U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION REPORT 75-105-241
H. C. Smith Company
Minot, North Dakota

DECEMBER 1975

I. TOXICITY DETERMINATION

A health hazard evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) from June 16 through 19, 1975, at seven missile silo sites in the Minot, North Dakota area. At the time of this evaluation, breathing zone and general area air samples were taken for lead, cadmium, chromium, iron oxide fume, and silica. A total of 72 construction workers were interviewed, and 67 blood lead and cadmium determinations were performed. Three elevated blood leads were confirmed. All physical examinations were within normal limits. Breathing zone and area air room samples for lead, cadmium, and iron oxide fume exceeded the most recent hygienic standards.

Based on the results of both medical and environmental evaluations, a potentially toxic condition is judged to exist in the missile silos from occupational exposures to lead, cadmium, and iron oxide fumes.

II. DISTRIBUTION AND AVAILABILITY

Copies of this hazard evaluation determination report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, Fifth and Walnut Streets, Cincinnati, Ohio 45202. Copies have been sent to:

(a) H.C. Smith Company
(b) Laborers International, Local 580, Grand Forks, North Dakota
(c) U.S. Department of Labor - Region VIII
(d) NIOSH - Region VIII

For the purposes of informing the affected employees, the employer shall promptly "post" the Determination Report at each missile silo work site for a period of approximately 30 days.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health,

Education, and Welfare, following a written request by any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health received such a request from the Laborers International, Local 580, Grand Forks, North Dakota, to evaluate the potential hazards associated with welding, sandblasting, and acetylene torch cutting, which are associated with demolition and reconstruction of missile silos.

IV. HEALTH HAZARD EVALUATION

A. Missile Silo Demolition

The missile silos visited during this evaluation were constructed in the 1950's and normally each contains a Minuteman missile. At the present time the Air Force is modifying the silos, which requires extensive alterations to the superstructure. These alterations involve oxyacetylene cutting through metal previously coated with lead-based paint. Other construction work during demolition and reconstruction involves sandblasting, welding, electrical modifications, chipping and grinding, and repainting the missile silo with non-lead-based paint.

Each missile silo work crew has a safety team and team leader trained in first aid. Since the silos are spread out over great distances, two-way radios are at each silo. No nurses are stationed in the field. Wash basins, soap and water are provided. Showers or facilities to change clothes are not provided.

Pre-employment and periodic screening of blood lead levels are not carried out by the H.C. Smith Construction Company.

An overview of the topside of a missile silo may be seen in photographs 1 and 2 of the Appendices. Before any work can be done on the interior of the missile silo, the top must be removed. It is slid off the missile tube on railroad-type tracks as shown in photograph 3. The structure covering the missile silo is also sanded and repainted. Sanding of the cover is shown in photograph 4. Workers may enter the missile silo either by a ladder or in a basket lowered on a winch cable as shown in photograph 5. Once inside the missile tube, the first operation monitored during this evaluation was sandblasting. The lead-based paint is removed from sections of metal which are to be removed by oxyacetylene torches. Photographs 6, 7, and 8 show areas where the paint has been removed (the dark area) and cutting operations which follow. Several of the photographs show airline respirators worn by employees. It was impossible to obtain samples

inside these respirators. However, breathing zone samples were collected on sandblasters by placing the cyclone and filter inside the sandblast helmet. Photograph 9 shows the type of sandblast helmet worn.

The Boeing Company, prime contractor to the U.S. Air Force (sub-contractor, H.C. Smith Co.), has obtained a variance from OSHA, DOL regarding the protection of workers from airborne lead. The variance states that surfaces covered with lead-based paint must be stripped for a distance of two inches from the area where heat is to be applied. This rule was generally not followed at the time of this evaluation. (See Photo 10.) The paint could have been sandblasted away from this section prior to oxyacetylene torch cutting. It is apparent from this discussion that workers may be exposed to elevated and potentially toxic concentrations of lead, silica, chromium, cadmium, and iron oxide fume during the demolition and reconstruction of missile silos.

B. Medical and Environmental Evaluation Design

There are approximately 133 laborers working at numerous missile silos. At one silo sandblasting operations may be in progress; while at another, oxyacetylene cutting, and perhaps welding, may be in progress. In order to obtain both medical and environmental samples of all typical work situations, seven different missile sites were visited.

The following work sites were inspected and are listed with their primary task:

Work Site	Primary Task
G-7	Demolition - Iron Working
G-8	Demolition - Iron Working
G-10	Demolition - Iron Working
H-10	
H-11	Demolition - Iron Working
I-10	Painting

Breathing zone samples were collected on as many workers as possible. These samples were analyzed for lead, cadmium, chromium, iron oxide fume, and silica.

At each work site as many workers as possible were interviewed. Informed consent was obtained from all participants. A questionnaire was administered in a non-directed manner and included the following information: occupational history to the present time; questions dealing with possible work-related illness and complaints; prior history of a blood lead determination; a review of symptoms that might

be related to the individual's job, and a series of questions related to work practices and smoking. A copy of this questionnaire may be found at the back (Attachment I). When deemed necessary by the NIOSH team physician who screened all completed questionnaires, a physical examination was performed, which included a neurological examination as well as an inspection of the skin and conjunctival color, and the presence or absence of a lead line. Blood samples for lead determination were obtained by standard venipuncture techniques; however, care was taken to scrub well the site for venipuncture to diminish the chances of sample contamination. Blood samples from the NIOSH field team were obtained and served as controls. In addition, several duplicate samples were obtained to determine the accuracy and reliability of laboratory results.

C. Evaluation Methods

All environmental metal samples were collected on filters and analyzed by atomic absorption spectroscopy. Blood samples were collected in lead-free containers and also analyzed by atomic absorption spectroscopy. All samples were analyzed at the Western Area Laboratory for Occupational Safety and Health in Salt Lake City, Utah.

D. Evaluation Criteria

1. Environmental Criteria

The three sources of criteria used to assess workroom concentrations of air contaminants in this evaluation are: (1) Recommended and proposed threshold limit values (TLV's) and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH) (1974); (2) occupational health standards as promulgated by the U.S. Department of Labor (Federal Register, June 27, 1974, Title 29, Chapter XVII, Subpart G); and (3) NIOSH criteria for recommended standard.

In the following tabulation of criteria, the most appropriate value is presented with its reference footnoted:

Substance		Permissible Exposures 8-Hour Time-Weighted Exposure Basis	
[1]Lead		0.15 mg/M^3	(a)
[2]Chromium		0.5 mg/M^3	
[3]Cadmium	"C"	0.05 mg/M^3	(b)
[4]Iron Oxide Fume		5.0 mg/M^3	
[5]Silica (Respirable fraction)		50.0 mcg/M	(c)

(a)
mg/M^3 = approximate milligrams of substance per cubic meter of air

(b)
"C" = ceiling concentration and should never be exceeded

(c)
g/M^3 = approximate micrograms of substance per cubic meter of air

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[1]Reference: 1974 ACGIH TLV and NIOSH criteria for recommended standard.
[2]Reference: 1974 ACGIH TLV and current OSHA standard.
[3]Reference: 1974 ACGIH TLV (notice of intended changes).
[4]Reference: 1974 ACGIH TLV (notice of intended changes).
[5]Reference: NIOSH criteria for recommended standard-1974.

Occupational health standards are established at levels designed to protect individuals occupationally exposed to individual toxic substances on an 8-hour per day, 40-hour per week basis over a normal working lifetime.

2. Medical Criteria

The medical criteria used to determine a toxic exposure to a substance consist of the signs and/or symptoms associated with exposure to the substance as well as the blood level determination and/or other biological tests.

The agent of primary concern and the one specifically noted in the Health Hazard Request is inorganic lead. H.C. Smith Company has received an OSHA variance permitting elevated air concentrations of inorganic lead in the silos provided airline respirators are worn.

Other air contaminants that were investigated include: chromium, cadmium, iron oxide fumes, and silica.

(a) Lead

Inorganic lead dust and fumes are generated during the air arcing, sandblasting and chipping and grinding procedures. The routes of absorption of lead are via the respiratory tract and gastrointestinal tract. Contamination of food and cigarettes are major routes of ingestion of lead and are the result of poor work practices. Hobbies involving the use of lead may pose another potentially hazardous exposure.

The classic signs and symptoms of chronic lead poisoning are: (1) lead colic characterized by poorly localized abdominal cramps; (2) constipation; (3) anemia; (4) "lead line" along the gum margins, and (5) peripheral neuropathy. Other lead-related medical illnesses include encephalopathy and nephropathy.

The absorption of lead by any route is slow and prolonged exposure is required for the development of signs and symptoms. The early diagnosis of lead poisoning prior to the development of irreversible damage and/or symptoms is of great importance. At the present time NIOSH recommends that an unacceptable absorption of lead posing a risk of lead poisoning is demonstrated at levels of 80 mcg Pb/100 ml whole blood or greater. However, at the present time there is much evidence to suggest that this "safe" level should be reduced to 60 mcg Pb/100 ml.

