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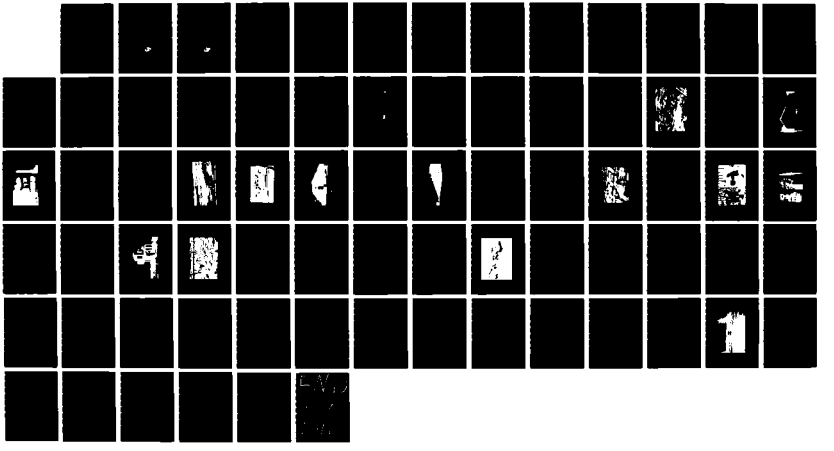

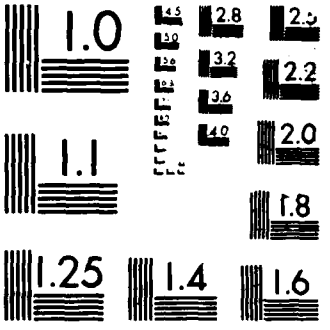
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HISTORIC PROPERTIES REPORT

INDIANA ARMY AMMUNITION PLANT

CHARLESTON, INDIANA

FINAL REPORT

AUGUST 1984

This document was prepared by the MacDonald and Mack Partnership, Minneapolis, Minnesota, under Contract CX-0001-2-0033 between Building Technology Incorporated, Silver Spring, Maryland, and the Historic American Buildings Survey/Historic American Engineering Record, National Park Service, U.S. Department of the Interior.

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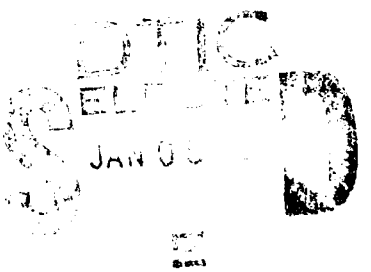

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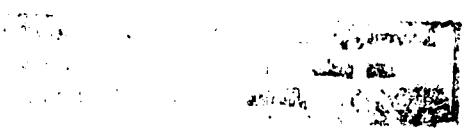


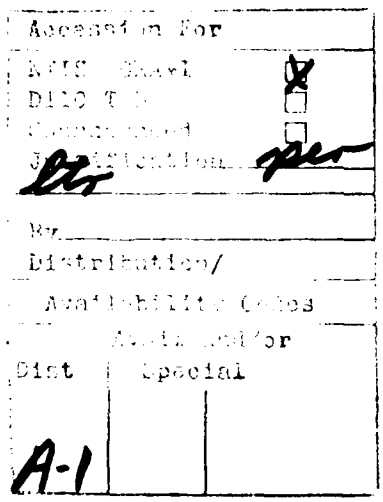
EXECUTIVE SUMMARY

Indiana Army Ammunition Plant (INAAP) is part of the Army's Armament, Munitions and Chemical Command (AMCCOM). It is a government-owned, contractor-operated installation situated on 10,650 acres on the west bank of the Ohio River. The plant is located just east of Charlestown, Indiana, and approximately fifteen miles north of Louisville, Kentucky. Constructed during 1940-1941, INAAP was the first single-base smokeless-powder plant authorized under the National Defense Program, and it served as a planning model for similar installations. In 1941-1942, INAAP expanded with a bag-manufacturing-and-loading plant, and in 1944-1945, with a double-base rocket-propellant plant, which, never completed, was later demolished. Designated a standby facility after V-J Day, the installation was reactivated for major production runs during the Korean and Vietnam Wars. In the 1970s, INAAP received authorization to build a new black-powder manufacturing facility and two modern propellant-loading lines. By the summer of 1983, the black-powder operation had been constructed, tested out, and placed in standby condition; the two loading-line projects were still in progress. Portions of the original bag-manufacturing-and-loading facilities are currently in intermittent production; the smokeles-powder lines in standby condition.

INAAP comprises approximately 1,400 buildings, about three-quarters of which date from the World-War-II period. The plant also contains two buildings that pre-date military use of the site: a wood-frame, clay-tile residence (Building 1101-37), and a small, brick, farmstead structure (no building number assigned) resembling a summer kitchen. Neither building is

of architectural or historical significance. Apart from the modernization projects of the 1970s, the INAAP's architecture and technology have experienced little modification since World War II and still strongly reflect their original design and purpose.

