S E C T I O N III

CONSTRUCTION PHASES OF PROPELLANT LOADING SYSTEM

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PART I -- GENERAL

FUNCTION OF PROPELLANT LOADING SYSTEM (PLS)

The function of the Propellant Loading System is to store and, upon command, to automatically load liquid oxygen, helium and gaseous nitrogen aboard the missile. The liquid oxygen (LOX) is transferred by pressurizing the LOX tank with nitrogen and forcing it aboard the missile. The helium and gaseous nitrogen are stored at 6,000 psi and 2,800 psi respectively and are transferred through regulating valves to the missile. The helium is forced through coils submerged in liquid nitrogen in the helium subcooler, cooling it to a minus 300° F before loading aboard the missile. These systems were designed to load the missile at a rapid load rate.

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The RP-1 portion of the Propellant Loading System is a "slow load" system wherein the RP-1 is pumped from the storage tanks to the missile.

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It was extremely important to keep the pipe and components of these systems to rigid level of cleanliness at all times. Any particle larger than 150 microns (approximately 1/3 the size of the dot over this i) in any of the systems could seriously compromise the reliability of the missile. In addition to the particle size limitations, there was a necessity to keep the hydrocarbons in the LOX system and its interconnected systems to a minimum since most hydrocarbons, even in small concentrations, will react violently with LOX. Thus elaborate precautions were taken to assure that the pipe was properly cleaned and remained clean during all phases of storage, installation and

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testing.

FABRICATION AND SUPPLY

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The majority of components such as valves, instruments, filters, vessels, pumps, pressure regulators, liquid sensors and instrument panels were supplied under assigned standardized equipment contracts. The only major components not supplied under standardized equipment contracts were flex hoses, expansion joints and strainers.

The majority of the RP-1 piping was carbon steel and was fabricated and cleaned in Rapid City. The RP-1 pipe spools were of welded construction and connected in the field with Victaulic couplings.

All Propellant Loading System piping, except the RP-1, is stainless steel and was fabricated in Oakland, California and shipped by truck or rail for cleaning in Rapid City.

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The missile silo LOX cribs and the missile silo fuel cribs, nine of each, were fabricated in Rapid City in a metal building previously used by a subcontractor. Each of these cribs was fabricated and installed as a unit.

CLEANING OF COMPONENTS

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The contractor constructed a new cleaning plant building in Rapid City to clean piping for the Propellant Loading System. The building had four main rooms categorized by the operation performed in them. In the pre-clean room, the major contamination was removed by steam cleaning, wire brushing and grinding. The cleaning room was used for degreasing, pickling, rinsing and drying. The pipe and com-

ponents were inspected in the inspection room and if accepted were transferred to the wrapping and storage area. The cleaning and inspection rooms were pressurized with filtered air to reduce air borne contamination. Despite the pressurization with filtered air, lint remained a major problem in these areas. The only other major problem encountered in the cleaning plant operation was the phenomenon of magnetic metallic particles clinging to the welded areas of the pipe. This problem was eventually brought under control by reducing the amount of grinding and by hand cleaning the weld areas.

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PART II -- INSTALLATION ASPECTS

The cleaned, sealed, pipe spools arrived at the site from the storage area in Rapid City and were temporarily stored at the top of each propellant terminal and missile silo. Pipe connections were made under polyethylene tents by workmen wearing nylon smocks, nylon hats and plastic gloves. To further reduce the chance of contamination, each connection was purged with a flow of clean, dry nitrogen. Each connection was inspected with a flashlight; and in cases of doubt, the pipes or components were inspected with a blacklight.

Following installation, an endeavor was made to keep the system clean by maintaining a positive pressure in all lines using clean, dry nitrogen. This was difficult and not always practical because the pipe was not generally connected in sequence.

The greatest overall problem encountered in the installation was the numerous complicated pipe support modifications, which in many instances required the recleaning of components.

Tabs 1 - 5 show the PLS system in the various stages of installation.

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PART III -- TESTING PHASES

FIVE TEST PHASES

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Testing was conducted in five (5) separate phases; the proof pressure test, leak test, blowdown test, cold flow test and flush test.

The proof pressure test was conducted on all systems by pressurizing the systems with nitrogen to 1 1/4 times the working pressure. This test was intended to prove the structural integrity of the systems. The only failures noted were two bellows type expansion joints.

