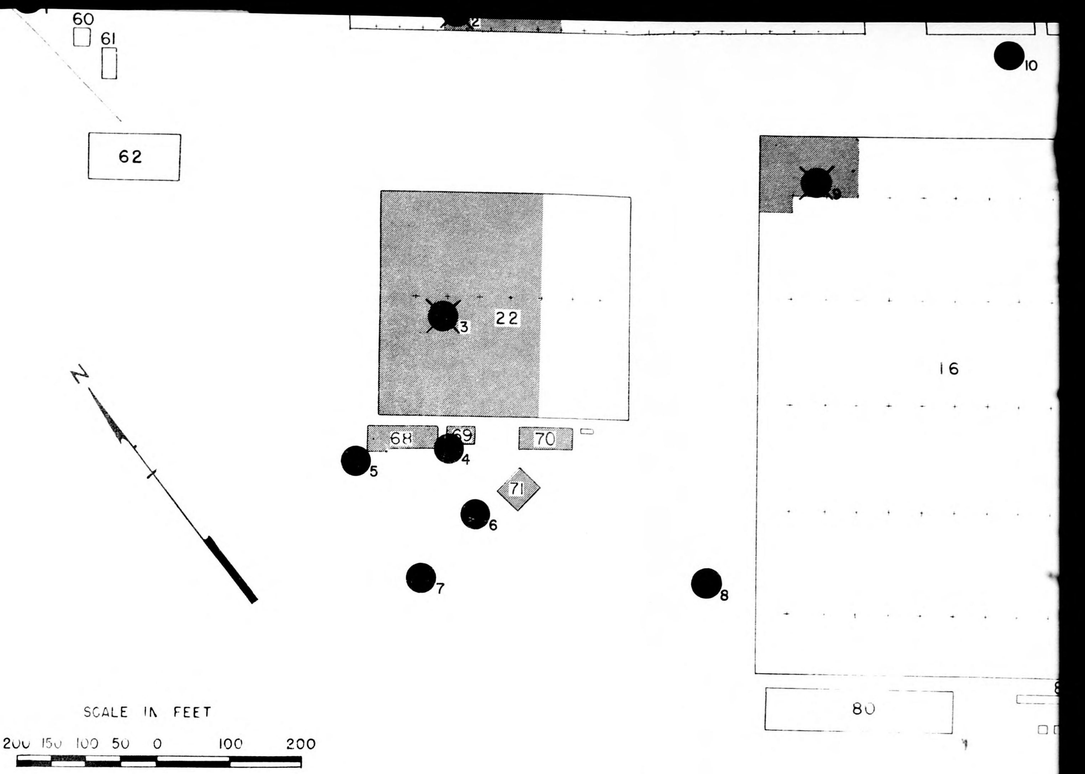
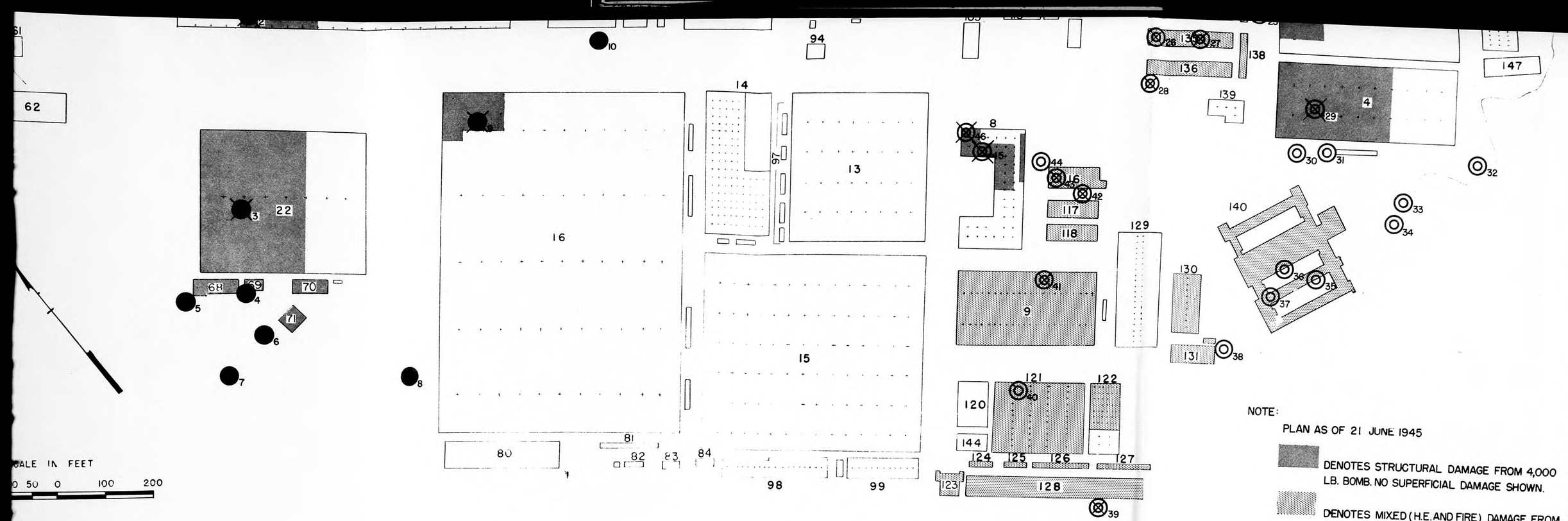
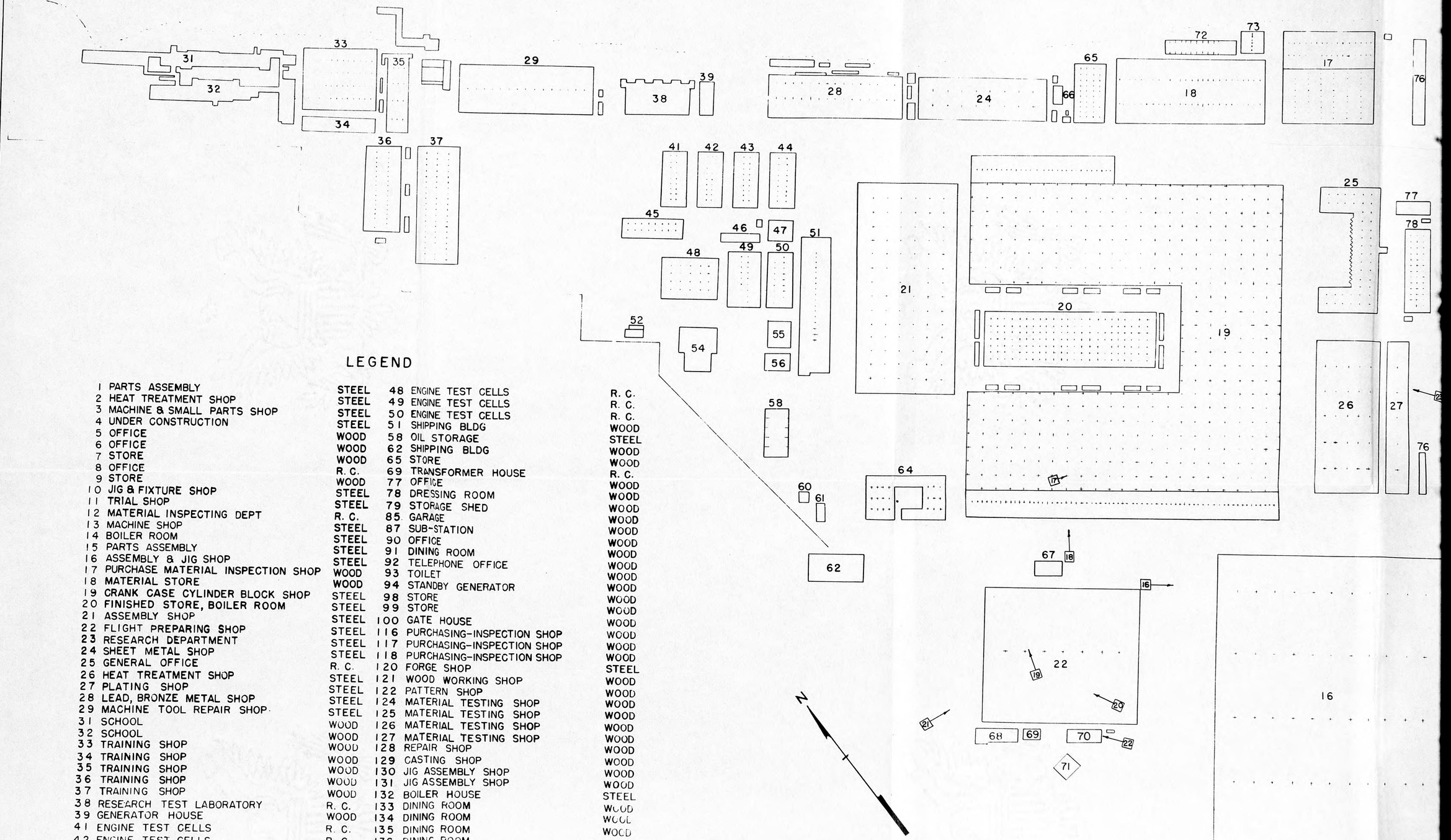