There are no Category I historic properties at INAAP. Because of their innovative engineering, the plant's seven Ranney water wells (Buildings 404-1 through 404-7) are Category II historic properties. There are two Category III historic properties: the Bag-Manufacturing Building (Building 1001), by virtue of its unique scale and prototype design qualities, and the Main Administration Building (Building 703), because of its functional and symbolic importance to the local community.



CONTENTS

PREFACE

This report presents the results of an historic properties survey of the Indiana Army Ammunition Plant (INAAP). Prepared for the United States Army Materiel Development and Readiness Command (DARCOM), the report is intended to assist the Army in bringing this installation into compliance with the National Historic Preservation Act of 1966 and its amendments, and related federal laws and regulations. To this end, the report focuses on the identification, evaluation, documentation, nomination, and preservation of historic properties at the INAAP. Chapter 1 sets forth the survey's scope and methodology; Chapter 2 presents an architectural, historical, and technological overview of the installation and its properties; and Chapter 3 identifies significant properties by Army category and sets forth preservation recommendations. Illustrations and an annotated bibliography supplement the text.

This report is part of a program initiated through a memorandum of agreement between the National Park Service, Department of the Interior, and the U.S. Department of the Army. The program covers 74 DARCOM installations and has two components: 1) a survey of historic properties (districts, buildings, structures, and objects), and 2) the development of archaeological overviews. Stanley H. Fried, Chief, Real Estate Branch of Headquarters DARCOM, directed the program for the Army, and Dr. Robert J. Kapsch, Chief of the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) directed the program for the National Park Service. Sally Kress Tompkins was program manager, and Robie S. Lange was project manager for the historic properties survey. Technical assistance

was provided by Donald C. Jackson.

Building Technology Incorporated acted as primary contractor to HABS/HAER for the historic properties survey. William A. Brenner was BTI's principal-in-charge and Dr. Larry D. Lankton was the chief technical consultant. Major subcontractors were the MacDonald and Mack Partnership and Jeffrey A. Hess. The author would like to thank the many employees at INAAP who graciously assisted him in his research and field surveys. He especially acknowledges the help of the following individuals: on the government staff, Lt. Col. Hawley, Commander; Paul Lock, Facilities Manager; Beverly Nicholson, Administrative Officer; and on the ICI Americas Inc. staff, A. L. Beck, Facilities Engineer; Walter McClellan, Land Manager; George E. Woods, Readiness Planner; Richard Schultz, Assistant Facility Project Manager.

The complete HABS/HAER documentation for this installation will be included in the HABS/HAER collections at the Library of Congress, Prints and Photographs Division, under the designation HAER No. IN-55.

Chapter 1

INTRODUCTION

SCOPE

This report is based on an historic properties survey conducted in August 1983 of all Army-owned properties located within the official boundaries of the Indiana Army Ammunition Plant (INAAP). The survey included the following tasks:

- Completion of documentary research on the history of the installation and its properties.

- Completion of a field inventory of all properties at the installation.

- Preparation of a combined architectural, historical, and technological overview for the installation.

- Evaluation of historic properties and development of recommendations for preservation of these properties.

Also completed as a part of the historic properties survey of the installation, but not included in this report, are HABS/HAER Inventory cards for 40 individual properties. These cards, which constitute HABS/HAER Documentation Level IV, will be provided to the Department of the Army. Archival copies of the cards, with their accompanying photographic

negatives, will be transmitted to the HABS/HAER collections at the Library of Congress.

The methodology used to complete these tasks is described in the following section of this report.

METHODOLOGY

1. Documentary Research

INAAP was constructed during 1940-1945 as three distinct production facilities: a smokeless-powder plant (Indiana Ordnance Works Plant No. 1), a rocket-propellant plant (Indiana Ordnance Works Plant No. 2), and a bag-manufacturing-and-loading plant for artillery, cannon, and mortar projectiles (Hoosier Ordnance Works). Since more than a dozen installations around the country were involved with similar operations, an evaluation of the INAAP's historical significance requires a general understanding of the American, wartime munitions industry. To identify relevant published sources, research was conducted in standard bibliographies of military history, engineering, and the applied sciences. Unpublished sources were identified by researching the historical and technical archives of the U.S. Army Armament, Munitions and Chemical Command (AMCCOM) at Rock Island Arsenal.[1]

In addition to such industry-wide research, a concerted effort was made to locate published sources dealing specifically with the history

and technology of INAAP. This site-specific research was conducted primarily at the AMCCOM Historical Office at Rock Island Arsenal; the Charlestown Public Library in Charlestown, Indiana; the Louisville Public Library in Louisville, Kentucky; and the government and contractor archives at INAAP. The Indiana State Historic Preservation Office (Department of Natural Resources, Indianapolis) was also contacted for information on the architecture, history, and technology of INAAP, but provided no pertinent data.

Army records used for the field inventory included current Real Property Inventory (RPI) printouts that listed all officially recorded buildings and structures by facility classification and date of construction; the installation's property record cards; base maps and photographs supplied by installation personnel; and installation master planning, archaeological, environmental assessment, and related reports and documents. A complete listing of this documentary material may be found in the bibliography.