(b) Chromium

The chief exposure to chromium containing substances in American industry is believed to be an acid-soluble water-insoluble chromate-chromite mixture produced in the production of chromates. The existence of a serious lung cancer hazard to workers in the production of chromates from chromite ore has been known for some time. Chrome ulcers and dermatitis are especially common among chromate workers in plating and anodizing operations. Much of the above is not applicable to the present hazard evaluation.

(c) Cadmium

Industrial exposure to Cadmium (Cd) may occur from the fumes emitted from the smelting of unpure zinc and in the distillation of Cd-sponge. The most common cases of accidental industrial exposure to Cd occurs in remelting scrap not suspected to contain Cd. Welding and cutting of metals containing cadmium are another source of exposure to cadmium fumes. Normal human blood is very low and highly variable in cadmium content. One study reported a range of 0.3 to 5.4 mcg Cd/100 ml with a median

concentration of 0.7 mcg. Another study determined the cadmium content of the blood of 243 adults from 19 cities in the United States. Less than one-half of the samples had detectable amounts of cadmium by the atomic absorption method used, and no consistent geographic pattern was apparent. More than half the samples had 0.50 mcg Cd/100 ml or less, and 83% had less than 1 mcg/100 ml. The median concentration was about 0.5 mcg/100 ml. Chronic exposure to cadmium fumes may cause emphysema and kidney injury, characterized by proteinuria.

(d) Iron Oxide

Prolonged, excessive exposure to this agent gives rise to "iron pigmentation" of the lungs, known as siderosis, which is, at the present time, considered a benign pneumoconiosis in that it does not lead to progressive pulmonary fibrosis (scarring) or predispose to lung cancer and tuberculosis as do asbestosis and silicosis, respectively. This type of dust or fume is found in a number of occupations such as welding, iron ore mining, foundry work, and fettling operations. Regarding the systemic absorption of iron from iron oxide inhalation, no evidence of systemic disease has been noted. With regard to local effects, mucous membrane irritation of the upper respiratory tract and sinuses have been known to occur with excessive exposure to this agent.

(e) Silica

In contrast to the nuisance dusts, the inhalation of excessive amounts of free crystalline silica results in permanent lung damage which may be progressive when exposure is stopped. Usually many years of exposure are required to initiate silicosis, unless massive exposure has occurred. The symptoms of silicosis are progressive shortness of breath and cough. Pulmonary function tests and chest X-rays are useful in diagnosing silicosis. Tuberculosis and other respiratory diseases are frequently associated with silicosis during its chronic course.

E. Evaluation Results

1. Environmental Results

Results of environmental samples show that hygienic standards were exceeded for lead, cadmium, and iron oxide fume. Exposure to free crystalline silica was below the presently recommended standard. To review the actual levels found, please refer to Tables I through V in the Appendices.

2. Medical Results

Seventy-two (72) persons were interviewed. The following list shows the number of persons interviewed by site:

Work Site	Number Interviewed
G-7	8
G-8	15
G-9	12
G-10	11
H-10	5
H-11	13
I-10	8
TOTAL	72

A total of 34 persons were examined. All physical examinations were unremarkable and within normal limits.

Analysis of the questionnaires revealed that 54 persons had no symptoms or complaints that the employee throught were related to his job when asked directly. The following list shows the types of problems elicited by Question #9 ("Do you have or have you had in the past any health complaints or problems which you feel are related to your present job?"):

Elevated Blood Lead Determinations	3
Mucous Membrane Irritation	2
Fatigue	8
Burns	1
Constipation	1
Chest Discomfort	1
Backache	2
None	54
TOTAL	72

The results of the review of symptoms (Question #11) have been tabulated and are found in Table VI. It can be readily seen that only 18 persons (25%) had negative review of symptoms, whereas 54 persons reported symptoms. This apparent discrepancy between the results of Questions #9 and #11 cannot be adequately explained. The following symptoms were reported: fatigue, 28%; confusion and poor memory, 0%; irritability, 19%; difficulty falling asleep, 10%; change in bowel habits, 2%; abdominal pain, 3%; muscle weakness, 10%; paralysis, 0%; and poor appetite, 10%. None are very specific

or diagnostic of lead toxicity. Fatigue was noted more frequently than the other symptoms noted above but, as will be discussed below, the presence of symptoms could not be correlated with an elevated mean blood lead determination. Other more frequently noted symptoms were: irritation of mucous membranes of the eyes, 36%; of the throat, 24%; and the upper respiratory tract, 18%; and a metallic taste in the mouth, 43%. Almost 99% of all symptoms were reported by men working on the demolition crews.

Twenty-five (25) employees reported having had previous blood lead determinations some of which were distinctly abnormal. The results of these tests and the individual's NIOSH blood lead determinations are found on Table VII. Three prior determinations were grossly elevated and these individuals were removed from the missile silos and were given jobs where the exposure to lead fumes might be less. Four others were greater than 60 mcg Pb/100 ml.

With respect to work practices, only two persons out of 72 (3%) admitted to not wearing respirators in the silos. In addition, 20 persons (28%) did not regularly wash before eating whereas 52 persons (72%) did wash regularly. Forty-six (46) persons (64%) admitted to smoking on the job and presumably down in the silos, whereas 26 persons (36%) did not smoke on the job. These data are summarized on Table VIII.

Blood samples for lead and cadmium determinations were obtained from 58 construction workers along with 9 split samples for a total of 67 determinations from the exposed population. Six (6) control samples were obtained. One sample clotted and could not be analyzed. Blood was collected in heparinized non-lead containing glass tubes, used specifically for blood lead determination. Blood lead and cadmium determinations were done by the atomic absorption method. The following are the limits of detection established for the samples submitted: cadmium, 0.033 mcg/sample; lead, 0.75 mcg/sample. There is, in general, good correlation between the results of the split samples for lead which are listed below:

Exposed Group: (mcg Pb/100 ml): 32.4/39.0, 41.1/54.0, 43.9/40.4, 21.3/24.2, 35.9/18.5, 46.2/54.9, 43.7/48.2 34.2/35.9, 39.3/43.3.

Control Group: (mcg Pb/100 ml): 16.4/16.0.

The mean blood lead value (±2 standard deviations) for the 67 determinations from the construction workers was 37.4 mcg Pb/100 ml ±23.2 mcg Pb/100 ml with a range from 15.9 mcg/100 ml to 64.2 mcg/100 ml. The mean value for the control samples was 13.5 mcg Pb/100 ml ±4.00 with a range from 11.4 mcg to 16.4 mcg. Forty-five cadmium determinations (67%) from the construction workers were essentially nondetectable, less than 0.30 mcg/100 ml. The remaining 22 determinations had a mean value of 1.47 mcg Cd/100 ml with a range from 0.45 - 10.2 mcg Cd/100 ml. Only one sample was greater than 5.0 mcg Cd/100 ml. All six control samples were less than 0.30 mcg/100 ml. A table containing the results of all blood lead and cadmium determinations done by NIOSH may be found at the back (Table IX).

Histogram describing the distribution of the 67 lead determinations from the exposed group is found at the back (Figure I). As can be seen, only three determinations are greater than 60 mcg/100 ml, while the majority are between 30-50 mcg/100 ml. The three individuals with blood lead determinations greater than 60 mcg Pb/100 ml. were all construction workers involved in the demolition jobs. Only one had had a prior blood lead determination which was 101 (units not known).

Focusing specifically on the individuals who had an abnormal (defined as 60 mcg Pb/100 ml or greater) blood lead determination (done either by NIOSH or by another laboratory), the survey revealed eight individuals, who noted the following "recent" symptoms: two noted fatigue alone; one noted fatigue, difficulty falling asleep, muscle/joint soreness, and a metallic taste in his mouth; one noted weight loss; one noted muscle/joint soreness alone; and two were asymptomatic. All were construction workers. As mentioned before, none of the symptoms are very specific for lead poisoning.

The data were analyzed to see if any of several variables affected the mean blood lead values. The analysis of variance method was employed. The several variables considered were: hand washing prior to eating; smoking at the work site (and presumably in the silo); the several work sites; the presence of symptoms; and duration of time at the job. The results of these comparisons are found on Table X. The mean values for each of the variables are equal with the exception of the work site. This finding was not unexpected since I-10 was a painting operation and the painters had lower blood lead levels and supports the fact that the demolition crews have a greater exposure to and systemic absorption of lead.

F. Summary of Investigations and Conclusions

A medical and environmental evaluation was conducted among missile silo construction workers. The purpose of this study was to assess the concentrations of air contaminants in the work area as well as to detect early lead poisoning resulting from exposure to inorganic lead fumes generated during the various demolition procedures.

Breathing zone and general room samples were taken for lead, cadmium, chromium, iron oxide, and silica. Breathing zone and general room samples for lead, cadmium, and iron oxide fume exceed the most recent hygienic standards.