713273 O - 47 (Face p. 32) No. 1



LEGEND

1	PARTS ASSEMBLY	STEEL 48	ENGINE TEST CELLS
2	HEAT TREATMENT SHOP	STEEL 49	ENGINE TEST CELLS
3	MACHINE & SMALL PARTS SHOP	STEEL 50	ENGINE TEST CELLS
4	UNDER CONSTRUCTION	STEEL 51	SHIPPING BLDG
5	OFFICE	WOOD 58	OIL STORAGE
6	OFFICE	WOOD 62	SHIPPING BLDG
7	STORE	WOOD 65	STORE
8	OFFICE	R. C. 69	TRANSFORMER HOUSE
9	STORE	WOOD 77	OFFICE
10	JIG & FIXTURE SHOP	STEEL 78	DRESSING ROOM
11	TRIAL SHOP	STEEL 79	STORAGE SHED
12	MATERIAL INSPECTING DEPT	R. C. 85	GARAGE
13	MACHINE SHOP	STEEL 87	SUB-STATION
14	BOILER ROOM	STEEL 90	OFFICE
15	PARTS ASSEMBLY	STEEL 91	DINING ROOM
16	ASSEMBLY & JIG SHOP	STEEL 92	TELEPHONE OFFICE
17	PURCHASE MATERIAL INSPECTION SHOP	WOOD 93	TOILET
18	MATERIAL STORE	WOOD 94	STANDBY GENERATOR
19	CRANK CASE CYLINDER BLOCK SHOP	STEEL 98	STORE
20	FINISHED STORE, BOILER ROOM	STEEL 99	STORE
21	ASSEMBLY SHOP	STEEL 100	GATE HOUSE
22	FLIGHT PREPARING SHOP	STEEL 116	PURCHASING-INSPECTION SHOP
23	RESEARCH DEPARTMENT	STEEL 117	PURCHASING-INSPECTION SHOP
24	SHEET METAL SHOP	STEEL 118	PURCHASING-INSPECTION SHOP
25	GENERAL OFFICE	R. C. 120	FORGE SHOP
26	HEAT TREATMENT SHOP	STEEL 121	WOOD WORKING SHOP
27	PLATING SHOP	STEEL 122	PATTERN SHOP
28	LEAD, BRONZE METAL SHOP	STEEL 124	MATERIAL TESTING SHOP
29	MACHINE TOOL REPAIR SHOP	STEEL 125	MATERIAL TESTING SHOP
31	SCHOOL	WOOD 126	MATERIAL TESTING SHOP
32	SCHOOL	WOOD 127	MATERIAL TESTING SHOP
33	TRAINING SHOP	WOOD 128	REPAIR SHOP
34	TRAINING SHOP	WOOD 129	CASTING SHOP
35	TRAINING SHOP	WOOD 130	JIG ASSEMBLY SHOP
36	TRAINING SHOP	WOOD 131	JIG ASSEMBLY SHOP
37	TRAINING SHOP	WOOD 132	BOILER HOUSE
38	RESEARCH TEST LABORATORY	R. C. 133	DINING ROOM
39	GENERATOR HOUSE	WOOD 134	DINING ROOM
41	ENGINE TEST CELLS	R. C. 135	DINING ROOM
42	ENGINE TEST CELLS	R. C. 136	DINING ROOM
43	ENGINE TEST CELLS	R. C. 137	DINING ROOM
44	ENGINE TEST CELLS	R. C. 138	DINING ROOM
45	ENGINE TEST CELLS	R. C. 141	STORE
46	ENGINE TEST CELLS	R. C. 142	STORE
148	DORMITORY	WOOD 144	MATERIAL TESTING SHOP

R. C.
R. C.
R. C.
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R. C.
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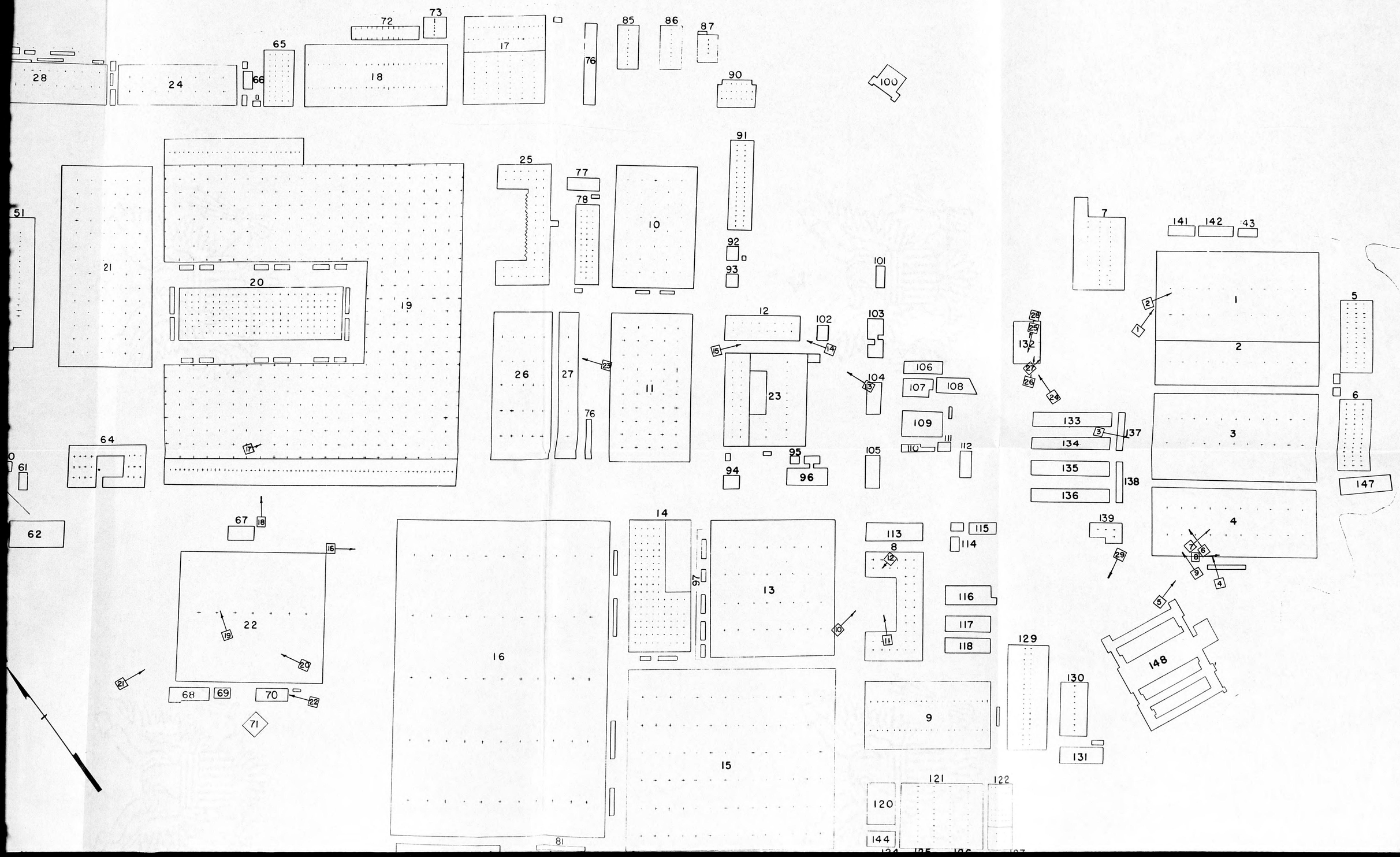
SCALE IN FEET