Following the proof pressure test, the pressure was reduced to the specified working pressure and the systems leak checked. All leak checking was done with "Leak Tec" with exception of the RP-1 system where "Joy" soap was used. The tape was removed from flanged connections before leak checking.

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With the exception of the RP-1 systems, all piping was subjected to the blowdown test. This test was accomplished by discharging the pressure vessels for a specified pressure drop through the piping, and through the connected blowdown pad, consisting of cheese cloth backed up with 150 micron brass mesh. The blowdown pad was analyzed for cleanliness by the contractor's independent laboratory in the lab trailer located on each complex.

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The cold flow tests were run on all liquid oxygen and liquid nitrogen piping using liquid nitrogen (boiling point minus 320° F) as a test media. The systems were filled with liquid nitrogen, pressurized to the transfer pressure, held for five minutes, and then

discharged to the surface for a specified length of time. A sample was taken of the effluent liquid and analyzed for compliance with cleanliness specifications.

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The RP-1 system was subjected to a flush test which consisted of pumping RP-1 through the piping from the storage tank through the tunnels, missile silo and fuel cribs. The RP-1 was returned through a 4 inch temporary rubber hose laid on the surface from the missile silo to the RP-1 storage tank. All portions of the piping were flushed until a clean sample could be obtained at the specified sample points.

Considerable trouble was experienced in getting a clean sample until an RP-1 pumping and filtering F-6 refueler was placed in series with the system filters and piping.

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TEST MEDIA AND GOVERNMENT-FURNISHED EQUIPMENT

Testing was supported by Government-furnished property which consisted basically of two categories: (1) Propellant Loading System test media and (2) Government-furnished equipment for Propellant Loading testing.

The test media used for Propellant Loading System testing, test equipment validation and test equipment cleaning consisted of liquid nitrogen (1,277,000 gal.), helium (1,207,000scf) and RP-1 (110,000 gal.). The Air Force procured the media in response to scheduling provided by the Corps of Engineers. On three occasions when delays in testing were inevitable due to a procurement shortage of liquid nitrogen, the test medium was removed from the LOX storage tanks in launchers previously tested to support Propellant Loading System Testing schedules.

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All test media was dispatched, transported and handled by subcontractors of the prime contractor in a satisfactory manner.

The following Government-furnished Propellant Loading System test equipment was made available to the contractor: Nitrogen rechargers (8 each), tubebank trailers (14 each), cryogenic trailers (10 each), helium compressors (4 each), RP-1 trailers (4 each), liquid nitrogen filters (10 each) and gaseous nitrogen filters (29 each). The above quantity of equipment was completely adequate for the contract testing schedule with the exception of liquid nitrogen filters.

The equipment in all instances was operated by the contractor or his subcontractors in a satisfactory manner except for the operation and maintenance of helium compressors where lack of experience initiated problem areas. Antiquated RP-1 trailers (F-6 refuelers, AF type) were a constant problem area in the testing program. Chronic troublesome operational conditions and non-availability of spare parts caused delays in RP-1 handling and system testing.

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PART IV -- USE OF INDEPENDENT TESTING LABORATORIES

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Because of the highly complex nature of the cleanliness tests required on the system, and the lack of sufficiently qualified personnel, it was necessary for the Area Office and the contractor to procure the services of qualified testing laboratories.

Therefore, the Government entered into a contract with the United Testing Laboratories (UTL) to assist in the system inspection. The number of UTL representatives averaged from three to five during installation to as many as eighteen during the peak testing period. These men were generally very capable and performed in a satisfactory manner.

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The contractor employed Inland Analytical Laboratories (IAL) as the independent laboratory required by the specifications. IAL certified the cleanliness of all pipe at the cleaning plant in conjunction with the Corps inspectors. Also, the blowdown pads, gas samples, flush samples and numerous other items were inspected and certified by them. IAL provided a laboratory trailer (8' x 17') at each complex with an additional one at the Ellsworth Air Force Base. Their facilities were first rate, their employees reasonably competent and their operation quite efficient. Some trouble was encountered, however, with blowdown pad and sample bottles which were apparently contaminated prior to use. This condition was discovered early in the testing program, at which time, IAL was directed to clean up its operation. This was effectively accomplished, and IAL performed in a highly satisfactory manner thereafter.