2. Field Inventory

Architectural and technological field surveys were conducted in August 1983 by Jeffrey A. Hess. Following general discussions with Paul Lock, Facilities Manager for the government, and A. L. Beck, Facilities Engineer for ICI Americas, Inc., the surveyor was provided with escorts for tours of major manufacturing buildings and a general field survey of all exterior areas at the installation. A. L. Beck served as escort for the smokeless-powder production areas; Walter

McClellan for the bag-manufacturing and bag-loading areas.

Field inventory procedures were based on the HABS/HAER Guidelines for Inventories of Historic Buildings and Engineering and Industrial Structures.[2] All areas and properties were visually surveyed. Building locations and approximate dates of construction were noted from the installation's property records and field-verified. Interior surveys were made of the major facilities to permit adequate evaluation of architectural features, building technology, and production equipment.

Field inventory forms were prepared for, and black and white 35 mm photographs taken of all buildings and structures through 1945 except basic utilitarian structures of no architectural, historical, or technological interest. When groups of similar ("prototypical") buildings were found, one field form was normally prepared to represent all buildings of that type. Field inventory forms were also completed for representative post-1945 buildings and structures.[3] Information collected on the field forms was later evaluated, condensed, and transferred to HABS/HAER Inventory cards.

3. Historical Overview

A combined architectural, historical, and technological overview was prepared from information developed from the documentary research and the field inventory. It was written in two parts: 1) an introductory description of the installation, and 2) a history of the installation

by periods of development, beginning with pre-military land uses. Maps and photographs were selected to supplement the text as appropriate.

The objectives of the overview were to 1) establish the periods of major construction at the installation, 2) identify important events and individuals associated with specific historic properties, 3) describe patterns and locations of historic property types, and 4) analyze specific building and industrial technologies employed at the installation.

4. Property Evaluation and Preservation Measures

Based on information developed in the historical overviews, properties were first evaluated for historical significance in accordance with the eligibility criteria for nomination to the National Register of Historic Places. These criteria require that eligible properties possess integrity of location, design, setting, materials, workmanship, feeling, and association, and that they meet one or more of the following:[4]

A. Are associated with events that have made a significant contribution to the broad patterns of our history.

B. Are associated with the lives of persons significant in the nation's past.

C. Embody the distinctive characteristics of a type, period, or method of construction, represent the work of a master, possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction.

D. Have yielded, or may be likely to yield, information important in pre-history or history.

Properties thus evaluated were further assessed for placement in one of five Army historic property categories as described in Army Regulation 420-40:[5]

Category I	Properties of major importance
Category II	Properties of importance
Category III	Properties of minor importance
Category IV	Properties of little or no importance
Category V	Properties detrimental to the significance of adjacent historic properties.

Based on an extensive review of the architectural, historical, and technological resources identified on DARCOM installations nationwide, four criteria were developed to help determine the appropriate categorization level for each Army property. These criteria were used to assess the importance not only of properties of traditional historical interest, but also of the vast number of standardized or prototypical buildings, structures and production processes that were

built and put into service during World War II, as well as of properties associated with many post-war technological achievements. The four criteria were often used in combination and are as follows:

1) Degree of importance as a work of architectural, engineering, or industrial design. This criterion took into account the qualitative factors by which design is normally judged: artistic merit, workmanship, appropriate use of materials, and functionality.

2) Degree of rarity as a remaining example of a once widely used architectural, engineering, or industrial design or process. This criterion was applied primarily to the many standardized or prototypical DARCOM buildings, structures, or industrial processes. The more widespread or influential the design or process, the greater the importance of the remaining examples of the design or process was considered to be. This criterion was also used for non-military structures such as farmhouses and other once prevalent building types.

3) Degree of integrity or completeness. This criterion compared the current condition, appearance, and function of a building, structure, architectural assemblage, or industrial process to its original or most historically important condition, appearance, and function. Those properties that were highly intact were generally considered of greater importance than those that were not.

4) Degree of association with an important person, program, or event. This criterion was used to examine the relationship of a property to a famous personage, wartime project, or similar factor that lent the property special importance.

The majority of DARCOM properties were built just prior to or during World War II, and special attention was given to their evaluation. Those that still remain do not often possess individual importance, but collectively they represent the remnants of a vast construction undertaking whose architectural, historical, and technological importance needed to be assessed before their numbers diminished further. This assessment centered on an extensive review of the military construction of the 1940-1945 period, and its contribution to the history of World War II and the post-war Army landscape.

Because technology has advanced so rapidly since the war, post-World War II properties were also given attention. These properties were evaluated in terms of the nation's more recent accomplishments in weaponry, rocketry, electronics, and related technological and scientific endeavors. Thus the traditional definition of "historic" as a property 50 or more years old was not germane in the assessment of either World War II or post-war DARCOM buildings and structures; rather, the historic importance of all properties was evaluated as completely as possible regardless of age.