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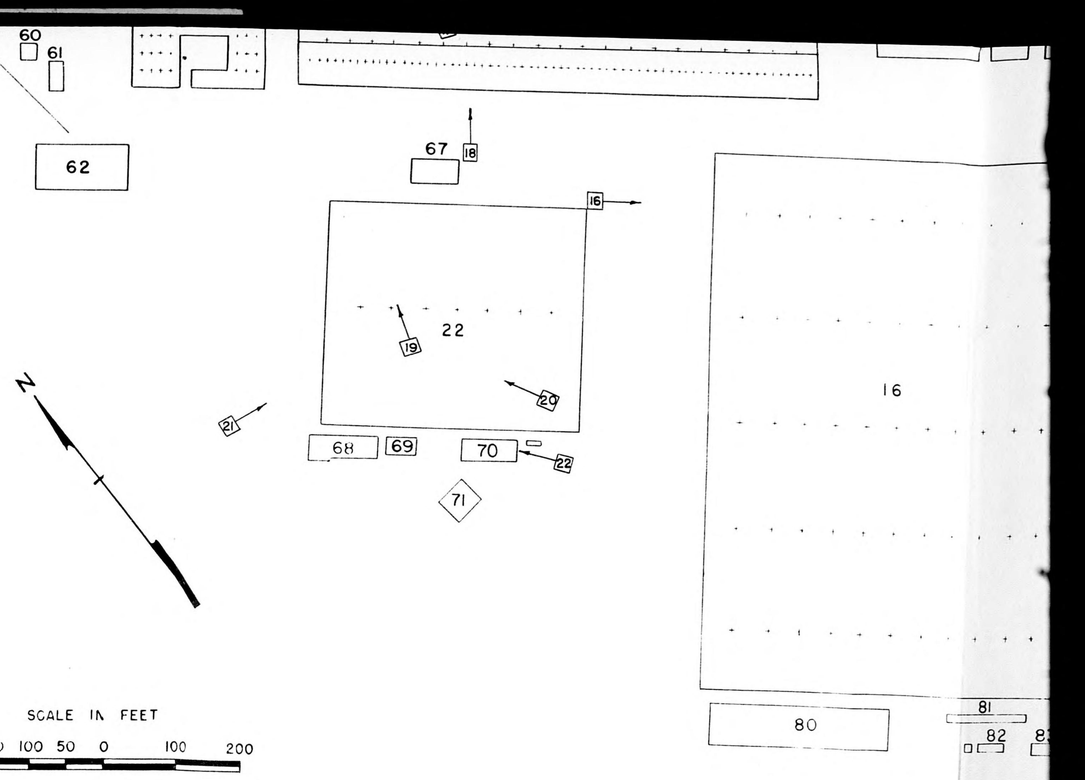
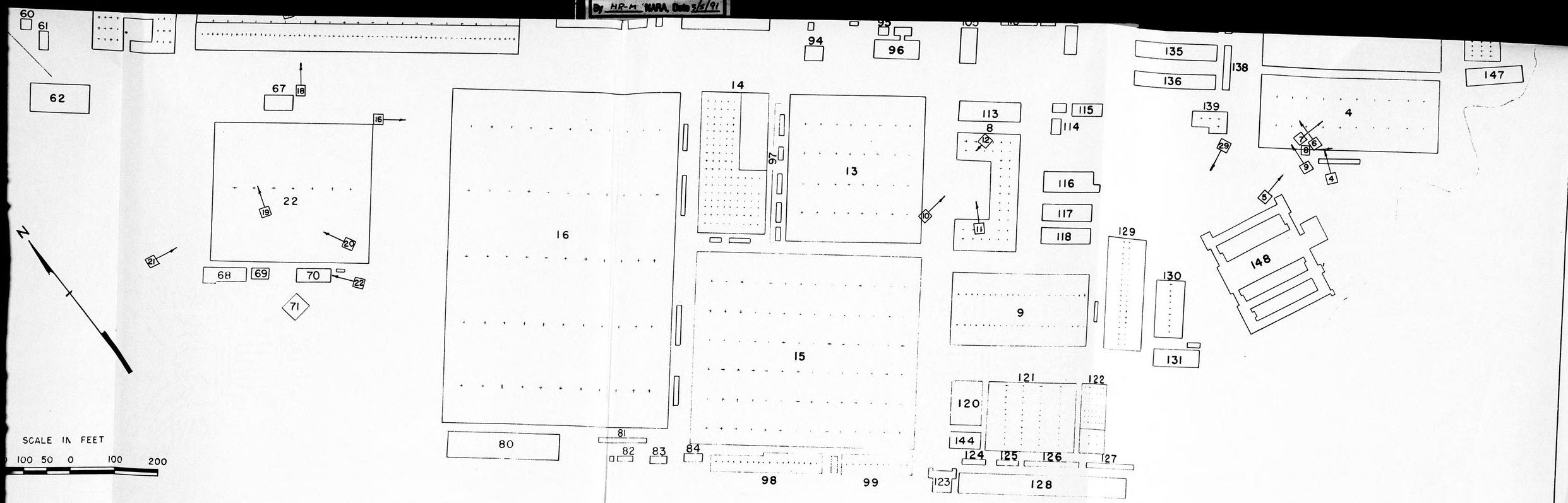
148

9 STORE	WOOD	77 OFFICE	WOOD
10 JIG & FIXTURE SHOP	STEEL	78 DRESSING ROOM	WOOD
11 TRIAL SHOP	STEEL	79 STORAGE SHED	WOOD
12 MATERIAL INSPECTING DEPT	R. C.	85 GARAGE	WOOD
13 MACHINE SHOP	STEEL	87 SUB-STATION	WOOD
14 BOILER ROOM	STEEL	90 OFFICE	WOOD
15 PARTS ASSEMBLY	STEEL	91 DINING ROOM	WOOD
16 ASSEMBLY & JIG SHOP	STEEL	92 TELEPHONE OFFICE	WOOD
17 PURCHASE MATERIAL INSPECTION SHOP	WOOD	93 TOILET	WOOD
18 MATERIAL STORE	WOOD	94 STANDBY GENERATOR	WOOD
19 CRANK CASE CYLINDER BLOCK SHOP	STEEL	98 STORE	WOOD
20 FINISHED STORE, BOILER ROOM	STEEL	99 STORE	WOOD
21 ASSEMBLY SHOP	STEEL	100 GATE HOUSE	WOOD
22 FLIGHT PREPARING SHOP	STEEL	116 PURCHASING-INSPECTION SHOP	WOOD
23 RESEARCH DEPARTMENT	STEEL	117 PURCHASING-INSPECTION SHOP	WOOD
24 SHEET METAL SHOP	STEEL	118 PURCHASING-INSPECTION SHOP	WOOD
25 GENERAL OFFICE	R. C.	120 FORGE SHOP	STEEL
26 HEAT TREATMENT SHOP	STEEL	121 WOOD WORKING SHOP	WOOD
27 PLATING SHOP	STEEL	122 PATTERN SHOP	WOOD
28 LEAD, BRONZE METAL SHOP	STEEL	124 MATERIAL TESTING SHOP	WOOD
29 MACHINE TOOL REPAIR SHOP	STEEL	125 MATERIAL TESTING SHOP	WOOD
31 SCHOOL	WOOD	126 MATERIAL TESTING SHOP	WOOD
32 SCHOOL	WOOD	127 MATERIAL TESTING SHOP	WOOD
33 TRAINING SHOP	WOOD	128 REPAIR SHOP	WOOD
34 TRAINING SHOP	WOOD	129 CASTING SHOP	WOOD
35 TRAINING SHOP	WOOD	130 JIG ASSEMBLY SHOP	WOOD
36 TRAINING SHOP	WOOD	131 JIG ASSEMBLY SHOP	WOOD
37 TRAINING SHOP	WOOD	132 BOILER HOUSE	STEEL
38 RESEARCH TEST LABORATORY	R. C.	133 DINING ROOM	WOOD
39 GENERATOR HOUSE	WOOD	134 DINING ROOM	WOOD
41 ENGINE TEST CELLS	R. C.	135 DINING ROOM	WOOD
42 ENGINE TEST CELLS	R. C.	136 DINING ROOM	WOOD
43 ENGINE TEST CELLS	R. C.	137 DINING ROOM	WOOD
44 ENGINE TEST CELLS	R. C.	138 DINING ROOM	WOOD
45 ENGINE TEST CELLS	R. C.	141 STORE	WOOD
46 ENGINE TEST CELLS	R. C.	142 STORE	WOOD
148 DORMITORY	WOOD	144 MATERIAL TESTING SHOP	WOOD

NOTE: NOS. 30,40,53,57,59,63,74,75,88,89,119,140,145, & 146 NOT USED
BLDG. NOS. 47,56,64,67,72,73,86,95,96,103,109,113,114,115 DESTROYED BY PREVIOUS RAILS.
MISCELLANEOUS UTILITY BUILDINGS OMITTED IN ABOVE LEGEND.