Medical questionnaires were administered, physical examinations were performed when necessary and blood was obtained for lead determination. A total of 72 persons were interviewed and 67 blood lead and cadmium determinations were performed. Three abnormally elevated blood lead determinations (greater than 60 mcg Pb/100 ml whole blood) were confirmed. All physical examinations were within normal limits. Review of the medical questionnaires revealed that 43% of employees noted a metallic taste in the mouth; 36% reported eye irritation; 31% reported muscle and/or joint soreness; 28% reported fatigue; 24% reported throat irritation, and 19% reported irritability. The symptoms and other complaints noted in the medical questionnaires cannot be correlated with blood levels since there was no difference between the mean blood levels of symptomatic and asymptomatic individuals. Moreover, no significant differences between mean blood levels could be found when considering hand washing prior to eating, smoking habits on the job, and length of employment. The results of the blood lead determinations revealed a mean blood level for the construction workers of 37.4 mcg Pb/100 ml whole blood ±23.2 mcg Pb/100 ml with a range from 15.9 mcg/100 ml to 64.2 mcg/100 ml. The results of the blood cadmium determinations revealed that 67% of the samples had 0.50 mcg Cd/100 ml or less, and that 90% were less than 1 mcg/100 ml. All samples except one were less than 5.0 mcg Cd/100 ml.

Based on the results of this survey, it appears that a potentially toxic situation exists. This conclusion is based on the following evidence: elevated air concentration of lead, cadmium, and iron oxide fumes; several elevated blood lead levels were confirmed despite the use of airline respirators were found; the differences between the blood lead levels for the painters and other construction workers were significantly different; and the fact that workers admit to smoking in the silos and not washing prior to eating.

V. RECOMMENDATIONS

1. It would, therefore, appear that certain protective measures, biologic surveillance every three months, and the limitation of employee exposure be implemented as long as the OSHA variance remains operative. Protective clothing and airline respirators are mandatory and the habit of smoking in the silos should be strictly prohibited. In view of the elevated blood lead levels found by the NIOSH survey, periodic biologic monitoring should be carried out no less than every three months. If a blood lead level of 60 mcg/100 ml or greater is found, and confirmed by a second sample taken within two weeks, the employee should be removed from exposure until the blood lead level is reduced to less than 60 mcg/100. In addition, more sensitive tests for lead toxicity such as urinary delta-aminolevulinic acid (ALA) should be performed as well as a hemoglobin determination. The employee should not be returned to his former job or job area until his blood lead determination is less than 60 mcg/100 ml.

2. Workers should be made aware of the potential dangers from overexposure to silica-containing agents, and fumes and dusts of inorganic lead, cadmium, and iron oxide resulting from improper care and use of airline respirators and poor work practices.

3. Employees should be prohibited from eating, drinking, or smoking inside missile silos.

4. Employees should be informed not to carry their cigarettes (even though they are not smoking them) inside the missile silo, since contaminants may concentrate in the cigarettes.

5. The present system provided for the workers to wash prior to eating is inadequate. Provisions should be made for adequate supply of water.

VI. REFERENCES

1. E. J. Underwood, Trace Elements in Human and Animal Nutrition, New York: Academic Press, 1971.

2. F. A. Patty, ed., Industrial Hygiene and Toxicology, 2nd ed., New York: Interscience Press, 1963.

VII. AUTHORSHIP AND ACKNOWLEDGEMENT

Report Prepared By:

Bobby J. Gunter, Ph.D.
Regional Industrial Hygienist
NIOSH - Region VIII
Denver, Colorado

Robert Rostand, M.D.
Medical Officer
Medical Services Branch - NIOSH
Cincinnati, Ohio

Study Participants:

Eileen Philbin, R.N.
Nurse Consultant
Medical Services Branch - NIOSH
Cincinnati, Ohio

Edward Burroughs
Industrial Hygienist
Hazard Evaluation Services Branch - NIOSH
Cincinnati, Ohio

G. Robert Schutte
Medical Technician
Medical Services Branch - NIOSH
Cincinnati, Ohio

Originating Office:

Jerome P. Flesch, Chief
Hazard Evaluation Services Branch - NIOSH
Cincinnati, Ohio

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ATTACHMENT I

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
518 POST OFFICE BUILDING
CINCINNATI, OHIO 45202

CONSENT

I voluntarily agree to participate in a study conducted by the U.S. Public Health Service. I understand that the medical evaluation will consist of my answering questions about my health, a blood test for lead and cadmium, and a limited physical examination, if deemed necessary by the examing physician.

I understand that my participation in this study is voluntary and that all information obtained will be considered confidential in accordance with U.S. Public Health Service Regulation (42 CFR Part).

Date _____ Signature _____

AUTHORITY TO GIVE MEDICAL REPORT

I agree to allow the Public Health Service to inform:

A. My personal physician

Name _____

Address _____ _____
Signature

City _____

B. Plant physician

Name _____

Address _____ _____
Signature

City _____

of any significant results of this study.

Information obtained in this study will be kept confidential in accordance with U.S. Public Health Service Regulation (42 CFR Part 1).

(6/75)

OCCUPATIONAL HISTORY TABLE

Complete the following table showing the entire work history of the individual from present to initial employment. Sporadic, part-time periods of employment (6 months or less) should be omitted.

Present Work:

Employer & Location	Tenure of Employment From Mo./Hr.	To Mo./Hr.	Occupation or Job Title	No. of Years on Job

1. Name _____
   Last First Middle

2. Current Address: (Number, Street or Rural Route, City or Town, County, State, Zip Code)

   _____

   _____

   _____

3. Phone Number _____ 4. Social Security No. _____

5. Birthday (Month, Day, Year) _____

6. Age Last Birthday _____ 7. Sex: 1 /__/ 2 /__/ Female

8. Race: Black /__/ White /__/ Other /__/

9. Do you have or have you had in the past any health complaints or problems which you feel may be related to your present job?

   Yes _____ No. _____ If "Yes":

   a. What are they? _____

   _____

   _____

   b. What do you feel they are related to and why? _____

   _____

   _____

   c. When and how often do they occur? _____

   _____

   d. Have you seen a physician in this regard?

      Yes _____ No _____

   e. Have you had a blood test for lead? Yes _____ No _____

      If yes, where and when?

REQUEST AND AUTHORIZATION FOR RELEASE OF MEDICAL INFORMATION

I, _____ , hereby

request and authorize _____
(Personal and/or Company Physician)

_____

_____
(Address)

to release to the National Institute for Occupational Safety and Health (NIOSH) such of my medical records as are requested by NIOSH as a part of Health Hazard Evaluation Number _____.

Date _____ Signature of Worker _____

Witness _____

10. Do you have any present problems for which you are seeing a doctor?
Yes _____ No _____ If "yes", what are they? _____

_____

_____

11. Have you recently experienced any of the following which you believe are related to your job?

	No	Yes
a. dry or sore throat	____	____
b. burning or itching eyes	____	____
c. cough	____	____
d. fatigue	____	____
e. headache	____	____
f. dizziness	____	____
g. confusion	____	____
h. poor memory	____	____
i. irritable	____	____
j. difficulty falling asleep	____	____
k. nausea/vomiting	____	____
l. weight loss	____	____
m. recent change in bowel habits	____	____
n. abdominal pain	____	____
o. muscle weakness	____	____
p. muscle and/or joint soreness	____	____

	No	Yes	
q. paralysis	____	____	_____
r. fever and chills	____	____	_____
s. poor appetite	____	____	_____
t. metallic taste in mouth	____	____	_____

12. Do you smoke on the job? Yes _____ No _____

    a. Do you wash your hands and face before smoking? Yes ____ No ____

13. Do you eat or drink at work site? Yes ____ No ____

14. Do you wash before eating or drinking? Yes ____ No ____

15. Do you change your clothing and shower before going home at the end of the shift? Yes ____ No ____

16. Do you use a respirator on the job? Yes ____ No ____

    Is it in working order? Yes ____ No ____

    How much time do you use it? Yes ____ No ____

17. Do you drink moonshine? Yes ____ No ____

18. Do you have any hobbies that would expose you to lead? Yes ____ No ____

PHYSICAL EXAM

1. Skin color

   Pallor _____

   Yellow discoloration _____

2. Conjunctival color _____

3. Lead line

4. Muscle strength

   finger squeeze

   biceps

   triceps

   quads

   wrist extensors

   toe walking

   heel walking

5. Gait

6. Tremor

7. Deep tendon reflexes

8. Sensory exam.

TABLE I

ATMOSPHERIC CONCENTRATIONS OF
LEAD, CHROMIUM, CADMIUM, AND IRON

H-11 Missile Site
June 17, 1975

Sample Number	Location	Time of Sample (min.)	Atmospheric Concentrations Lead	Chromium	Cadmium	Iron Fume	Type Sample
			mg/M^3				
H-11-2	Inside Minuteman Missile Silo	67	19.0	.05	.23	14.0	OBZ
H-11-3	"	185	1.5	.01	.02	5.5	OBZ
H-11-4	"	360	2.5	.01	.11	5.7	OBZ
H-11-5	"	197	4.3	.02	.25	7.3	General Room
H-11-6	"	195	2.8	<.01	.22	2.8	General Room
H-11-7	"	310	0.02	<.01	.00	1.1	OBZ
H-11-8	"	130	2.4	<.02	.24	4.5	OBZ
H-11-9	"	152	4.4	.02	.07	5.1	General Room
H-11-10	"	207	2.1	<.01	.06	2.2	OBZ
	HYGIENIC STANDARDS		0.15	.5	C .05	5.0	