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PART V -- IMPACT OF MODIFICATIONS

As with other phases of this project, modifications were numerous and troublesome. Each phase of work was affected by major modifications.

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Fabrication was changed by Modification 72 which changed the configuration of much of the piping primarily by adding loops in the piping for flexibility.

The cleaning was effected by Modification 3 which increased the stringency of the cleaning specification.

The installation phase was hampered by four major modifications -- 80, 81, 147 and 165 which collectively changed the design concept of the entire pipe support system.

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Modification 34 and its associated modifications changed the testing section of the specifications so extensively that the entire original section of the specification was deleted and replaced. Basically, it changed the test procedures, the amount of Government-furnished equipment available and responsibility for test media delivery to the complexes.

There were also numerous other modifications of a lesser degree which affected each of the phases.

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PART VI -- CHRONOLOGICAL LIST OF SIGNIFICANT EVENTS

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(1) Construction of the Propellant Loading System cleaning plant started July 1960.

(2) First Propellant Loading System Pipe spools arrived at Rapid City on 11 August 1960.

(3) Cleaning Plant essentially completed on 15 September 1960.

(4) First Propellant Loading System pipe accepted at cleaning plant - 20 November 1960.

(5) First Propellant Loading System pipe installed at Complex 1B - 20 January 1961.

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(6) First Propellant Loading System pipe installed at Complex 1A - 1 February 1961.

(7) First Propellant Loading System pipe installed at Complex 1C - 10 February 1961.

(8) Testing started at Complex 1B - 1 July 1961.

(9) Testing completed at Complex 1B - 30 September 1961.

(10) Testing started at Complex 1A - 23 September 1961.

(11) Testing completed at Complex 1A - 23 October 1961.

(12) Testing started at Complex 1C - 16 October 1961.

(13) Testing completed at Complex 1C - 27 November 1961.

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APPENDIX C

SECTION III - REFERENCES

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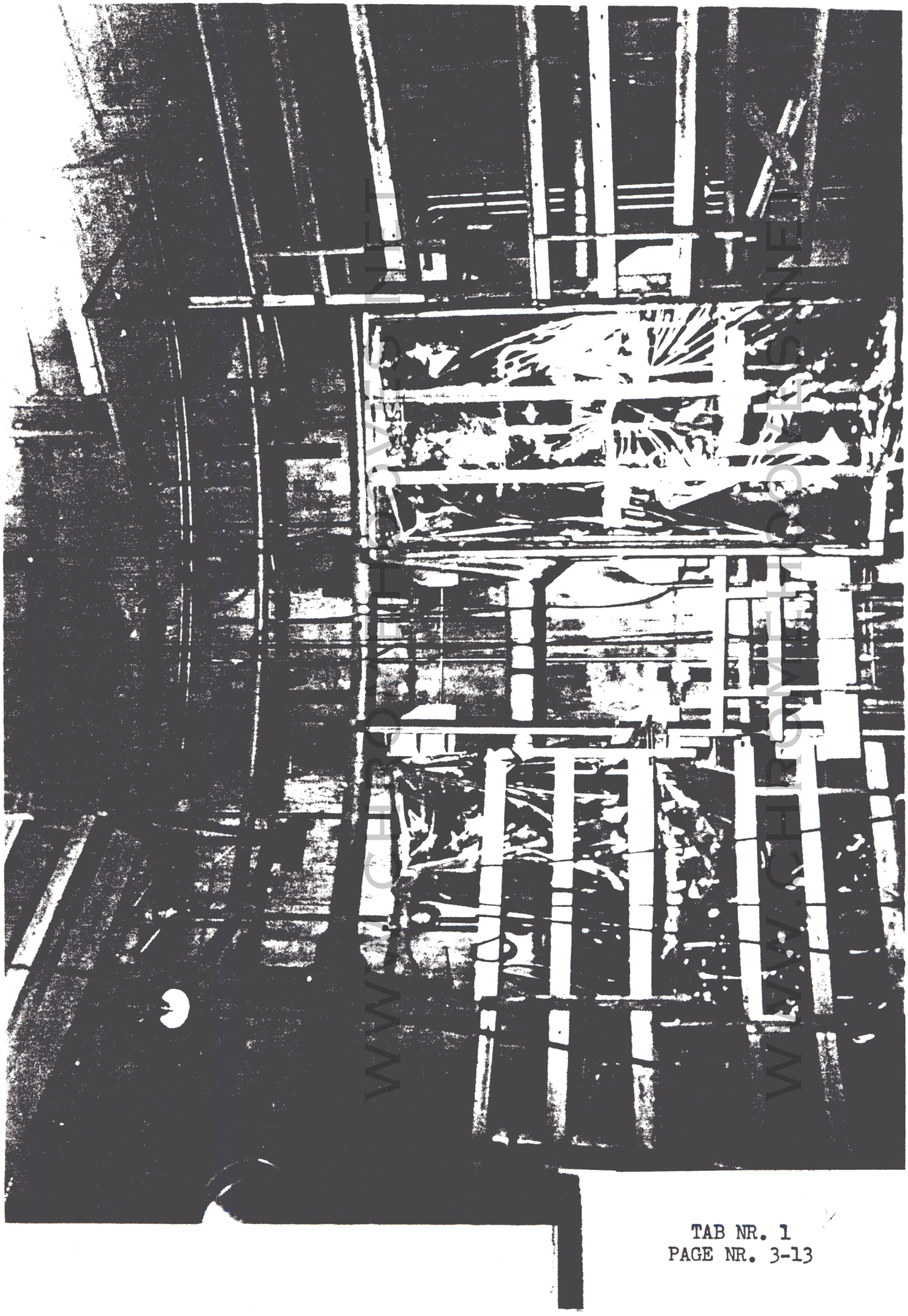