By HR-M NARA, Date 3/6/91



U.S. STRATEGIC BOMBING SURVEY

KAWASAKI AIRCRAFT INDUSTRIES
AKASHI PLANT

GEN. LAYOUT & PHOTO PLOT FIG. 6

713273 O-47 (Face p. 33) No. 2

ANNEX TO BOMB PLOT FIGURE 5

Following is a brief résumé of the points of impact of all the 4,000-pound light-case M56 bombs which struck the Akashi plant of the Kawasaki Aircraft Co. It should be kept in mind that these bombs were all fuzed instantaneous nose and non-delay tail.

Bomb No.	*Description*
1	Deep and wide crater with slow fuze action in soft soil.
2	Air burst [1] with detonation at main truss level.
3	Air burst with superquick fuze action at roof surface level.
4	Slight crater. Bomb burst probably occurred 4 to 6 feet above ground level.
5	Shallow and wide crater with immediate fuze action on contact with ground.
6	Shallow crater with fuze action on contact with rubble pile approximately 2 feet high.
7	Deep and wide crater with slow fuze action in soft soil.
8	Deep crater with much of the blast deflected upward.
9	Air burst just above building eaves.
10	Small cone-shaped crater with little deflection of the blast.
11	Air burst high and above eaves.
12	Wide, shallow crater with little deflected blast.
13	Wide, shallow crater.
14	Air burst above roof initiated on contact.
15	Air burst above roof initiated on contact.
16	Crater 6 feet to 8 feet deep with steep sloping sides.
17	Crater 6 feet to 8 feet deep with steep sloping sides.
18	Crater 6 feet to 8 feet deep with steep sloping sides.
19	This bomb was plotted by Japanese, but at time of survey ground evidence neither confirmed nor denied its location or its detonation.
20	Deep, wide crater.
21	Air burst point of detonation not determined.
22	Air burst well below the eaves.
23	Air burst below eaves and outside of building.
24	This bomb was plotted by Japanese, but at time of survey ground evidence neither confirmed nor denied its location or its detonation.
25	Small crater with steep sides.
26	This bomb was plotted by Japanese, but at time of survey ground evidence neither confirmed nor denied its location or its detonation.
27	This bomb was plotted by Japanese, but at time of survey ground evidence neither confirmed nor denied its location or its detonation.
28	This bomb was plotted by Japanese, but at time of survey ground evidence neither confirmed nor denied its location or its detonation.
29	Air burst at or just below eaves.
30	Small crater with steep sides. No more than 15 feet in diameter, no lip.
31	Small crater with steep sides. No more than 15 feet in diameter, no lip.
32	Wide crater in side of embankment with blast deflected upward.
33	Wide, shallow crater with thin scattered lip.
34	Wide, shallow crater with thin scattered lip.
35	Crater size undetermined.
36	Crater size undetermined.
37	Crater size undetermined.
38	Wide, shallow crater.
39	This bomb was plotted by Japanese, but at time of survey ground evidence neither confirmed nor denied its location or its detonation.
40	Small crater with steep sides.
41	This bomb was plotted by Japanese, but at time of survey ground evidence neither confirmed nor denied its location or its detonation.
42	This bomb was plotted by Japanese but at time of survey ground evidence neither confirmed nor denied its location or its detonation.
43	This bomb was plotted by Japanese, but at time of survey ground evidence neither confirmed nor denied its location or its detonation.
44	Shallow crater with instantaneous fuze on contact of bomb with gound.
45	Air burst above roof on contact.
46	Air burst above roof on contact.

[1] Reference to air-burst bombs throughout means bombs which were activated and detonated by some solid object prior to contract with the ground.

PART 2

EFFECTS OF 4,000-POUND BOMBS DROPPED ON THE PLANT OF THE SUMITOMO LIGHT METALS INDUSTRY, LTD., OSAKA, JAPAN

Target 90.25-263A

Dates of Survey: 24 October–16 November 1945

TABLE OF CONTENTS

	Page
I. OBJECT OF STUDY	34
II. SUMMARY	34
III. GENERAL INFORMATION	34
IV. THE TARGET	34
V. THE ATTACKS	36
VI. ANALYSIS OF DAMAGE	36
VII. MACHINE TOOL DAMAGE	39
VIII. CONCLUSIONS	41

Photos 1 to 67, inclusive.

Figures 1 to 10, inclusive.

Tables A to D, inclusive.

I. OBJECT OF STUDY

The object of this study was to determine the amount of physical damage done to the Sumitomo Light Metals Industry plant at Osaka by 4,000-pound, light-case, M56 high-explosive bombs.

II. SUMMARY

1. The Sumitomo plant, located in the outskirts of the city of Osaka, was roughly trapezoidal in shape and covered 91.5 acres. The plant as a whole was divided into two sections, the light metals industry and the propeller plant; aluminum and copper alloys were produced in the former and finished propellers in the latter. Each of these divisions employed its own individual manager, although both were part of the Sumitomo (Osaka) plant. Buildings of both divisions were principally one-story, wood- or steel-frame structures. The steel-frame structures had moderate spans and large-capacity cranes. In comparison with other targets studied by this team, this target had a high ratio of buildings (45.4 acres) to the total area (91.5 acres).

2. The plant was bombed, as a primary target, by Twentieth Air Force B–29 aircraft on 26 June 1945 and 24 July 1945. Both attacks were made with 4,000-pound, light-case, M56 bombs. The attack of 26 June 1945 was made with the aid of radar and resulted in only slight damage to the target. The attack of 24 July 1945, however, used visual aiming and caused considerable damage. In both attacks a total of 870 tons of high-explosive bombs was released over the target and visual inspection showed that 104 bombs struck the plant proper. Of these, 85 exploded in or on buildings and 19 exploded in the open. There was no evidence of unexploded bombs or low-order detonations.

3. Field survey determined that of a total of 1,978,700 square feet of original roof area, 1,416,075 square feet was structurally damaged by 4,000-pound, high-explosive bombs. In comparison, Photo Intelligence estimated that of a total of 2,119,400 square feet of roof area, 705,800 square feet was structurally damaged.

III. GENERAL INFORMATION

1. The study of the Osaka plant of the Sumitomo Light Metals Industry, Ltd., was made during the period 24 October–16 November 1945.

2. This study was made by Field Team 3 which made the report contained in Part 1 herewith.

3. All data contained in this report were gathered from Twentieth Air Force operational reports, plant records, personal interviews, and visual observation.

4. Several drafts of bomb plots were supplied by plant officials, but due to errors in these drafts it was necessary for the ordnance members of the team to prepare new plots.

5. The target area at the time of the survey was in a condition of ruin as a result of United States air attacks. Minor salvage activities were in progress but presented no problems and did not obscure any pertinent facts.

IV. THE TARGET

1. *Official personnel.*—Mr. H. Kasuga was president of the Sumitomo Light Metals Industry, Ltd., and Dr. Tomojiro Tanabe was managing director of the copper works (target 263A) at Osaka. General information concerning plant functions, employees, attack damage, and other topics of interest was supplied by Dr. Tanabe.

2. *Location.*—The Osaka plant of the Sumitomo Light Metals Industry, Ltd., was located near the water front on reclaimed land between the Shin Yodo and Aji Rivers. The installation consisted of two parts—one, the light-metals industry, and the second, the propeller plant. Though both parts were units of the Sumitomo Light Metals Industry, Ltd., at the same location, each was managed separately.

a. Information obtained from the operators of Sumitomo Light Metal Industry indicates that at the time the plant was built doubt existed as to the stability of the soil conditions and, for this reason, exceedingly heavy building foundations were used. As time passed, settlement did occur, amounting to more than an inch a year. The area in which the plant was located was subject to extreme fluctuations in water level, so that under the worst conditions the entire area was inundated. The Sumitomo plant was surrounded by heavy sea walls and a canal running through the center of the plant was buried. Seepage of water into the plant area was rather high, and a pumping station was installed to keep the water level down by pumping water from furnace flues and machinery pits. As the soil conditions became progressively worse, additional pumps were placed in service to keep ahead of the seeping water. During the 4,000-pound-bomb attacks, large cracks developed in the sea walls and the pumping station was totally damaged. The plant area was at once almost entirely covered with 3 to 4 inches of water. As a result production was impeded and all equipment and materials suffered damage.

3. *Building data.*—The light-metals plant of the Sumitomo Light Metals plant was approximately square, with a total built-up area of 35.6 acres. Generally speaking, the principal buildings were one-story, steel-frame structures having moderate spans and fairly large-capacity cranes. Minor buildings were of wood construction. The propeller manufacturing portion of the plant adjoined the other and was triangular in shape; the majority of the buildings were wooden and covered 9.8 acres. When viewed together, the propeller plant and the light-metals works were trapezoidal in shape. The propeller plant was at the south end of the plot; building numbers in the propeller plant are followed by the letter P on Figures 9 and 10.