OBZ = Operator's Breathing Zone

C = Ceiling concentration and should never be exceeded

TABLE II

ATMOSPHERIC CONCENTRATIONS OF
LEAD, CHROMIUM, CADMIUM, AND IRON

G-7 Missile Site

June 19, 1975

Sample Number	Location	Time of Sample (min.)	Atmospheric Concentrations Lead	Chromium	Cadmium	Iron Fume	Type Sample
				mg/M^3			
G-7-1	Inside Minuteman Missile Silo	135	.01	<.005	<.02	0.12	OBZ
G-7-2	"	157	.008	<.004	<.01	0.06	OBZ
G-7-3	"	148	.16	<.005	<.01	1.02	OBZ
G-7-4	"	147	.63	.032	<.01	3.6	OBZ
G-7-5	"	131	.20	.005	<.02	1.6	OBZ
G-7-6	"	144	.19	<.005	<.01	1.5	OBZ
G-7-7	"	141	.5	.009	<.01	3.8	OBZ
G-7-8	"	113	.08	.012	<.02	1.3	OBZ
G-7-9	"	112	.2	<.006	<.02	1.5	OBZ
	HYGIENIC STANDARDS		0.15	.5	C .05	5.0	

OBZ = Operator's Breathing Zone

C = Ceiling concentration and should never be exceeded

TABLE III

ATMOSPHERIC CONCENTRATIONS OF
LEAD, CHROMIUM, CADMIUM, AND IRON

G-9 Missile Site

June 18, 1975

Sample Number	Location	Time of Sample (min.)	Atmospheric Concentrations mg/M^3 Lead	Chromium	Cadmium	Iron Fume	Type Sample
G-9-1	Inside Minuteman Missile Silo	248	0.008	< 0.002	< .002	2.7	OBZ
G-9-2	"	242	0.033	< 0.002	.006	4.0	OBZ
G-9-3	"	218	0.73	0.08	.024	16.4	OBZ
G-9-4	"	219	0.5	0.06	.02	15.0	OBZ
G-9-5	"	179	1.3	0.14	.03	14.0	OBZ
G-9-6	"	171	0.9	0.04	.04	14.0	OBZ
G-9-7	"	178	1.0	0.007	.01	6.6	OBZ
G-9-8	"	147	5.3	1.0	.08	63.2	OBZ
G-9-9	"	161	1.4	0.008	.04	12.0	OBZ
G-9-10	"	138	3.5	< 0.002	.01	5.0	OBZ
	HYGIENIC STANDARDS		0.15	.5	C .05	5.0	

OBZ = Operator's Breathing Zone

C = Ceiling concentration and should never be exceeded

TABLE IV

ATMOSPHERIC CONCENTRATIONS OF
LEAD, CHROMIUM, CADMIUM, AND IRON

G-10 Missile Site

June 17, 1975

Sample Number	Location	Time of Sample (min.)	Atmospheric Concentrations Lead	Chromium mg/M^3	Cadmium	Iron Fume	Type Sample
H-10-1	Inside Minuteman Missile Silo	276	.21	.005	< .003	0.38	OBZ
H-10-3	"	280	.20	< .001	< .003	1.2	OBZ
	HYGIENIC STANDARDS		.15	.5	C .05	5.0	

OBZ = Operator's Breathing Zone

C = Ceiling concentration and should never be exceeded

TABLE V

ATMOSPHERIC CONCENTRATIONS OF
FREE SILICA

H -10 Missile Site

June 15, 1975

Sample Number	Location	Time of Sample (min.)	Atmospheric Concentrations Free Silica $\mu g/M^3$	Type of Sample
MP-21	Underneath air-supplied sand blasting hood; inside Minuteman Missile Silo	212	< 20.0	OBZ
MP-6	"	208	< 20.0	OBZ
	HYGIENIC STANDARD		50.0	

OBZ = Operator's Breathing Zone

TABLE VI

REVIEW OF RECENT SYMPTOMS

LOCATION	THROAT IRRITATION	EYE IRRITATION	COUGH	FATIGUE	HEADACHE	DIZZINESS	CONFUSION	POOR MEMORY	IRRITABLE	DIFFICULTY FALLING ASLEEP	NAUSEA/VOMITING	WEIGHT LOSS	BOWEL HABIT CHANGES	ABDOMINAL PAIN	MUSCLE WEAKNESS	MUSCLE/JOINT SORENESS	PARALYSIS	FEVER/CHILLS	POOR APPETITE	METALLIC TASTE IN MOUTH	TOTAL NO. OF COMPLAINTS/ NO. OF PERSONS COMPLAINING	NO. OF PERSONS WITHOUT COMPLAINTS
G-7 (N=8)	2	1	1	3	2	1	0	0	0	1	0	1	0	0	0	3	0	0	0	2	17/6	2
G-8 (15)	7	9	5	8	2	0	0	0	5	4	0	1	0	1	5	7	0	0	4	10	56/15	0
G-9 (12)	1	4	0	2	1	2	0	0	4	0	0	0	0	0	0	3	0	0	0	6	25/9	3
G-10 (11)	3	8	3	1	1	2	0	0	1	0	0	1	1	0	1	5	0	0	1	8	36/9	2
H-10 (5)	2	1	3	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	11/5	0
H-11 (13)	2	1	1	4	0	0	0	0	3	1	0	1	0	0	0	3	0	0	1	3	20/7	6
I-10 (8)	0	2	0	1	1	1	0	0	0	0	1	1	0	1	1	0	0	0	1	1	11/3	5
TOTAL (n=72)	17	26	13	20	7	6	0	0	14	7	1	5	1	2	7	22	0	0	7	31	176/54	18/72(25%)
Percent	24%	36%	18%	28%	10%	8%	0	0	19%	10%	2%	7%	2%	3%	10%	31%	0	0	10%	43%		

TABLE VII

SUBJECT NUMBER	PREVIOUS BLOOD Pb DETERMINATIONS	NIOSH Pb DETERMINATION	APPROXIMATE TIME BETWEEN SAMPLING
4	67	36.2	1 mo.
5	44	32.4/39.0	1 mo.
8	101	64.1	1 mo.
10	126-171	N.D.*	-
13	53	34.5	2 mo.
23	135	40.5	1 mo.
27	18	64.2	1 mo.
30	25	25.8	1 mo.
36	47	44.2	2 mo.
38	44	26.9	2 mo.
39	48	25.9	2 mo.
44	52	44.4	3 mo.
45	24/31	N.D.	-
46	31	33.3	1 mo.
47	31	N.D.	-
48	31	46.2/54.9	2 mo.
49	31	43.7/48.2	1 mo.
54	51/61	N.D.	-
57	44	34.2/35.9	1 mo.
59	47	39.5	1 mo.
60	39	33.2	2 mo.
61	46	43.6	2 mo.
63	77/29	31.1	3 mo.-6 wks
65	50	40.6	2 mo.
67	46	39.3/43/3	3 wks

*Not Done

TABLE VIII

1.	PREVIOUS BLOOD LEAD DETERMINATIONS	YES - 25	(35%)
		NO - 47	(65%)
2.	SMOKING ON THE JOB	YES - 46	(64%)
		NO - 26	(36%)
3.	WASHING REGULARLY PRIOR TO EATING	YES - 52	(72%)
		NO - 20	(28%)

TABLE IX

BLOOD LEAD AND CADMIUM DETERMINATIONS

SUBJECT NO.	BLOOD LEAD DETERMINATIONS (mcg Pb/100 ml)	BLOOD CADMIUM DETERMINATIONS (mcg Cd/100 ml)
2	37.9	1.26
3	46.6	<0.30
4	36.2	<0.30
5	32.4/39.0	<0.30
7	30.7	0.99
8	64.1	0.77
9	41.1/54.0	1.70/10.2
12	43.9/40.4	1.23/0.90
13	34.5	<0.30
14	12.8	0.64
16	43.4	<0.30
17	26.6	0.88
18	33.9	1.22
22	35.7	0.56
23	40.5	0.55
24	44.4	<0.30
25	30.0	<0.30
26	44.7	<0.30
27	64.2	<0.30
28	44.9	<0.30
29	62.0	<0.30
30	25.8	<0.30
31	30.9	<0.30
32	51.7	<0.30
33	19.7	<0.30
34	21.3/24.2	0.87/0.63
35	18.8	<0.30
36	44.2	0.90
37	43.5	1.93
38	26.9	<0.30
39	25.9	<0.30
40	20.0	<0.30
41	35.9/18.5	<0.30
43	50.1	<0.30
44	44.4	<0.30
46	33.2	<0.30
48	46.2/54.9	<0.30/0.77
49	43.7/48.2	<0.30
50	28.9	<0.30
56	20.7	<0.30
57	34.2/35.9	<0.30/3.38
59	39.5	<0.30