Property designations by category are expected to be useful for approximately ten years, after which all categorizations should be

reviewed and updated.

Following this categorization procedure, Category I, II, and III historic properties were analyzed in terms of:

- Current structural condition and state of repair. This information was taken from the field inventory forms and photographs, and was often supplemented by rechecking with facilities engineering personnel.

- The nature of possible future adverse impacts to the property. This information was gathered from the installation's master planning documents and rechecked with facilities engineering personnel.

Based on the above considerations, the general preservation recommendations presented in Chapter 3 for Category I, II, and III historic properties were developed. Special preservation recommendations were created for individual properties as circumstances required.

5. Report Review

Prior to being completed in final form, this report was subjected to an in-house review by Building Technology Incorporated. It was then sent in draft to the subject installation for comment and clearance and, with its associated historical materials, to HABS/HAER staff for

technical review. When the installation cleared the report, additional draft copies were sent to DARCOM, the appropriate State Historic Preservation Officer, and, when requested, to the archaeological contractor performing parallel work at the installation. The report was revised based on all comments collected, then published in final form.

NOTES

1. The following bibliographies of published sources were consulted: Industrial Arts Index, 1938-1957; Applied Science and Technology Index, 1958-1980; Engineering Index, 1938-1983; Robin Higham, ed., A Guide to the Sources of United States Military History (Hamden, Conn.: Archon Books, 1975); John E. Jessup and Robert W. Coakley, A Guide to the Study and Use of Military History (Washington, D.C.: U.S. Government Printing Office, 1979); "Military Installations," Public Works History in the United States, eds., Suellen M. Hoy and Michael C. Robinson (Nashville: American Association for State and Local History, 1982), pp. 380-400. AMCCOM (formerly ARRCOM, or U.S. Army Armament Materiel Readiness Command) is the military agency responsible for supervising the operation of government-owned munititions plants; its headquarters are located at Rock Island Arsenal, Rock Island, Illinois. Although there is no comprehensive index to AMCCOM archival holdings, the agency's microfiche collection of unpublished reports is itemized in ARRCOM, Catalog of Common Sources, Fiscal Year 1983, 2 vols. (no pl.: Historical Office, AMCCOM, Rock Island Arsenal, n.d.).

2. Historic American Buildings Survey/Historic American Engineering Record, National Park Service, Guidelines for Inventories of Historic Buildings and Engineering and Industrial Structures (unpublished draft, 1982).

3. Representative post-World War II buildings and structures were defined as properties that were: (a) "representative" by virtue of construction type, architectural type, function, or a combination of these, (b) of obvious Category I, II, or III historic importance, or (c) prominent on the installation by virtue of size, location, or other distinctive feature.

4. National Park Service, How to Complete National Register Forms (Washington, D.C.: U.S. Government Printing Office, January 1977).

5. Army Regulation 420-40, Historic Preservation (Headquarters, U.S. Army: Washington, D.C., 15 April 1984).

Chapter 2

HISTORICAL OVERVIEW

BACKGROUND

Indiana Army Ammunition Plant (INAAP) is a government-owned, contractor-operated installation situated on a 10,650-acre site on the west bank of the Ohio River (Figure 1). The plant is located just east of Charlestown, Indiana, and approximately fifteen miles north of Louisville, Kentucky. Constructed during 1940-1941, INAAP was the first single-base smokeless-powder plant authorized under the National Defense Program, and it served as a planning model for similar installations. In 1941-1942, INAAP expanded with an addition of a bag-manufacturing-and-loading plant, and in 1944-1945, with a double-base rocket-propellant plant, which, never completed, was subsequently demolished. Designated a standby facility after V-J Day, the installation was reactivated for major production runs during the Korean and the Vietnam Wars. In the 1970s, INAAP received authorization to build a new black-powder manufacturing facility and two modern propellant-loading lines. By the summer of 1983, the black-powder operation had been constructed, tested out, and placed in standby condition; the two loading-line projects were still in progress. Portions of the original bag-manufacturing-and-loading facility are currently in intermittent production; the smokeless-powder lines in standby condition.

Currently, INAAP comprises approximately 1,400 buildings, about three-quarters of which date from the World-War-II period. Apart from