4. *Capital.*—As of 1 June 1945 the Sumitomo Light Metals Industry, Ltd., had a paid-up capital of 415,000 yen ($98,770 at the prewar rate of exchange). The Sumitomo holding company held 24 percent of the stock.

a. Value of the Osaka plant was reported by the Japanese to be—

Buildings	¥85, 734, 610
Machinery	48, 824, 718
Materials and finished and partly finished products	90, 821, 700
	225, 381, 028

5. *Products.*—The light-metals works produced aluminum alloys (rolled, forged, extruded, etc.) and copper alloy. The monthly production of aluminum alloys was 1,800 tons, and that of copper alloy, 1,200 tons. The propeller plant, using the alloys, turned out finished propellers. The raw materials and finished propellers were sent to various aircraft factories throughout the country.

6. *Air attacks reported by Japanese.*—Plant officials reported that three air attacks were carried out against this target on the dates given below. They also indicated the number and type of bombs which struck the plant area. Detailed information on air attacks will be found under Section V.

Date	Bomb type	Bomb hits
1 June 1945	Incendiary	158
	Small high-explosive	120
26 June 1945	High-explosive	3
24 July 1945	do	116

7. *Employees.*—This plant employed 11,000 workers. Average attendance in 1945 prior to air attacks was 85 percent. This relatively high percentage dropped to between 40 and 50 percent for a period of 10 days after the attack of 26 June 1945. Following the 24 July 1945 attack the number of workers dropped to only 20 percent of the original total, and at the time of the survey only a few small salvage crews were working.

8. *Dispersal of machines and equipment.*—The main machines, including 251 furnaces and 70 machine tools, totaling 1,978, were moved to the near-by Nauiwa higher school. About one-half of the research instruments and equipment was moved to the Tsujiku building in Osaka. All of these tools and instruments remained undamaged, as neither of these places of safety was hit in any air attacks.

9. *Financial loss.*—The high-explosive-bomb attack of 24 July 1945 was, according to the Japanese, so effective that the entire plant was demolished to a point where only scrap remained.

a. This scrap value was itemized as follows:

Buildings	¥102, 321
Machinery	73, 507
Materials, products, etc	5, 657, 579
	5, 833, 407

b. According to the Japanese, the total damage resulting from all attacks, in percentage of destruction, was as follows:

	Percentage
Buildings	92. 9
Machines	89. 1
Materials and products	93. 4

c. It was estimated by the Japanese that it would have taken 1 year to repair a maximum of 15 percent of the damaged machinery due to the lack of proper electrical equipment.

10. *Casualties.*—Table A, supplied by the Japanese, shows the number of dead and wounded resulting from each of the three air attacks on this target.

TABLE A

Date	Killed	Injured
1 June 1945	3	0
26 June 1945	0	0
24 July 1945	250	100

V. THE ATTACKS

1. The Sumitomo (Osaka) plant was attacked with high-explosive bombs by aircraft of the Twentieth Air Force on 26 June 1945 and 24 July 1945. In both of these attacks it was designated as the primary visual and radar target. The weapon employed was the 4,000-pound, light-case, M56 high-explosive bomb. (Detailed information on these high-explosive attacks will be found in Table C.) The Japanese reported attacks on 1 June 1945, 26 June 1945, and 24 July 1945. A brief résumé of each attack which affected the plant follows. In addition, bomb plot, Figure 10, shows the location of each high-explosive bomb hit, and the annex to the bomb plot shows the point of detonation of each bomb hit.

a. 1 June 1945.—A force of 458 B–29 aircraft of the Twentieth Air Force dropped 2,788.5 tons of incendiary and fragmentation bombs on the industrial urban area of Osaka of which target 263A was a part. Some of these bombs, though not specifically aimed at Target 263A, spilled over into the plant area and the Japanese therefore recorded an attack which, they added, did no appreciable damage to the plant proper. The fragmentation bombs were dropped to prevent efficient fire fighting by the Japanese, and it is assumed that the "small bombs" referred to by plant officials were these 20-pound fragmentation bombs.

b. 26 June 1945.—The Sumitomo (Osaka) plant was attacked by two groups of the 58th Wing, Twentieth Air Force. It was designated as the primary visual and radar target, with one assigned mean point of impact (MPI).

(1) Ten-tenths overcast at the assembly point prevented aircraft from forming and bombing visually. Bombing was accomplished by single aircraft utilizing radar.

(2) Bombing altitudes varied between 19,000 and 23,000 feet. Sixty-four aircraft, carrying an average of 13,000 pounds of 4,000-pound light-case bombs, released their loads over the target.

c. 24 July 1945.—The primary target was attacked by two groups of the 58th Wing, Twentieth Air Force, with 4,000-pound, light-case, M56 bombs. Visibility was excellent and all formations made visual runs.

(1) Bombing altitudes were 19,900 feet base for the lead squadron in each group, the second and third air squadrons being stacked at intervals of 500 feet above the lead squadron.

(2) The greatest difficulty encountered was from smoke in the target area which partly obscured the aiming point. Reference and offset aiming points were used, and bombing was accomplished as planned.

2. On visual inspection it was found that a total of 104 4,000-pound bombs struck the target. Table C shows the distribution of hits in buildings and in the open, and the bomb plot, Figure 10, shows the location of each hit. No evidence of unexploded bombs or low-order detonations was found.

3. The following table contains Photo Intelligence and Field Survey measurements of damage done by 4,000-pound bombs in the two attacks on this plant.

TABLE B

	Original roof area	Roof area structurally damaged	Roof area structurally damaged
	Square feet	*Square feet*	*Percentage*
Photo Intelligence [1]	2,119,400	705,800	33
Field Survey	1,978,000	1,416,100	71

[1] Based on Central Interpretation Unit, Twentieth Air Force, Damage Assessment Report No. 160, dated 2 Aug. 1945.

VI. ANALYSIS OF DAMAGE

1. The damage assessment contained in this report is shown on the damage plot, Figure 10, and in Table D, and was made on the basis of structural and superficial damage.

2. The total roof area at this plant prior to air attacks comprised 1,978,700 square feet. The two 4,000-pound-bomb attacks on this target resulted in the structural damage of 1,416,075 square feet. Primary and secondary fires caused 348,300 square feet of the roof-area damage and obliterated all evidence of blast and fragmentation damage. Though the origin and spread of fires were not determined, burned buildings were assessed as structurally damaged if they appeared on photos taken prior to the high-explosive attacks. All damage assessed resulted from either blast or fire unless otherwise specified.

TABLE C

	Date of Attack		
	26 June 1945	24 July 1945	Total
Weapon:			
Weight in pounds	4,000	4,000	
Type	Light-case	Light-case	
Model	M56	M56	
Fuzing:			
Nose	Instantaneous	Instantaneous	
Tail	Nondelay	Nondelay	
Aircraft bombing:			
Visual	1	82	83
Radar	63	0	63
Total	64	82	146
Number bombs dropped	191	244	435
Tons released over target	382	488	870
Mean point of impact planned	Southwest corner of Building 12	Center of east side of Building 58	
Axis of attack	35° T	35° T	
Altitude of release:			
Highest (feet)	23,000	22,100	
Lowest (feet)	19,000	19,900	

Total 4,000-pound hits: In buildings, 85; in open, 19; total, 104. Further details on bomb plot, Figure 10.

3. Damage plot, Figure 10, shows the roof areas structurally and superficially damaged by 4,000-pound bombs, as well as locations of buildings in the target. Bombs referred to by number following text may be located on the bom bplot, Figure 10.