TABLE IX

BLOOD LEAD AND CADMIUM DETERMINATIONS

SUBJECT NO.	BLOOD LEAD DETERMINATIONS (mcg Pb/100 ml)	BLOOD CADMIUM DETERMINATIONS (mcg Cd/100 ml)
60	33.2	< 0.30
61	43.6	< 0.30
63	31.1	< 0.30
64	42.3	< 0.30
65	40.6	< 0.30
66	45.2	< 0.30
67	39.3/43.3	< 0.30/0.88
72	50.1	< 0.30
73	15.9	0.96
74	48.6	< 0.30
75	22.9	< 0.30
76	42.5	0.63
77	43.7	< 0.30
78	23.1	< 0.30
79	47.4	< 0.30
80	16.7	0.45

TABLE X

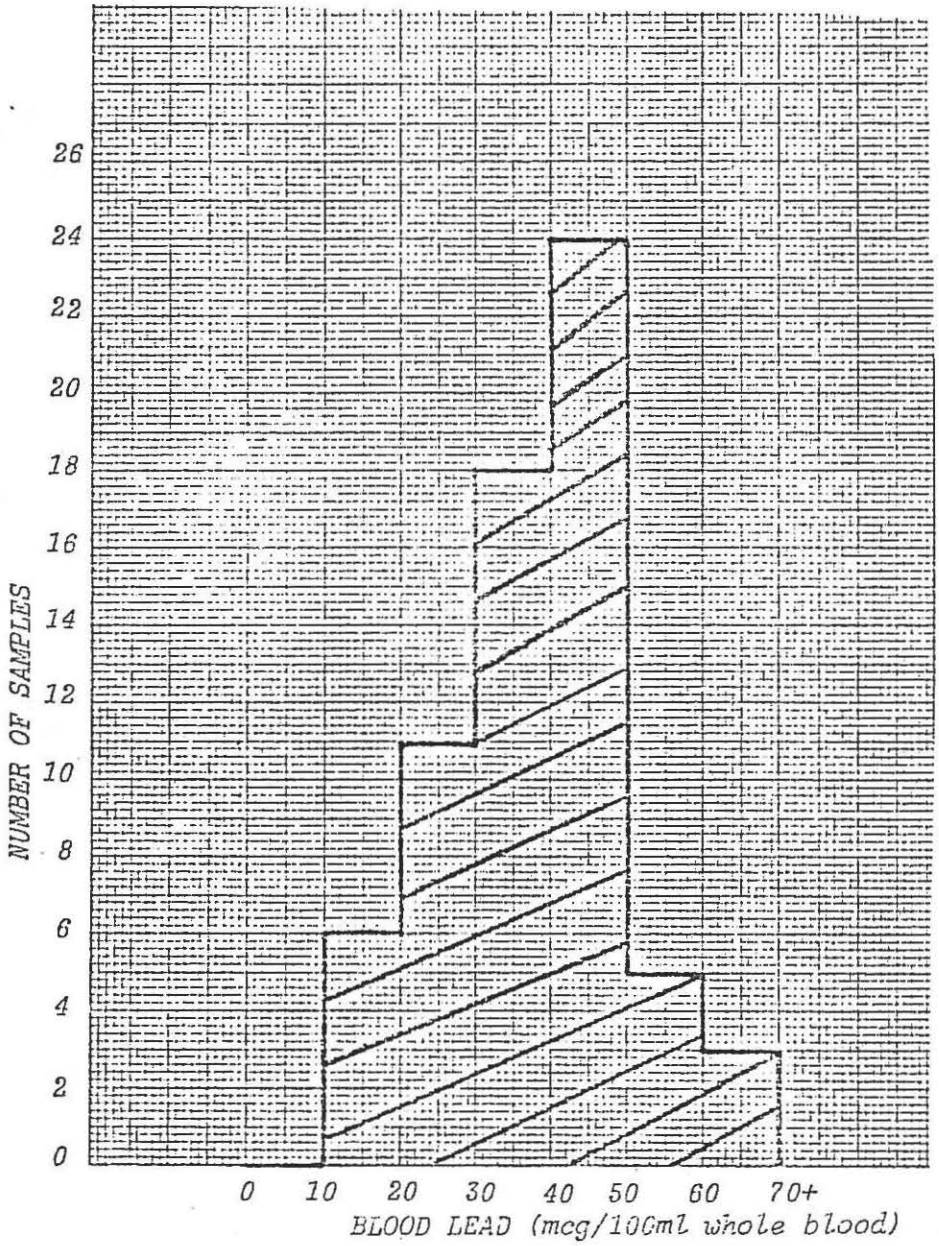
VARIABLE		MEAN BLOOD LEAD DETERMINATION (mcg Pb/100 ml)		STATISTICAL RESULTS
1. HANDWASHING		Regular Washing	No Washing	
		36.5	41.8	N.S.*
2. SMOKING HABITS		Smoking at Work Site	No Smoking	
		38.9	36.1	N.S.
3. WORK SITE				
	I-10	28.0		
	H-11	41.7		
	G-10	39.3		p<0.01
	H-10	46.3		
	G-9	39.4		
	G-7	43.1		
	G-8	31.4		
4. SYMPTOMATOLOGY		Symptomatic for Lead Toxicity	Assymptomatic+	
		39.7	33.2	N.S.
5. DURATION OF EMPLOYMENT				
	0-4 months	35.9		
	5-8 months	39.2		
	9-12 months	40.4		
	>12 months	36.3		

* Not Significant - $p>0.05$

+ The assymptomatic group contains several persons who reported only mucous membrane irritation.

FIGURE I

BLOOD LEAD DETERMINATIONS



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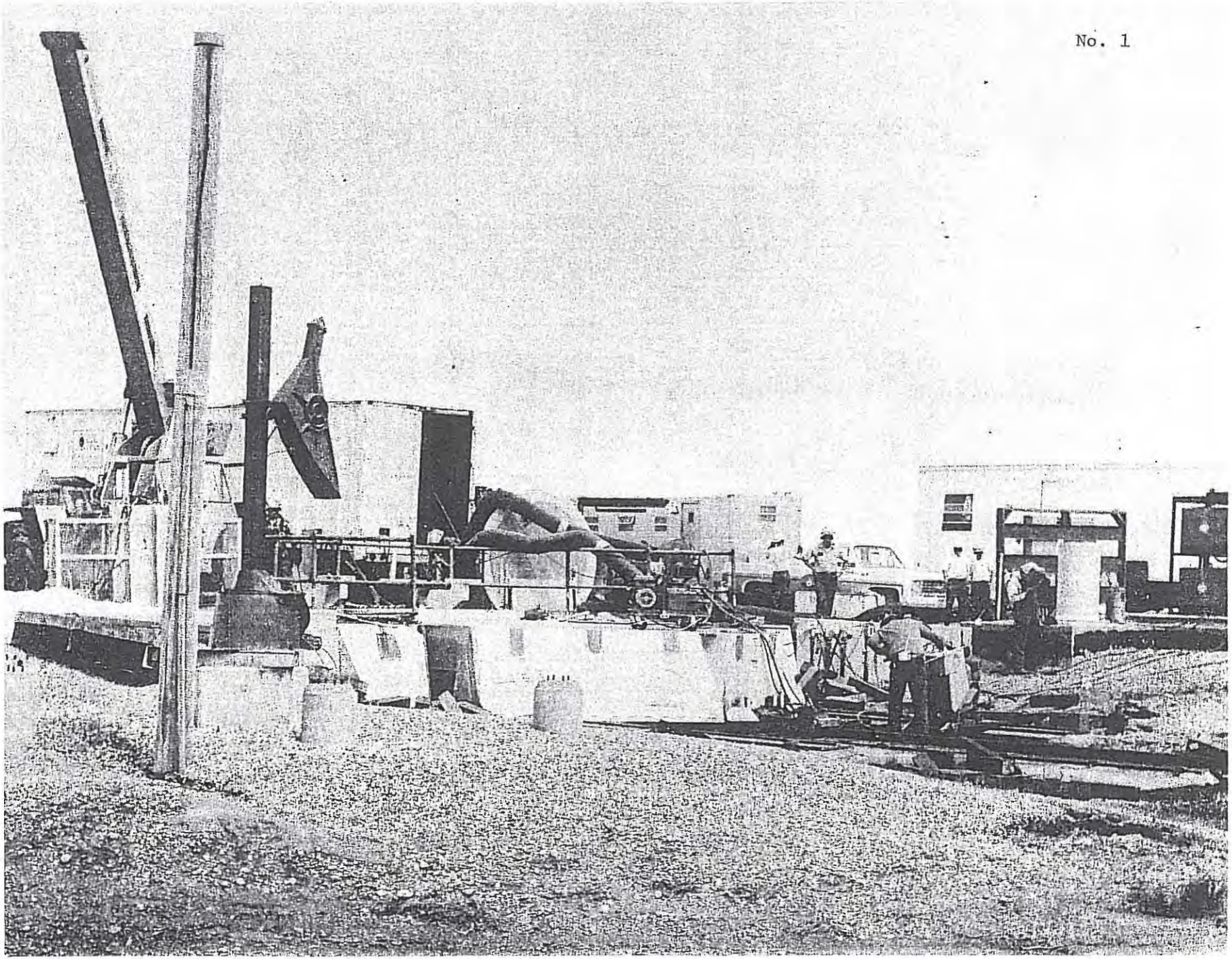