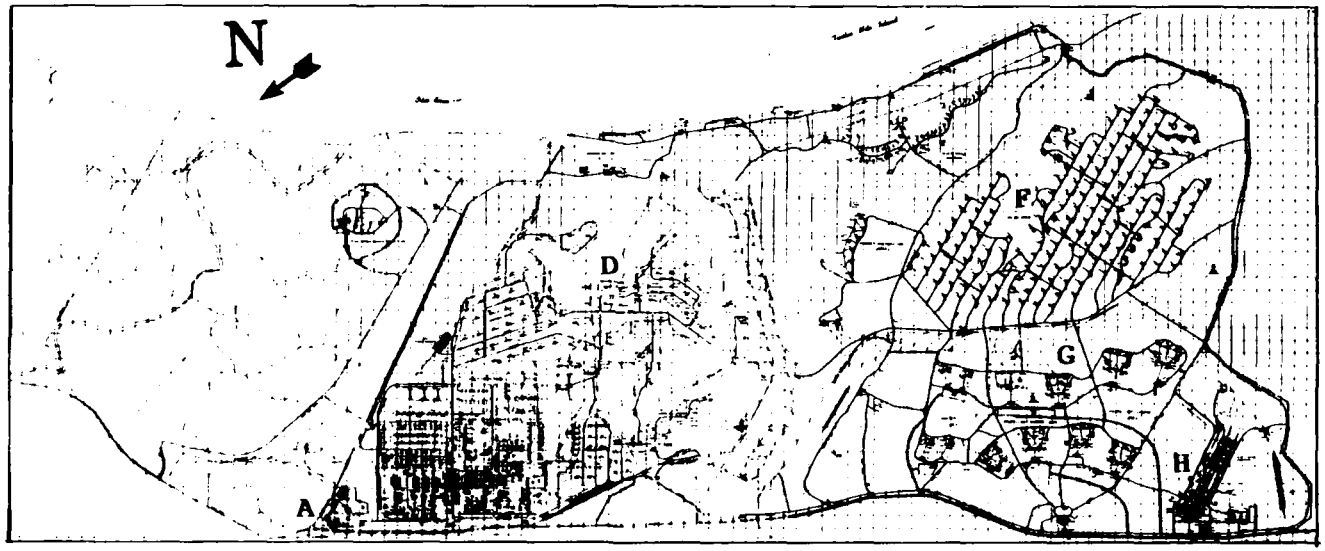


Figure 1: Installation site plan. (Source: ICI Americas, Inc. Archives, INAAP.)

A. Main administration compound.
B. Smokeless-powder manufacturing.
C. Black-powder manufacturing.
D. Above-ground magazines.
E. Residential district.
F. Earth-sheltered magazines.
G. Loading lines.
H. Bag-manufacturing and warehouse area.

the modernization projects of the 1970s, the INAAP's production lines still closely resemble standard, World-War-II, manufacturing practices. The installation also maintains its original water-supply system, consisting of seven Ranney water wells (Buildings 404-1 through 404-7). At the time of their construction, the wells were recognized as innovative engineering structures, and they now are among the oldest surviving examples of this particular technology.

WORLD WAR II

Although the United States constructed an extensive munitions-manufacturing network during World War I, few facilties survived the country's "return to normalcy" and disarmament of the 1920s. The dismantling of powder and explosives works was particularly thorough. By the mid-1930s, there were only four active plants for manufacturing single-base smokeless powder, which was the primary propellant for American military ammunition. Two of these installations were owned and operated by the federal government: the Army's Picatinny Arsenal in New Jersey, and the Navy's Indian Head Plant in Maryland. The other two, both located in New Jersey, were owned by private industry: the Carney's Point Plant of du Pont de Nemours & Co, Inc., and the Kenvil Plant of Hercules Powder Co., Inc. Although these facilities employed modern manufacturing techniques, their combined capacities were barely equal to the task of supplying the nation's peacetime armed forces. As a first step toward expanding American smokeless-powder capability, the U. S. Ordnance Department in 1937-1938 requested Hercules and du Pont to assist in the preparation of engineering specifications for a series of new plants. At the same time, the

government began stockpiling "powder machinery and specialized equipment . . . that might not be readily available in an emergency."[1] The emergency came with the fall of France in the summer of 1940, when Congress appropriated defense funds for three new powder plants. Because of the Ordnance Department's advance planning, two of the three installations were in operation by 1941. INAAP was constructed as part of this initial "National Defense Program."[2]

Site Selection and Former Land Use

The selection of the INAAP site was governed by the same basic criteria used in evaluating locations for all three of the new powder plants. These considerations included:

(1) a southerly location to ensure easy access to cotton, a basic raw material for smokeless powder production;
(2) a mid-continental location as a defense against enemy bombardment;
(3) proximity to main railroad lines;
(4) availability of an ample water supply for processing purposes;
(5) availability of suitable labor.[3]

The first parcel of land purchased for INAAP was a rectangular strip bounded on the east by the Ohio River and on the west by Indiana State Highway 62. Located less than a mile east of the small farming community of Charlestown, Indiana, and about fifteen miles north of Louisville,

Kentucky, the site satisfied all selection criteria. The City of Louisville was a major rail center, and housed a sizeable industrial work force. The area's geology also assured an abundance of readily accessible well water. When the federal government took possession of the 5,500-acre site in the summer of 1940, the boundaries enclosed a "patchwork of cornfields, pasture and underbrush." About sixty families were required to vacate their farms and residences.[4] Only two buildings from this earlier period currently remain at INAAP. The larger is a two-story, wood-frame residence with clay-tile cladding (Building 1101-37). Constructed in a craftsman-bungalow style, it dates from about 1925. The second structure, built about 1910, is a diminutive, brick outbuilding with a wood porch and a brick chimney (no building number assigned). Given its limited floor space and large chimney, the building may have served as a summer kitchen for a farmstead.