4. Following are descriptions of incidents in this target which were subjected to analytical observation. In a considerable number of cases, the buildings were so severely damaged that the exact details of the effect of individual bombs could not be determined. Effort was made to describe several typical incidents in each type of construction.

a. Building 3 was a one-story, steel-frame structure used as a shop for the manufacturing of tubing. Bomb 42 struck in the building near the western side. One exterior column was torn out and other columns were severely distorted. Photo 1 shows the nature of damage in this building.

b. Building 9 was a steel-frame warehouse with a heavy crane runway, used for loading purposes, which extended over the river bank. Bomb 46 struck this building near the river edge, demolishing a considerable area of the framing. Since the crane was on the overhanging portion of the structure, this part collapsed into the water. The rest of the building, extending back approximately 360 feet from the shore line, was severely distorted throughout. Photo 2 shows the state of collapse.

c. Building 11, a steel-frame mill building, used as a forging shop, received one hit (Bomb 47) in the north end. No columns were knocked out, and the damage was confined to the northern half of the building.

d. Building 13 was a one-story, steel-frame machine shop. Bomb 37 struck this building, demolishing steel for six bays. The entire building was collapsed or severely distorted. Photos 3 and 4 show the destruction in this building.

e. Building 14, a heat-treating shop, was a one-story, steel-frame mill building. In plan this building was L-shaped, one wing running west, the other south, from the re-entrant angle. Two bombs struck the building. Bomb 44 exploded on contact with the ground, cutting several columns and causing collapse or distortion of the entire west wing. Bomb 43 struck in the re-entrant angle. Two steel stacks were knocked over, falling south, and the entire south wing of the building was distorted, leaning south and about 4 feet out of plumb. In addition, all columns failed (Photos 5 and 6). The building evidently had light connections running north from the re-entrant angle, and the two wings were broken apart by the blast of bomb 43 (Photo 7).

f. Building 16 was a small two-story concrete building adjoining a wooden building which had been destroyed. Bombs 38 and 39 struck the concrete portion of this building, damaging the entire structure.

g. Building 18 was a steel-frame boilerhouse. Bomb 7 struck near the northwest corner of the building, knocking out the corner column and the

two adjacent side columns. The building was distorted throughout, but not collapsed. A steel stack approximately 50 feet from the center of the bomb crater was damaged by fragmentation only to a height of 75 feet.

h. Building 33 was a steel-frame structure, the last of a series of warehouses (Buildings 32, 53, 52), and had a loading crane at the water edge. Bomb 71 struck this building, knocking down six columns and damaging the entire structure (Photo 8). One column was hurled approximately 85 feet, crashing into and reducing to ruins a small powerhouse south of the building.

i. Building 42 was a one-story, steel-frame mill building. Bomb 75 struck in the northwest corner, knocking out four exterior columns and two interior columns. The portion of the building immediately surrounding the bomb burst was distorted, but collapse did not occur over a widespread area. Bomb 74 struck just outside the north side of the building, bending exterior columns and distorting the framing. Bomb 72 struck in the southeast corner of the building, knocking out four exterior columns and one interior column (Photo 49). Collapse of the building was confined to the immediate areas of demolished columns, but the entire structure was distorted.

j. Building 43 was a one-story, steel-frame mill building. Bomb 93 struck in this building, severely damaging two exterior columns and two interior columns. The building was also affected by the detonation of Bomb 74. Photos 10 and 11 show damage to the building, all of which collapsed or was distorted.

k. Building 51 was a large, one-story, steel-frame mill building. Bomb 92 struck in the northeast corner of the building, knocking out nine exterior columns and four interior columns. Bomb 91 knocked out two interior columns. The combined effects of bombs 91 and 92 collapsed a large area of the building (Photo 12). Bomb 77 knocked out two interior columns, causing collapse of the building in the immediate area (Photo 13). Bomb 80 struck 20 feet from the west side of the building, knocking out three external columns and collapsing the exterior bay. Bomb 78 knocked out four exterior columns and two interior columns, collapsing the building in the immediate vicinity (Photo 14). Bomb 66 collapsed an entire wing of the building (Photos 15, 16, 17). Bomb 68, which struck approximately 20 feet from the southside of the building, knocked out three exterior columns, but caused no collapse. Bomb 76 did not knock down any columns, but severely damaged the roof trusses for three bays and distorted several columns. The entire building except for a small area on the south side collapsed or was severely distorted (Photos 18, 19).

l. Building 58 was a one-story, steel-frame building with heavy crane runways. Bays were spaced at 65-foot intervals and the height of the bottom chord of the roof trusses above the brick floor was 32 feet. The structure was hit by six bombs; three were air bursts and three cratered. Bomb 53, striking in Building 119, adjacent to Building 58, also did considerable damage.

(1) Bombs 49 and 36 were air bursts. The structure was damaged heavily from the blast of these bombs. The resultant effect of this blast was to damage severely the roof trusses in the areas of the bursts. The damage was sufficient to twist the members of the roof truss and to destroy any continuity in the bracing system. The roof framing collapsed in several bays as a result. Adjacent to this area, the alignment of the crane runway girders was disturbed and the crane rendered useless. In general, columns in the bay where each bomb detonated were smashed and twisted severely.

m. Building 62 was a one-story, steel-frame building with reinforced-concrete curtain walls tied into the exterior steel columns and beams. The building, which contained power-generating equipment and was 30 feet in height to the eaves, was damaged by Bomb 34, a near-miss. As the concrete exterior walls were tied into the steel columns, they transmitted the full effect of the blast into the columns, and the result was that the entire building was damaged. Photo 20 shows this effect.

n. Building 74 was a one-story, heavy, mill-type, steel-frame structure. Five bombs hit this structure, all of them being air bursts. The effect in the immediate area of a bomb burst was severe distortion of the trusses and columns. The bays adjacent to those where the bombs struck were distorted, and crane runway girders were knocked out of line. It was therefore impossible to use the overhead crane for moving materials, and transportation of assemblies in the shop was definitely halted. Photo 21 shows the type of collapse and distortion of steel referred to above. Photo 22 shows the collapse of structure and damage to crane runway girders. Photo 23 illus-

trates a similar case. Collapse of the structure shown in Photo 21 definitely precludes the possibility of any work being carried on even though damage to the material and equipment was not severe. This condition is typical of Target 263A.

o. Building 77 was a large, one-story, steel-frame mill building. Bomb 64 knocked out three exterior columns and slightly damaged an adjacent stack. Bomb 63 knocked out two exterior columns and one interior column. Roof trusses and crane runways were severely damaged for two bays. Bomb 62 exploded in the roof steel, demolishing it for five bays. Surrounding columns were distorted but not knocked down. Bombs 54, 55, 57, and 58 combined to demolish or very severely distort the entire southern portion of the building (Photos 24, 25, 26, 27, 28, 29, and 30).

p. Building 82 was a one-story, steel-frame building with concrete curtain walls. Trusses were of the arch type and had a span of 100 feet. The building sustained damage from Bombs 23 and 56, both near-misses. Photo 31 shows the crater made by Bomb 56 and the resulting damage. Damage in this instance was limited to the exterior truss and did not extend into the structure.

q. Building 83 was a one-story, L-shaped, steel structure. The building was divided into two sections; the short part of the L serving one function and the long part another. Steel framing in both sections was similar. The building was hit by six bombs, one of them an air burst. The damage in the short part of the L was similar to damage previously discussed for this type of structure. This building is shown on the left side of Photo 32. The other part of the structure was hit by Bombs 14 and 28 which landed near the center line of columns of the eastern edge of the structure and cratered. The blast and shock from these two bombs pushed all the exterior columns inward and collapsed the structure. In some cases the foundations were uprooted; in others, the columns were torn from the anchor bolts.

r. Building 84 was a boilerhouse having concrete exterior walls 8 feet above grade and steel-frame construction from that height to the roof. The structure was damaged by one direct hit which was an air burst and by four near-misses. The steel frame was severely damaged throughout as a result of both the direct hit and the collapse of one of the reinforced-concrete chimneys over it. Photos 33 and 34 illustrate this damage. The furnaces and frames supporting the boilers were severely damaged. There were two chimneys, one at each end of the building. The near-misses cratered, and shock and blast were sufficient to collapse both of the chimneys. Photo 35 shows this condition and Photo 36 gives a detailed view of the fracture of the chimney at its base.

s. Building 100 was a one-story, steel-frame building. It was struck by Bomb 59 which collapsed the roof steel and distorted the entire building as shown in Photo 37.

t. Building 17P was a one-story, steel-frame building used as an assembly shop in the propeller plant. The building was hit by Bomb 101, an air burst. The close spacing of the columns and low height of the roof made it possible for the bomb to cause severe damage to the steel structural members in the immediate area of the hit. About 50 percent of the damage suffered, as shown on the damage plot, was fire damage. Inflammable insulation board and wood backing on the underside of the trusses caught fire and distorted the steel. Photos 38 and 39 show the type of damage caused by Bomb 101.

u. Building 25P, situated in the propeller plant, was a one-story building constructed of steel and wood. The wooden part of the structure comprised 75 percent of the building. Bombs 96 and 97 were direct hits and Bombs 95 and 104 exploded near the building. The wooden portion of the building was totally damaged by fire, and the steel portion adjacent to Bomb 104 was damaged for two bays. At the other end of the building, which was of steel, the damage extended over the entire area. Photo 40 shows the wooden portion of the building burned to the ground and in the background the steel-frame portion of the structure.