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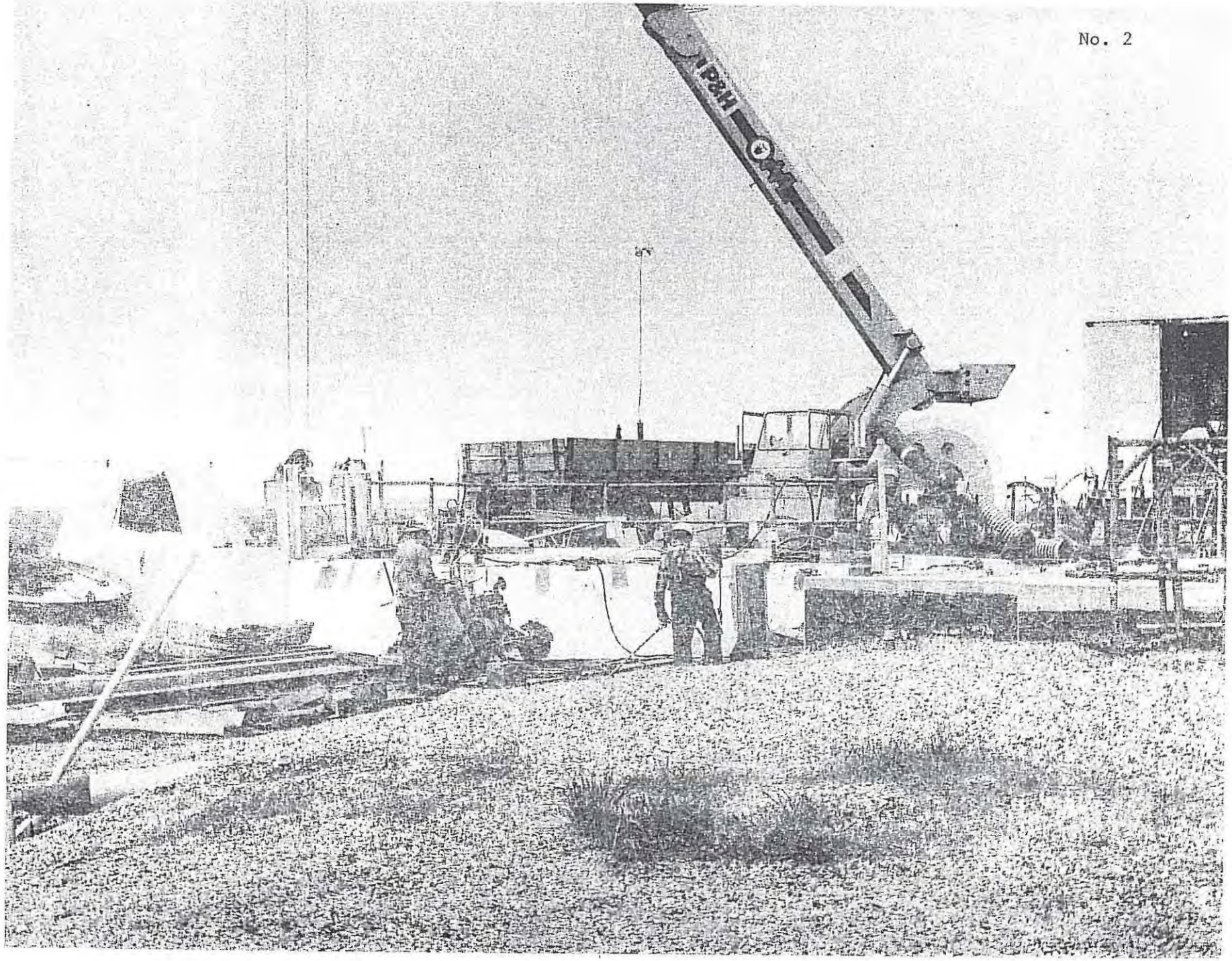

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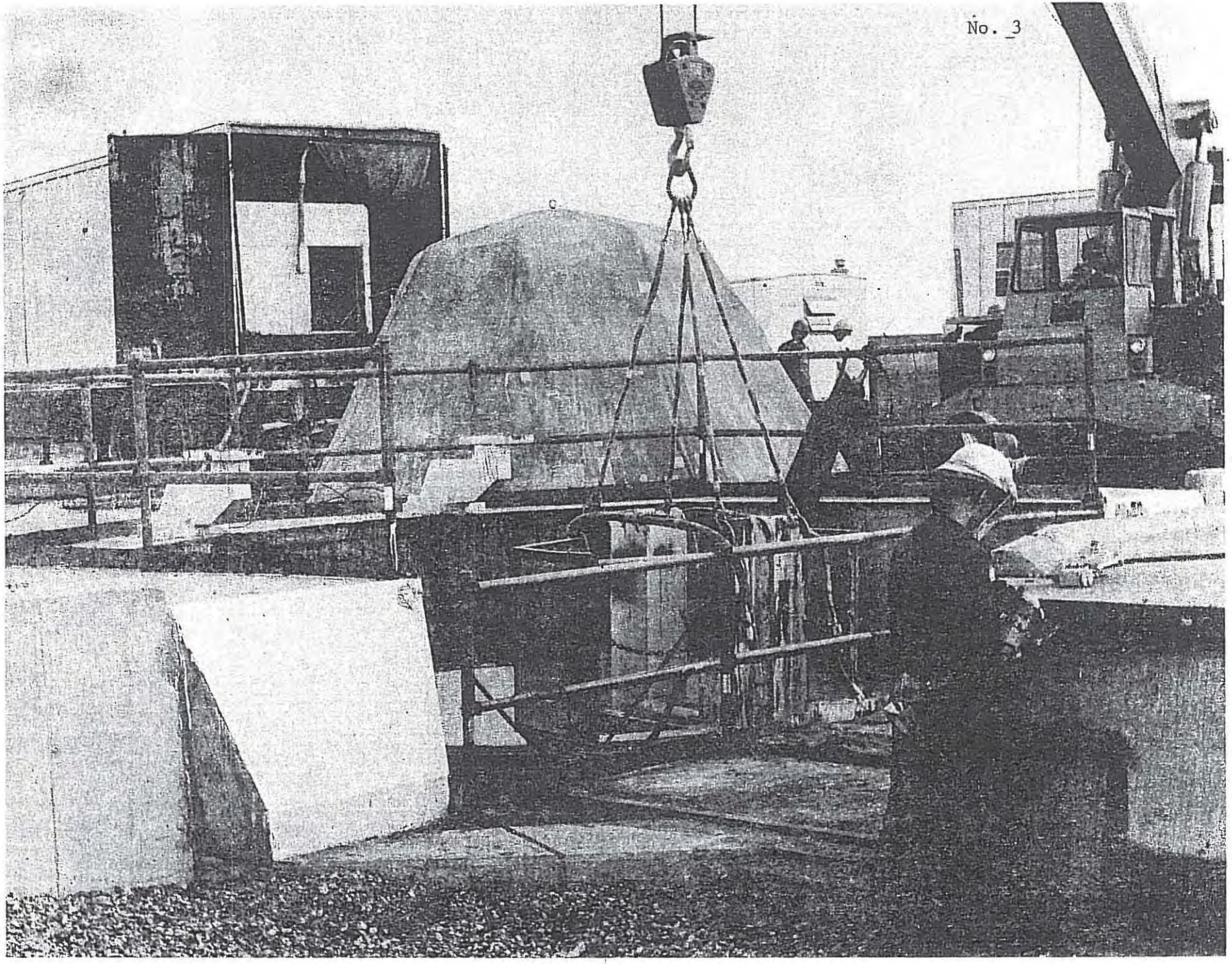