In January 1941, the federal government expanded INAAP by acquiring approximately 4,900 acres on the southern boundary of the smokeless- powder plant. This tract was slated for development as a bag-manufacturing-and-loading facility. It contained about fifty farmhouses and thirty-five summer cottages.[5] All of these structures were subsequently removed from the site. The third and last expansion of INAAP occurred in 1944, with the addition of about 8,300 acres for a rocket-propellant plant on the northern boundary of the smokeless-powder facility. The parcel included several farmsteads and an abandoned amusement park known as Rose Island.[6] None of the structures acquired with the land survive within the present boundaries of INAAP.

Construction

During World War II, INAAP comprised three distinct production facilities: a smokeless-powder plant (Indiana Ordnance Works Plant No. 1), a rocket-propellant plant (Indiana Ordnance Works Plant No. 2), and a bag-manufacturing-and-loading facility for artillery, cannon, and mortar charges (Hoosier Ordnance Works). The smokeless-powder facility was the first to be planned and built. Construction commenced on August 26, 1940, under the general supervision of the Quartermaster Corps. The country's oldest explosives-manufacturing firm, E. I. du Pont de Nemours & Co., Inc. of Wilmington, Delaware, served as both architect and general contractor for the project. At the completion of construction in the spring of 1941, the smokeless-powder plant numbered approximately 800 buildings, at least two-thirds of which were production facilities.[7] From north to south, the plant divided into the following four main areas:

(1) An administrative compound containing a Main Administration Building (Building 703), Telephone Exchange (Building 702), Hospital (Building 719-1), Repair Shop (Building 716-3), Cafeteria (Building 708-1), Guard Headquarters (Building 720), and Office Building (Building 703-1C).

(2) A shop-and-production area dominated by six parallel and nearly identical manufacturing lines for smokeless powder; two Power Houses (Buildings 401-1, 401-2); two Ammonium Oxidation Plants (Buildings 302-1, 302-1); and two Nitric-and-Sulfuric-Acid Concentration Plants (Buildings 303-1, 303-2) (Figure 2).