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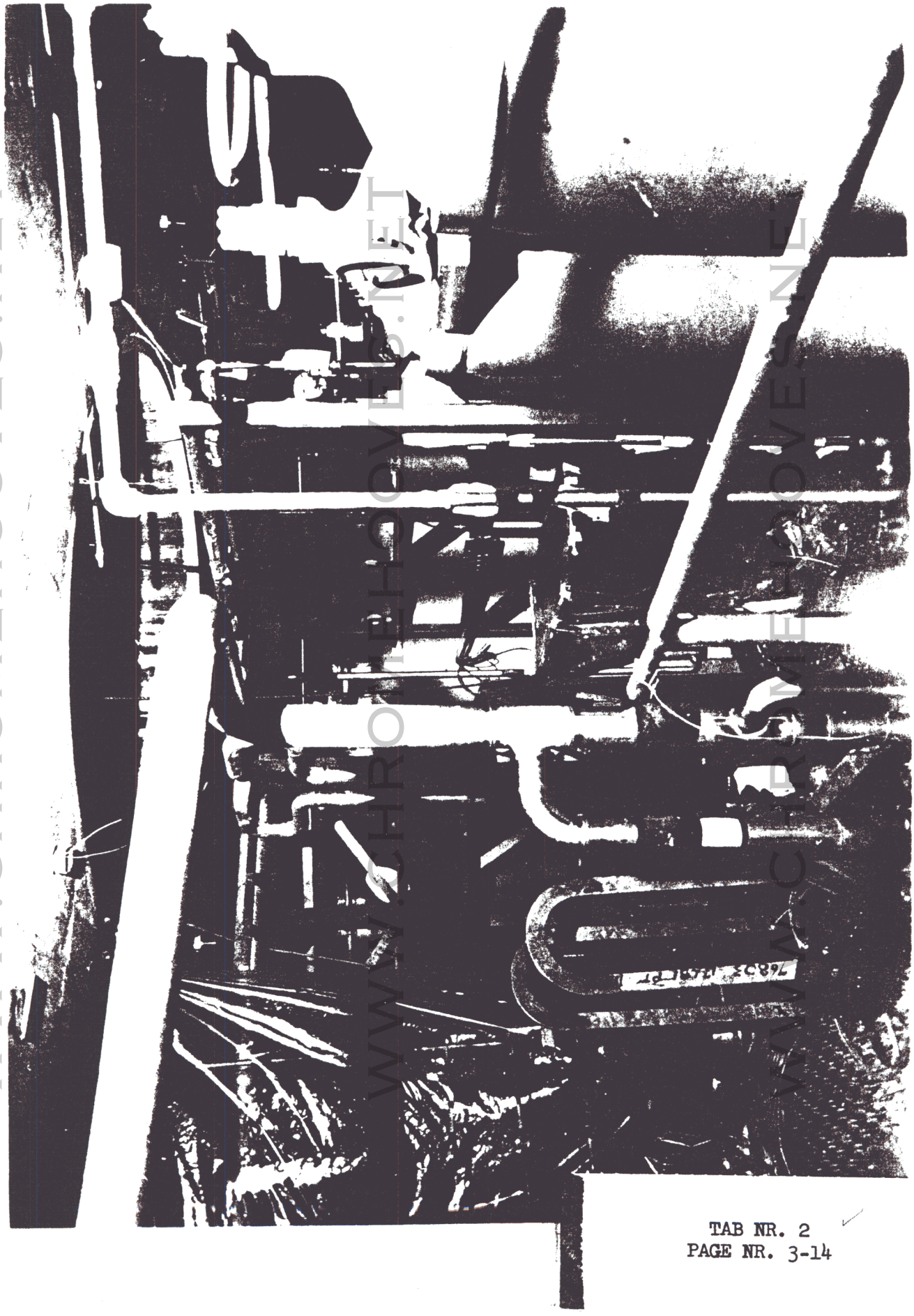