VII. MACHINE TOOL DAMAGE

1. The following outline of damage to machine tools covers several of the major buildings of this plant. The locations of machines in each building at the time of the attacks, the extent of damage, and notes on individual machines are shown on Figures 1 to 8. Bomb hits are shown on bomb plot, Figure 10.

2. This assessment considers damage to machine tools such as lathes, milling machines, and boring machines; and to other equipment such as hydraulic presses, rolling mills, and heat-treating furnaces. All of these items of equipment are included in the term "machine tools"

for the purpose of this report. The pattern of damage to various machines and their reaction to blast, fragmentation, shock, and debris were observed to be generally as follows:

a. The effect of falling structural steel upon machine tools was generally slight since the steel did not collapse with sufficient violence to break the machines. Some damage to the machines was caused by flying brick and concrete, but such damage was usually slight, comprising breakage of handles and other small projecting parts.

b. The amount of damage done to machines depended upon the type of machine. The types of machines and damage might be classified roughly as follows:

(1) Heavy equipment, such as rolling mills and hydraulic presses, were almost undamaged by blast unless struck by a direct hit or near-miss of not more than crater-radius distance from the bomb. Fragments did some damage to working surfaces, but unless the fragment concentration was very great, the time required for repairs should have been little. Steam hammers were somewhat more vulnerable to fragments because of the possibility of cylinders being pierced. The bodies of these machines, however, were classed as heavy equipment.

(2) Machinery having most of the working parts inside large castings, such as heavy milling machines, slotters, planers, boring mills, and planer millers had few exposed gears, pulleys, or shafts but usually had bearing surfaces exposed. Such machines were more vulnerable to fragmentation than to blast. Machines having long beds, such as lathes, were subject to damage from blast and shock even though the main gear boxes were unaffected.

(3) Standard-size equipment of medium- and small-capacity machine shops, such as lathes and milling machines, had a considerable amount of exposed working surface, screws, gears, and brackets, and consequently were quite vulnerable to damage from both blast and fragmentation.

(4) Machines such as jig borers, small precision lathes and millers, and small automatic lathes were the most vulnerable to bomb damage by virtue of their many small exposed parts and standards of critical accuracy. Blast usually had little effect on small equipment, but fragmentation and debris were most damaging.

(5) Electric motors were quite vulnerable. The castings broke readily and were easily penetrated by fragments.

3. The 4,000-pound bombs used against this target exploded in the roof steel or upon contact with the ground. Overhead cranes were particularly vulnerable to roof bursts. Damage to floor equipment from falling roofing material was slight because of the light weight of such material. Some blast walls had been constructed of bricks (laid with mortar) and some of concrete. These walls were somewhat effective in arresting fragments and debris, but were subject to disintegration, whereupon they in turn became dangerous as debris.

4. *Building 42* was a machine shop. Figure 1 shows the locations and types of machines, and the extent and severity of damage. Fire had spread through the building, burning the wires from all machines, switches, and relays. All motors not heavily encased required rewinding, and approximately 30 percent were not salvageable. The four machines in the northwest corner were burned beyond salvage. Other machines were damaged by being overturned or by being pierced by fragments.

5. *Building 43* was a shop for the processing of rods and tubing. Figure 2 shows the locations and types of machines and the extent and severity of damage. Destruction of machines by debris was heavy. Some damage from fragmentation was noted.

6. *Building 51* was a shop for the processing of rods and tubing. Figure 3 shows the locations and types of machines and the extent and severity of damage. In this building machines in the immediate vicinity of exploding bombs were totally or heavily damaged. Other machines sustained very slight damage or none at all.

7. *Building 55* was a small forge shop. Figure 4 shows the locations and types of machines and the extent and severity of damage. This building was flooded; the one bomb affecting it caused slight damage only to one hydraulic pump.

8. *Building 58* was a shop for the processing of rods and tubing. Figure 5 shows the locations and types of machines and the extent and severity of damage. The high-water level in this building (2 to 4 inches above the floor) made it impossible to operate the heat-treating furnaces. Some heavy damage was observed from blast and minor damage from fragmentation.

9. *Building 64* was a shop for the processing of sheet metal. Figure 6 shows the locations and types of machines and the extent and severity of damage. Damage to machinery was very severe,

resulting largely from blast, with fragmentation and flying debris also causing some damage.

10. *Building 74* was a shop for the processing of sheet metal. Figure 7 shows the locations and types of machines and the extent and severity of damage. Several machines were slightly damaged by fragments, but those machines which were near the bomb explosions were completely demolished.

11. *Building 77* contained forging, heat-treating, and machine-shop equipment. Figure 8 shows locations and types of machines and extent and severity of damage. Throughout two areas, totaling approximately 30 percent of the area of the building, the machinery was totally damaged. Several brick furnaces were completely collapsed, but the steel stokers and other parts were usable. A number of machines suffered slight to heavy damage from fragmentation and flying debris.

VIII. CONCLUSIONS

1. The conclusions in this section are a compilation of opinions formed as a result of general observation and study by various members of the team. They represent the deductions of the team as a whole, based on the study in its entirety rather than on specific incidents. Where the term "bombs" is used, unless otherwise specified, it refers to the type of bomb dropped on this target.

2. *General over-all effects of the attack.*—In the attack of 26 June 1945 some buildings were damaged by three bomb strikes on the target; on 24 July the plant was heavily damaged. In the latter attack approximately 71 percent of the buildings collapsed or were severely distorted; plant production was brought to a stop; the processing which had been dependent on the use of overhead cranes was inhibited to such an extent that complete rebuilding would have been necessary. In most cases even undamaged machines and tools could have been removed and utilized elsewhere only after costly and laborious clearing of debris.

3. *Bomb effectiveness.*—Four-thousand-pound, light-case bombs which explode in the roof steel or on contact with the roofs of steel-frame buildings generally cause structural damage over a wider area than those which detonate on contact with the floor within buildings. After the first attack on the average-size target, little or no light roof covering will be left on buildings and, with the exception of those that strike structural steel members, bombs dropped on buildings during subsequent attacks will detonate only upon impact with the floor or machinery and equipment. The important feature of damage to this target was building collapse which made repair impossible and which extended the damage caused by individual bombs beyond the maximum radial distance at which the direct blast of the bombs would have caused structural damage. This was true of short-span as well as long-span buildings. Another observation was that the effective near-miss radius of the bomb was so great that in a densely built-up target bombs falling outside buildings often caused considerable damage. The blast from the bombs on this target was so severe that reinforced-concrete smoke stacks, generally invulnerable to anything but direct hits (and even then seldom knocked over), were in several cases overturned by near misses. The 4,000-pound, light-case bomb is superior to other common types of demolition bombs for attack on mill-type, steel-frame buildings. This superiority becomes more pronounced as the weight of construction increases.

4. *Machine-tool damage.*—A greater concentration of 4,000-pound, light-case bombs is required to cause total or heavy damage to machine tools in a mill-type structure than is required to cause 100 percent structural damage to the entire building. Collapsing structural members are comparatively ineffective in producing serious damage to machine tools. Although debris cannot be relied on as an agent for causing heavy damage, it is an important factor in the effectiveness of large-blast bombs. Brick blast walls tended to break up under the high-pressure blast and became the source of additional dangerous debris. The effect of blast (such as blowing over small machines and damaging some heavier equipment), although severe near the point of detonation, was not sufficiently widespread to justify classing 4,000-pound, light-case bombs as being efficient against machine tools on a tonnage basis.