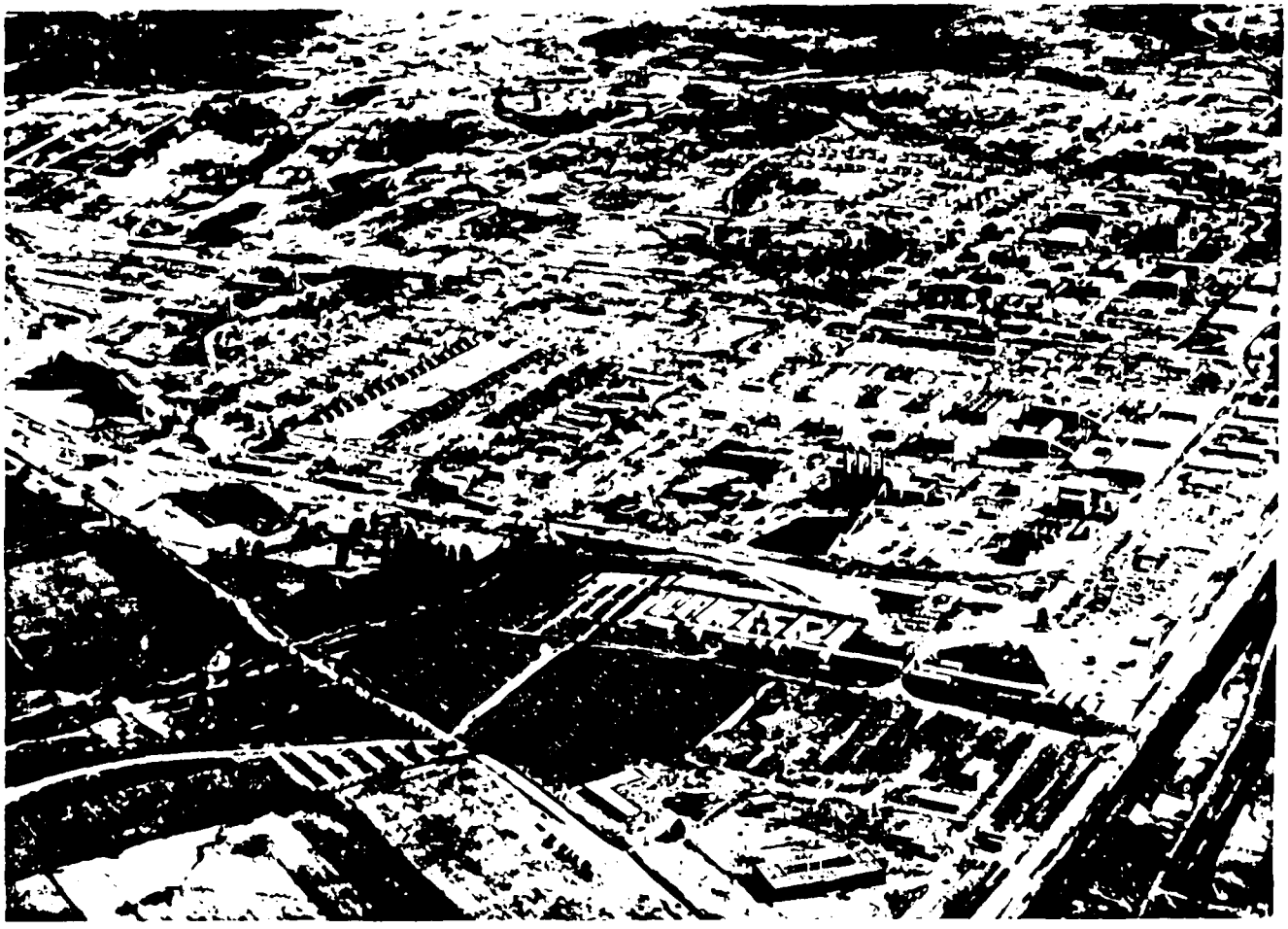


Figure 2: Aerial photograph of the smokeless-powder plant, looking south, c. 1942. The Main Administration Building (Building 703) is in the foreground; the smokeless-powder lines are immediately above; and a portion of the above-ground magazine area is in the upper left. (Source: INAAP Administrative Archives.)

(3) An extensive storage-and-shipping area containing approximately one hundred above-ground magazines (229-series buildings) (Figure 3).

(4) A staff residential district of nineteen, two-story, wood-frame houses (Buildings 1101-18 through 1101-36) (Figure 4).

INAAP was the largest of the three smokeless-powder plants authorized in the summer of 1940, and the only one to be designed as a permanent facility. Although the dimensions and layout of its buildings generally conformed to Ordnance Department specifications standardized in the late 1930s, the quality and durability of its construction set INAAP apart from its companion installations. As contemporary observers noted, "About two-thirds of [the] buildings are of steel frame"; "where wood construction is essential, as in many of the processing buildings and storage houses, heavily reinforced timbers make the buildings almost the equivalent of steel or concrete."[8] The permanent nature of the installation was especially evident in the administration area, where all buildings were constructed of brick, and several adorned with pre-cast concrete accents.

INAAP also had the distinction of being the first large-scale defense project to be built in small-town America, and it was viewed by both governmental agencies and the national press as a kind of "laboratory experiment in the many questions of defense, from how fast basic production can get going to what happens when a boom alights on a bewildered countryside." [9] The INAAP's impact on the nearby village of Charlestown was immediate and profound:

Figure 3: Building 229-36 is typical of the approximately 150 buildings in the above-ground magazine area. (Source: Field inventory photograph, 1983, Jeffrey A. Hess, MacDonald and Mack Partnership.)

Figure 4: Building 1101-26 is representative of the housing facilities constructed in 1941 for plant supervisory personnel. (Source: Field inventory photograph, 1983, Jeffrey A. Hess, MacDonald and Mack Partnership.)

> A sleepy town of 936 inhabitants before the Battle of Britain began, [Charlestown] presently accommodated 2,500 persons, not to mention hundreds of families living in trailers. Instead of one modest beanery, it soon had fourteen cafes and restaurants. Served by a single drugstore in July, it had three by December. . . . Overwhelmed by the growth thrust upon it, Charlestown appealed to the State Defense Council of Indiana for assistance. The first step taken [was] to draft a zoning ordinance to regulate the locations of the many new structures being built. Next a building code was adopted, ending the conversion of garages into living quarters. Then traffic regulations were put into effect, and in due time provisions were made for collecting garbage and rubbish, instituting mail delivery, offering a recreation program, expanding educational services, and in other ways transforming a village into a city.[10]

Because of its pioneering role, INAAP emerged as a national symbol of the new defense program, and it provided subsequent munitions projects with "systems and methods for the control of material, equipment and construction practices."[11]

On January 10, 1941, while the smokeless-powder plant was about half finished, construction began on an adjoining bag-manufacturing-and- loading plant of approximately 400 buildings. Architectural and engineering services were provided by Shreve, Anderson & Walker, Inc. of Detroit. Over thirty construction companies participated in the project, with the four largest firms serving as general contractor on a partnership basis. These principals were C. F. Haglin and Sons, Inc. (Minneapolis); Missouri Valley Bridge and Iron Company; Sollit Construction Company, Inc. (South Bend, Indiana); and Winston Bros. Company (Minneapolis). Despite delays caused by shortages of workmen and materials, construction was completed within a calendar year.[12] From east to west, the plant was laid out in the following five major areas:

(1) A small administration compound containing an Administration Building (Building 2501), Employment Building (Building 2511), and Hospital (Building 2601).

(2) A production-maintenance-and-storage area including two dozen warehouses (1500-series buildings), a Repair Shop (Building 2561), a Fire Station (Building 2521), a Heating Plant (Building 2541), and a huge Bag-Manufacturing Building (Building 1001) covering almost four acres of ground (Figure 5).