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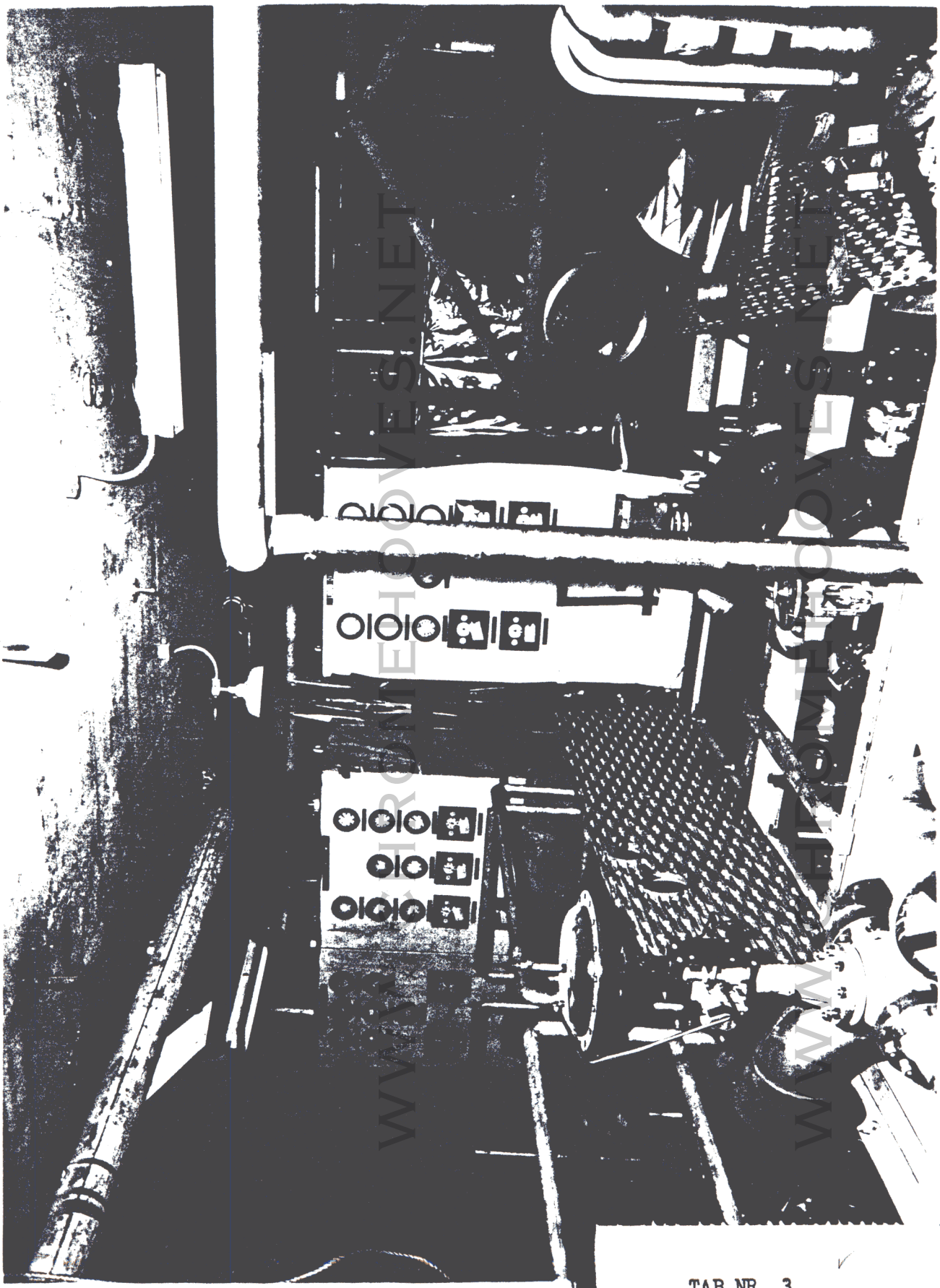