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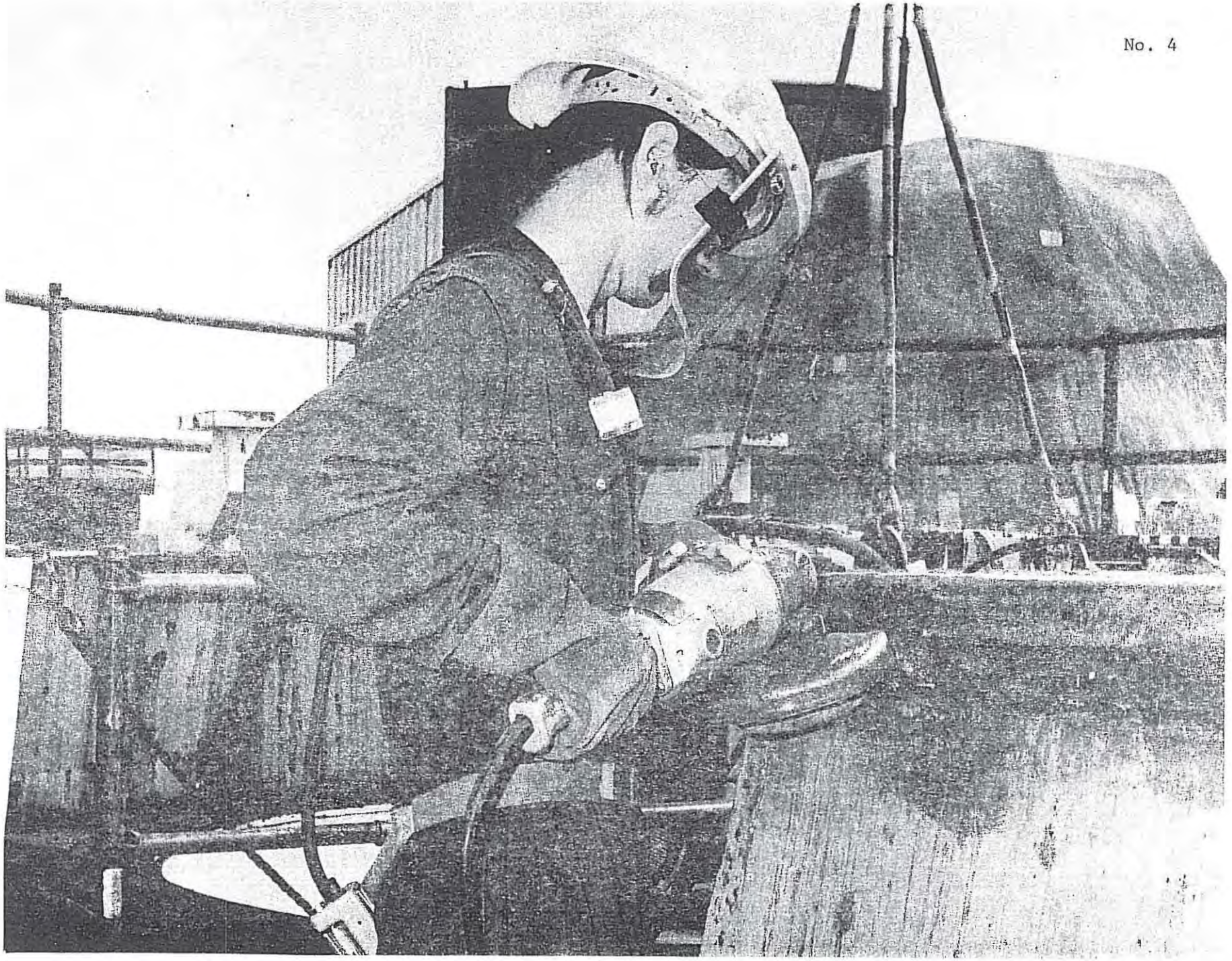

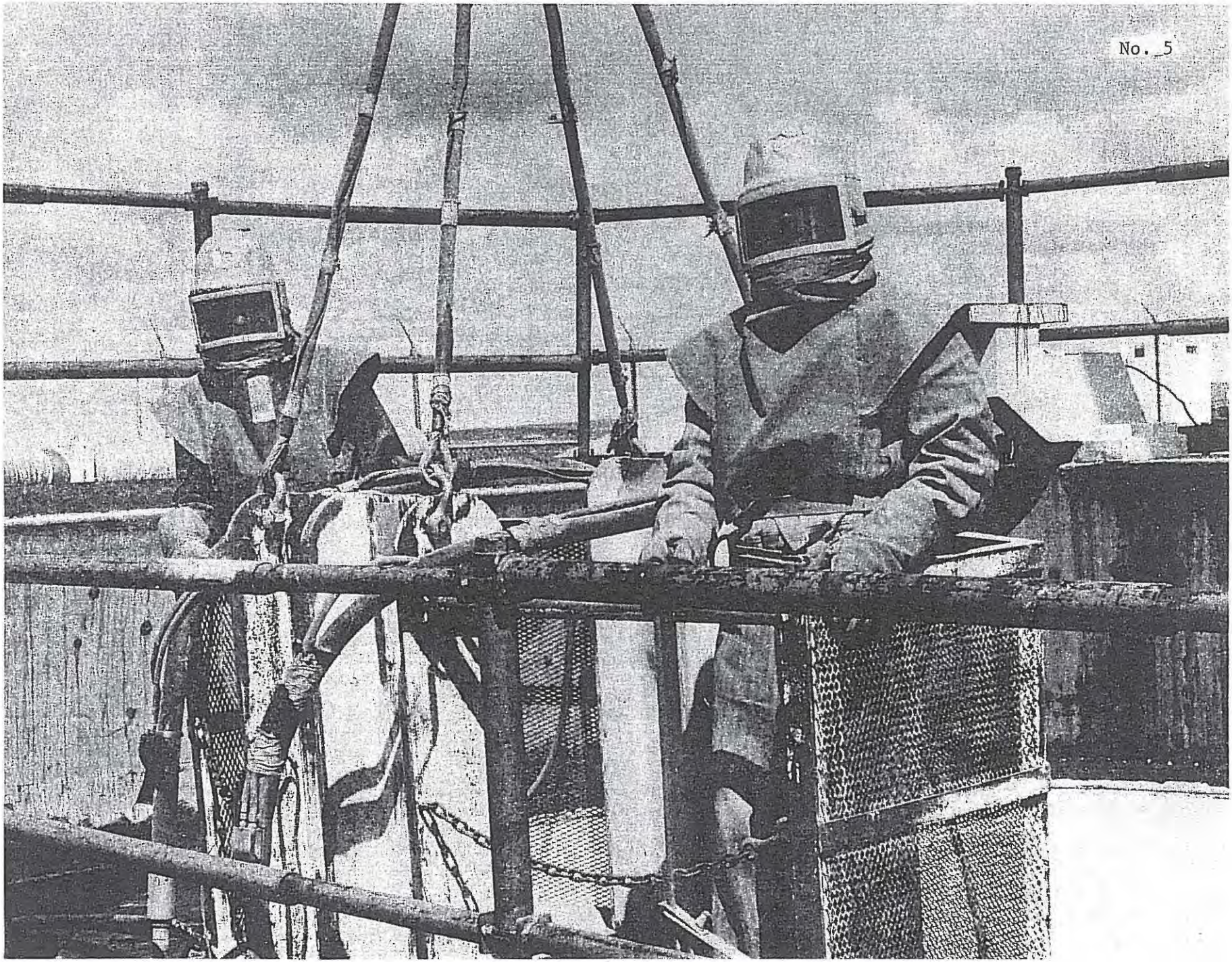
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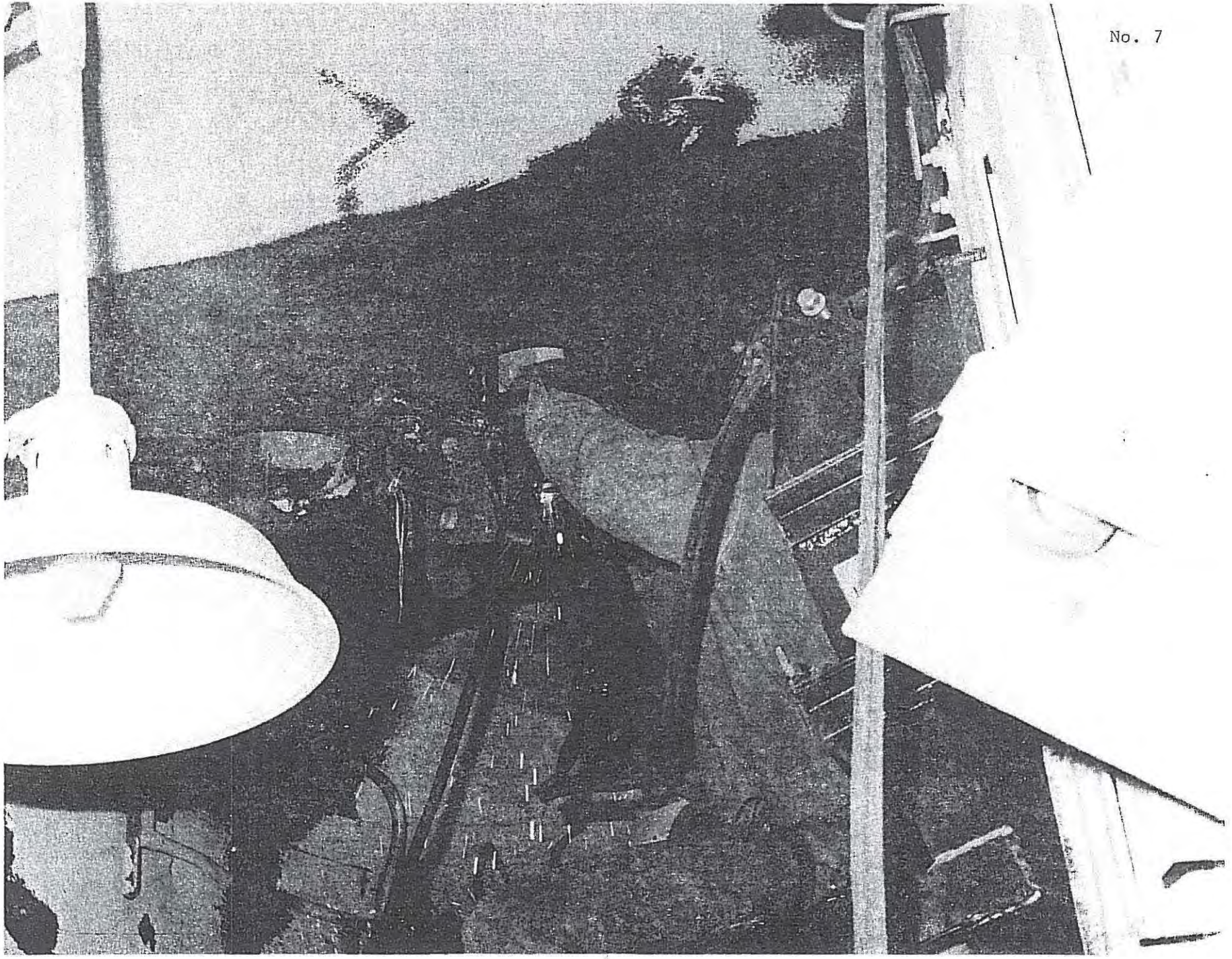