TABLE D

TARGET NO. 263A NAME OF PLANT SUMITOMO LIGHT METAL INDUSTRY

NO OF BLDG	NAME OF BLDG	GROUND AREA OF BUILDING IN SQ FT	NO. STORIES	FLR AREA IF MORE THAN ONE STORY IN SQ FT	HT OF EAVES IN FT	DESCRIPTION OF STRUCTURE A JTG Classification	VULNERABILITY: FIRE RESISTIVE	VULNERABILITY: NON COMBUSTIBLE	VULNERABILITY: COMBUSTIBLE	FLOORS TYPE & THICKNESS	EXTERIOR COLUMNS & DIMENSIONS C.C.	INTERIOR COLUMNS & DIMENSIONS	TRUSSES TYPE – SPAN	EXTERIOR WALLS BEARING, CURTAIN – THICKNESS	INTERIOR WALLS BEARING, CURTAIN THICKNESS	ROOF	DAMAGE TO BLDG SQ FT FLOOR AREA	REMARKS
8	TUBING AND ROD SHOP	82,643	1		30	STEEL FRAME CONSTRUCTION B2		X		CONC.	18" 4 L's 5"x3" LACED. EXTENDED TO EAVES	4 L's 6"x4" LACED 32'-10" ℄ 20 FW	32'-10"	8" REINFORCED CONC. 8'0" HIGH STEEL SASH TO EAVES	NONE	WOOD SHEATHING ON STEEL PURLINS	22,205	SUPERFICIAL DAMAGE 75%
9	WAREHOUSE	17,278	1		28	STEEL FRAME CONSTRUCTION B2		X		CONC.	16" 4 L's 4"x3" LACED, SET IN CONCRETE 10'S ABOVE FLOOR & RUN TO EAVES	NONE	58' COMPOUND PINK	8" REINFORCED CONC. 5'0" HIGH STEEL SASH TO EAVES	NONE	CORRUGATED IRON ON STEEL PURLINS	17,209	
11	SMITH SHOP	15,613	1		40	STEEL FRAME CONSTRUCTION B2		X		CONC.	7" SECTIONS USED ALTERNATELY AS COLUMNS.	DO SAME SCHEDULE	40' 10' 40'	6" CONCRETE CURTAIN TO 5' - STEEL SASH AND GLASS TO EAVES	NONE	STEEL PURLINS CORR. METAL ROOFING	5,968	SUPERFICIAL DAMAGE 60%
13	MACHINE SHOP	14,572	1		30	HEAVY MILL STEEL FRAMED STRUCTURE B2		X		8" CONC. REINF.	2-12" CHANNELS 4" FLANGE 12" I BEAM 1" WEB	2-10" ▯ LACED	50'	STEEL SASH AND GLASS TO EAVES - CURTAIN	NONE	CORR. METAL ROOFING OVER STEEL PURLINS	14,572	
14	MELTING SHOP N. WING	27,964	1		30	STEEL FRAME CONSTRUCTION B2		X		REINF. CONC. (VARIES)	2-12" ▯ TIED EVERY 30" WITH ⅜"x 8" PLATE	NONE	TRUSSES AT 18' C.C. 50'	CURTAIN - STEEL SASH TO EAVES WITH CORR. METAL SIDING	NONE	STEEL PURLINS AND CORR. METAL ROOF	27,964	
14	MELTING SHOP S. WING		1		30	STEEL FRAME CONSTRUCTION		X		REINF. CONC.	4-4"x6"x⅝ L's LACED 12" CONC. THROUGH CONC. 6" 16'-10"	4-4"x6"x⅝ L's LACED	TRUSSES AT 15' C.C. 80'	CURTAIN - STEEL SASH TO EAVES WITH CORR. METAL SIDING	NONE	STEEL PURLINS AND CORR. METAL ROOF	PART OF NO 14	
16	ENGINEERING OFFICE	1,249	2	2,498	30	REINFORCED CONCRETE BUILDING D	X			REINF. CONC. 10" 1ST 8" 2ND	22" 1"℄ TIED AT 1'-0" O.C. ON RUN.	SAME AS EXT. COL.		BEARING 10" REINFORCED CONCRETE ON SIDE WALLS 12" THICK ON END WALLS	6" REINFORCED CONCRETE CURTAIN WALL	REINFORCED CONCRETE WITH FELT ROOFING	1,388	SUPERFICIAL DAMAGE 45%
17	RESEARCH LABORATORY	1,735	1		20	STEEL FRAME CONSTRUCTION D		X		BRICK	12½" 4 L's 6"x5" LACED	13½" LACED CROSS BAR ANGLE BRACES	30' 30'	CORRUGATED IRON - CURTAIN WALL	NONE	CORR. IRON ON STEEL PURLINS, PRESSED SEAWEED USED AS INSTALLATION ON UNDERNEATH SIDE	1,735	SUPERFICIAL DAMAGE 10%
17P	ASSEMBLY SHOP	167,924	1		20	STEEL FRAME CONSTRUCTION B2		X		CONC.	11½" 4 L's 4"x4"	SAME AS EXT. COL.	35'	CORR. IRON	NONE	CORR. IRON STEEL PURLINS	24,009	SUPERFICIAL DAMAGE 85%
18	BOILER ROOM	4,649	1		30	STEEL FRAMED CONSTRUCTION PART MILL TYPE D		X		CONC.	6" 24" 10" I SECTION CONC. THROUGH CONC. TO EAVES.	NONE	TRUSSES COMP. FINK AT 20' C.C. 50'	CURTAIN REINF. CONCRETE TO 6'6" ON ENDS OF BUILDING STEEL SASH TO EAVES FR. FLR. TO EAVES ON SIDE	NONE	CORR. SHEET METAL ON STEEL PURLINS	4,649	
25P	ASSEMBLY SHOP	109,704	1		20	PART STEEL FRAME OTHER PART WOOD FRAME B2		X	X	WOOD BLOCKS	11½" LACED 2"x 6" IRONS BOTH SIDES WOOD	SAME AS EXT. COL.	35' 35'	CORR. IRON AND CURTAIN WALL	NONE	CORR. IRON ON WOOD PURLINS	98,742	SUPERFICIAL DAMAGE 10%
33	LOADING CRANE SHED	6,800	1		45	STEEL FRAME CONSTRUCTION D		X		CONC.	5' 4 L's 4"x 4"x⅝ 4 L's 6"x 6" LACED WITH 2"x 8"	NONE	70'	6" CONC. CURTAIN ALONG PART OF SIDE OPEN ABOVE THIS TO EAVES	NONE	CORR. METAL ON STEEL PURLINS	6,800	
42	REPAIR SHOP	37,887	1		40	STEEL FRAME CONSTRUCTION B2				CONC.	10" 4 L's 5"x3½" TIED TO 10'-7" TIED AT 5' SPACING UP COL. LACED	10" 4 L's 5"x3½" LACED & TIED TO 2'-10" 5'-10" SPACING.	TRUSSES AT 17' C.C. 25'	REINFORCED CONCRETE CURTAIN TO 5' STEEL SASH CORR. METAL AND GLASS TO EAVES	NONE	ALTERNATING STEEL AND WOOD PURLINS CORR. METAL ROOF	37,887	
43	TUBING AND ROD SHOP	32,960	1		45	STEEL FRAME CONSTRUCTION B2		X		CONC. WOOD BLOCK & BRICK	ALTERNATING COLS 4 L's 5"x3½" & 4 L's 6"x4" LACED 4 L's 5"x3½"	SAME AS EXT. COL #2	TRUSSES AT 17' C.C. 40'	REINFORCED CONCRETE CURTAIN TO 5' STEEL SASH CORR. METAL AND GLASS TO EAVES	NONE	CORR. METAL ON STEEL PURLINS	32,960	
51	TUBING AND ROD SHOP	182,218	1		60	STEEL FRAME CONSTRUCTION B2		X		CONC	4 L's 3"x3" & 4 L's 5"x3" OUTER L's TIED TO INNER L's WITH CLIP AT 1'-10" UP COL.	SAME AS EXT. COL.	TRUSSES AT 30' C.C. 70'	CURTAIN-6" REINF. CONC. TO 4'6" ABOVE FLOOR STEEL SASH GLASS & CORR. METAL TO EAVES	NONE	CORR. METAL ON STEEL PURLINS	176,111	SUPERFICIAL DAMAGE 5%
55	CASTING DEPT.	12,282	1		14	STEEL FRAME CONSTRUCTION B2		X		CONC.	12" 4 L's 3"x 3" LACED. ⅜" W	6" 7/16	45'	CORR. IRON - CURTAIN WALL	NONE	CORR. IRON ON STEEL PURLINS	8,327	SUPERFICIAL DAMAGE 35%
58	TUBING AND ROD SHOP	159,458	1		32	STEEL FRAME CONSTRUCTION HEAVY MILL TYPE B2		X		BRICK	20" 8"	20" 5/8"	FINK 68'	STEEL SASH AND CORR. IRON ON STEEL PURLINS CURTAIN WALL	NONE	CORR. IRON ON STEEL PURLINS	61,271	SUPERFICIAL DAMAGE 60%
59	PRODUCTION SHOP	14,433	1		20	STEEL FRAME CONSTRUCTION B2		X		BRICK	8" 1¼"	8"	36'	CORR. IRON - CURTAIN WALL	NONE	CORR. IRON ON STEEL PURLINS	9,020	SUPERFICIAL DAMAGE 40%
62	POWER GENERATING HOUSE	3,886	1		30	STEEL FRAME CONSTRUCTION D		X		CONC.	18" 7/16	NONE	FINK 40'	6" REINF. CONC. TO EAVES NON-BEARING SUSPENDING SPANDERAL	NONE	STEEL PURLINS & WOOD FRAMES	3,886	