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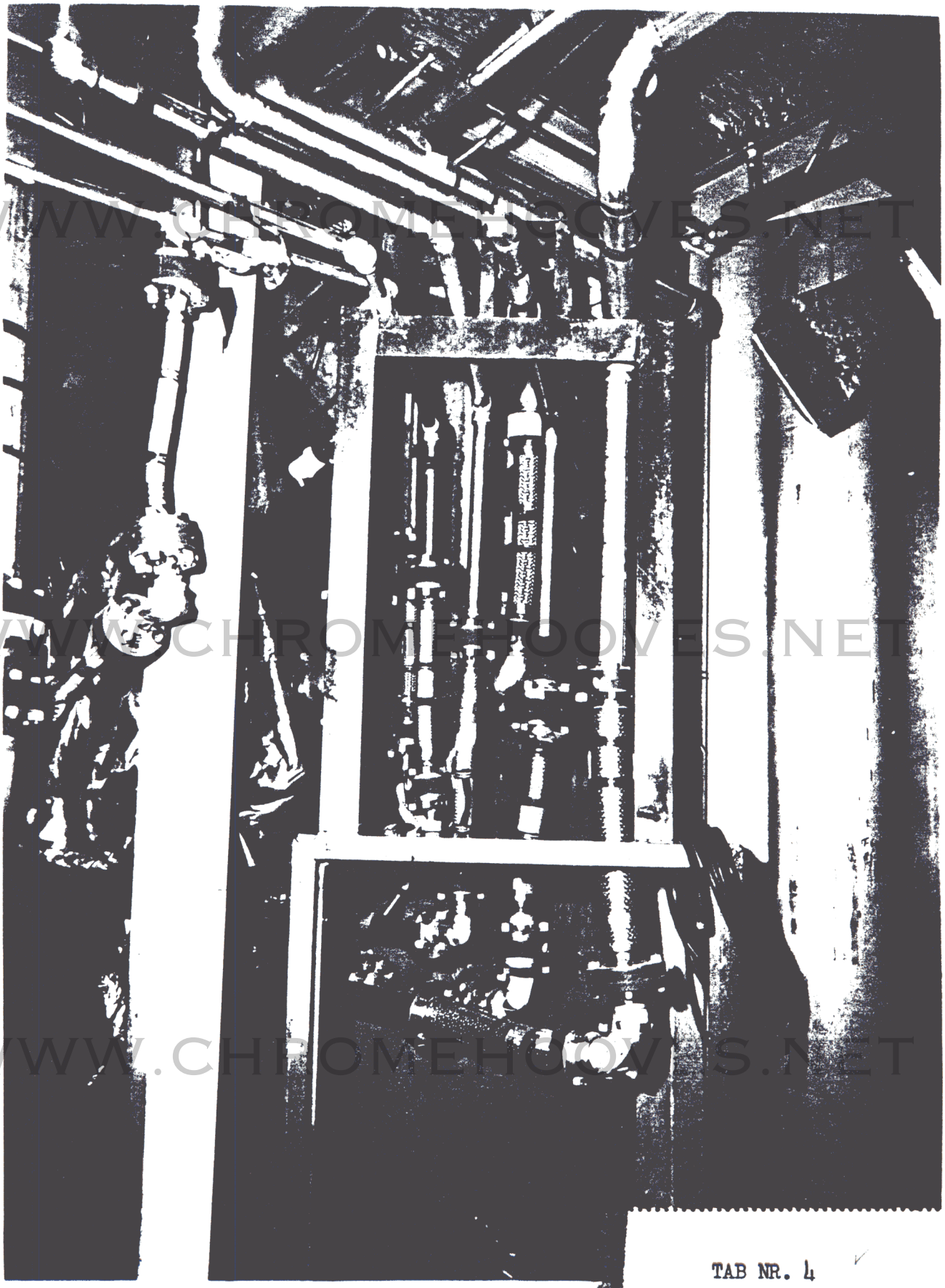