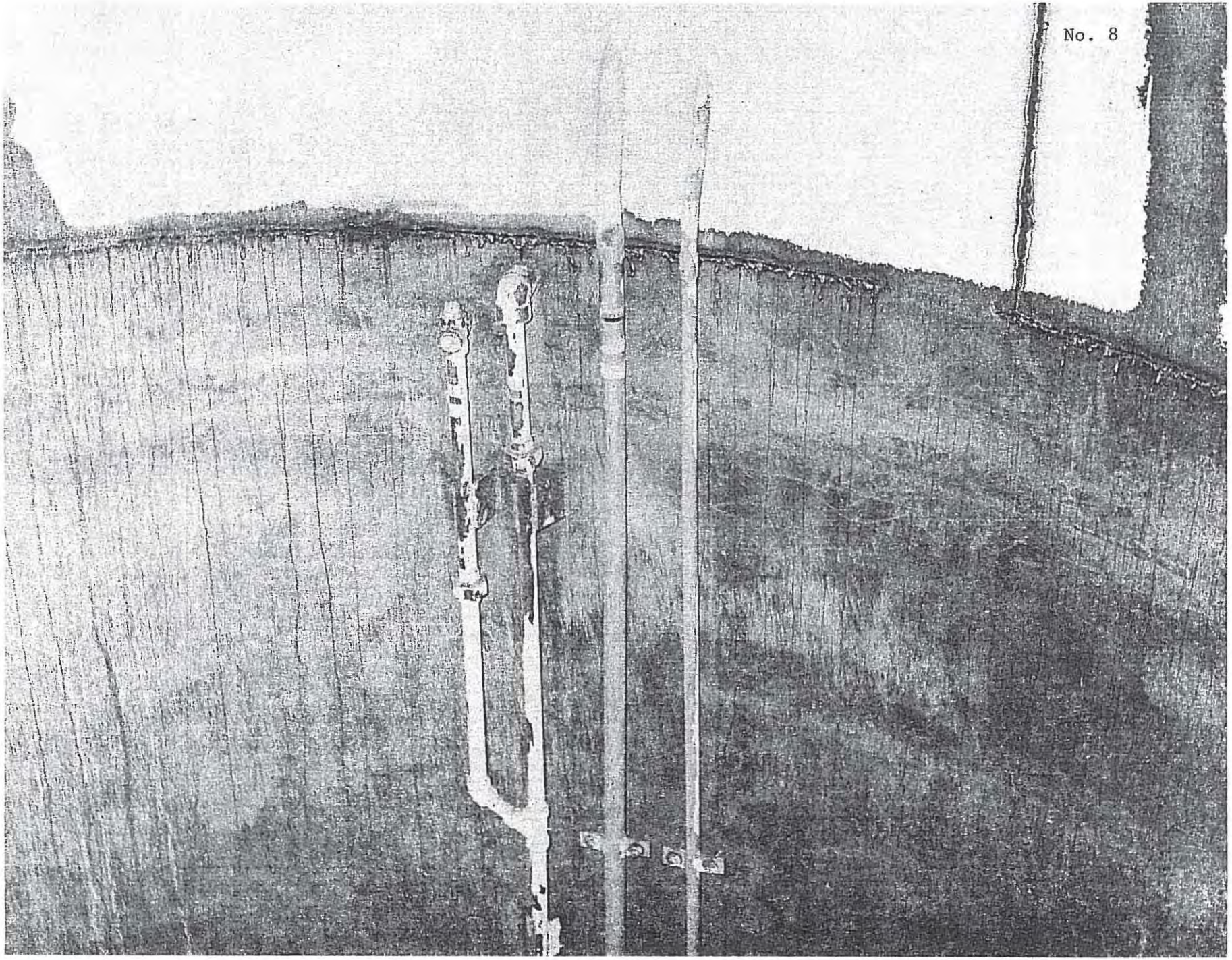
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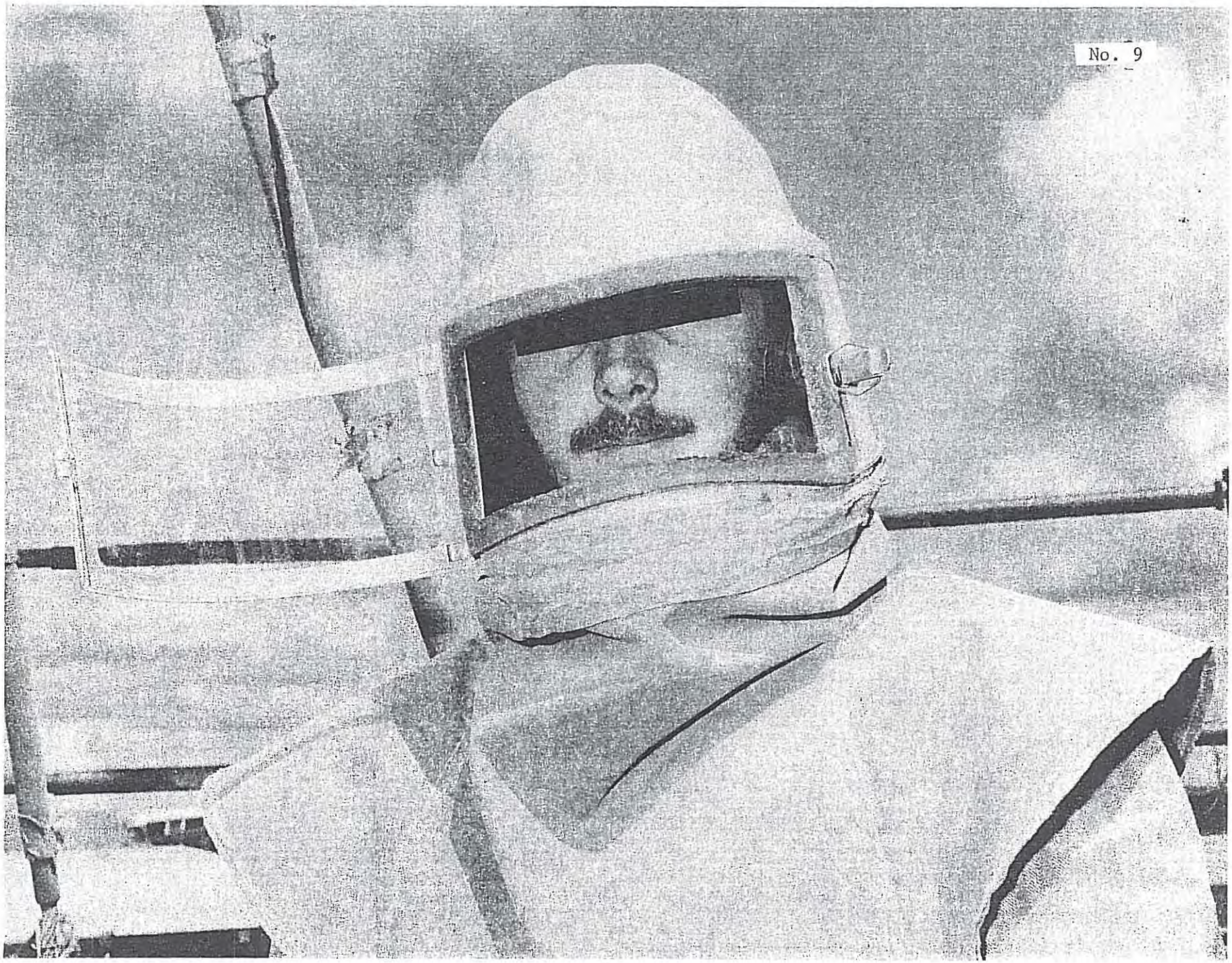
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