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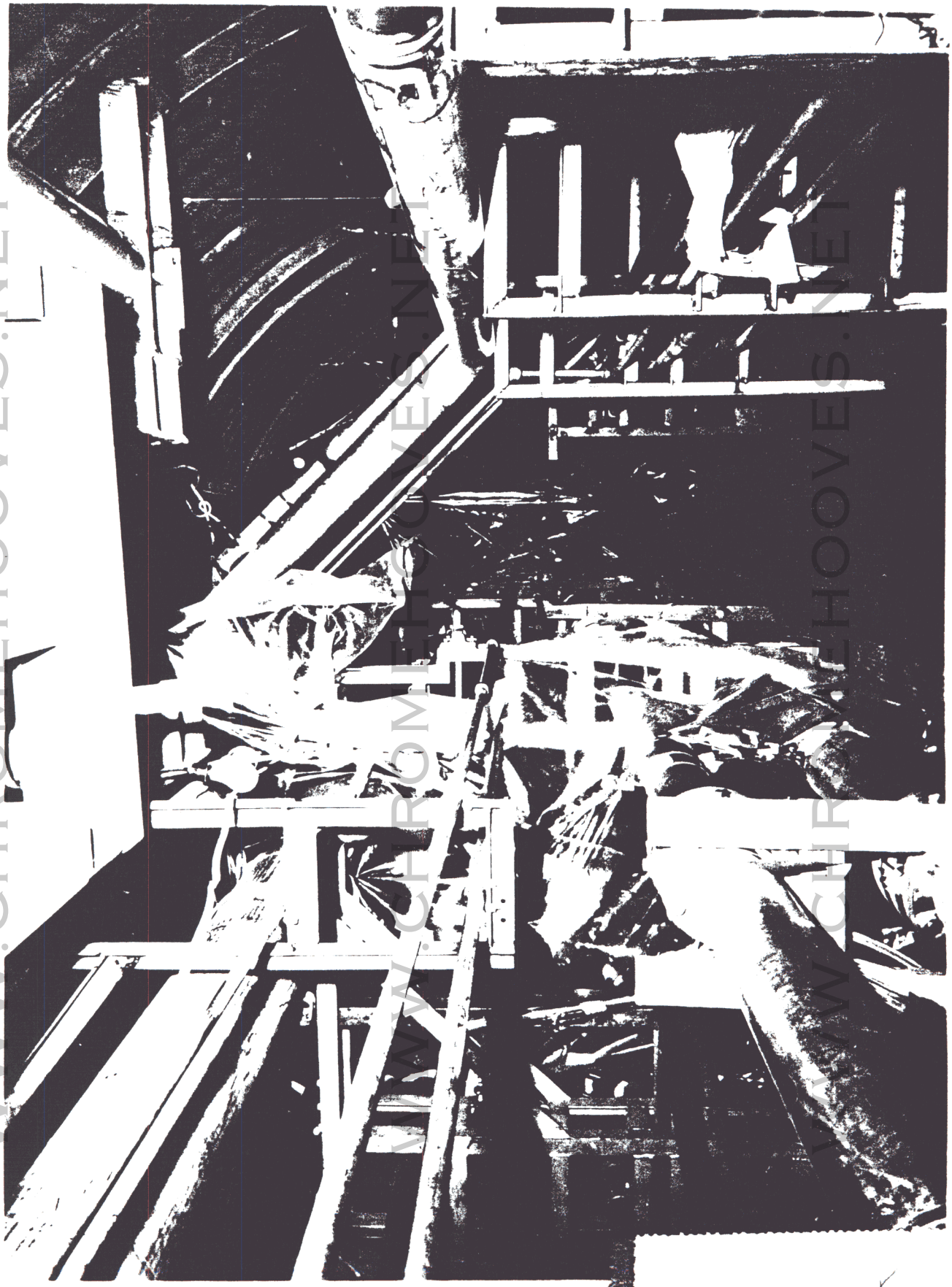

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