(3) A charging area comprising eight identical lines for bag-loading smokeless powder (3000-series buildings), and four identical lines for bag-loading black powder (4000-series buildings) (Figure 6).

(4) An extensive powder magazine area containing 177 earth-sheltered, reinforced-concrete, barrel-shaped "igloos" (Figure 7).

(5) A staff residential district of seventeen, two-story, wood-frame houses (Buildings 1101-1 through 1101-17), similar in design and adjacent to the staff residences constructed for the smokeless-powder plant.

In contrast to the smokeless-powder area, the bag-manufacturing-and-loading plant was not designed as a permanent installation. Whenever safety permitted, its structures, especially in the administration and shop areas, were built of cheaper and less durable materials -- wood-framing instead of steel framing, clay tile and concrete block instead of brick. For the most part, the design of the production buildings conformed to standardized

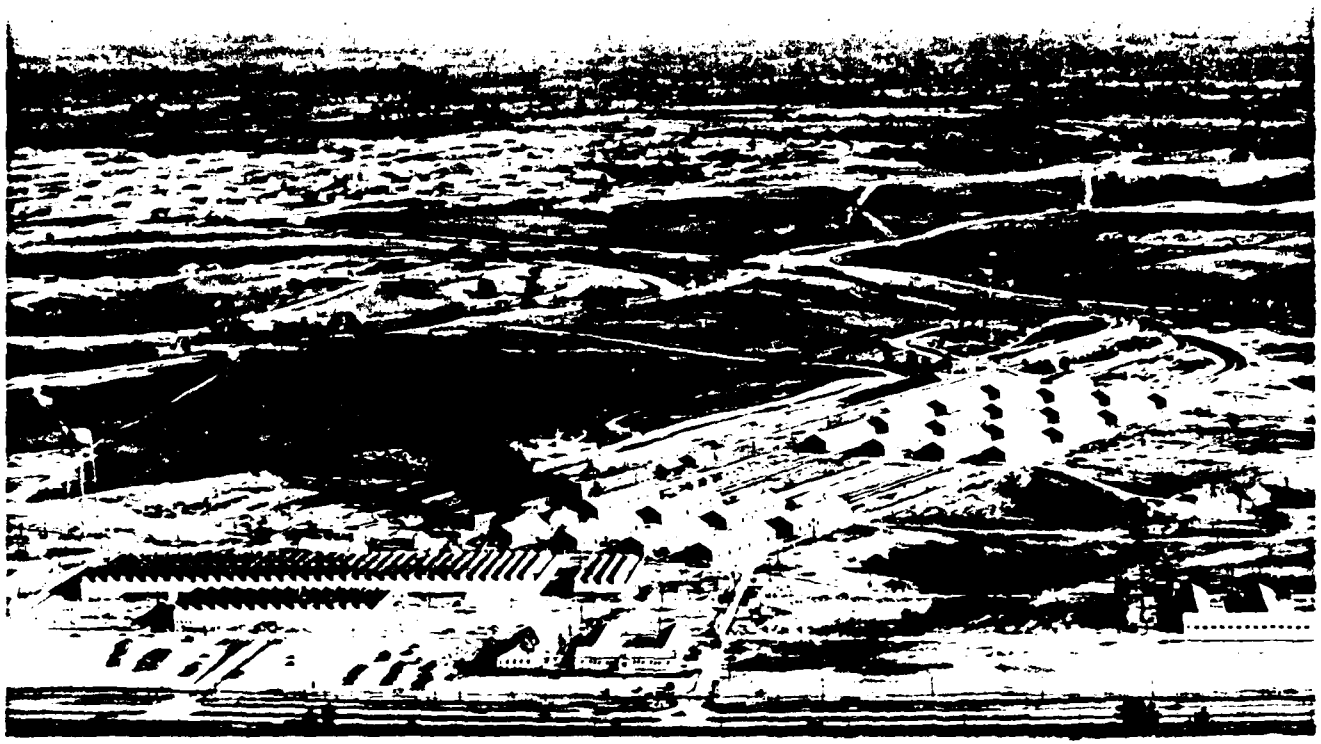


Figure 5: Aerial photograph of the bag-manufacturing area, looking east, c. 1942. The Employment Building (Building 2511) is in the central foreground. Immediately to the upper left is the Bag-Manufacturing Building (Building 1001), and to the upper right, the warehouse area. (Source: INAAP Administrative Archives.)

Figure 6: Aerial photograph of a typical propellant-loading line, looking east, 1941. The five buildings in the line are connected by covered walkways. Two mirror-image, L-shaped loading buildings occupy the center of the photo. Immediately above are three powder magazines; immediately below is the employee canteen. (Source: INAAP Administrative Archives.)

Figure 7: Building 5056 is typical of the plant's earth-sheltered magazines. (Source: Field inventory photograph, 1983, Jeffrey A. Hess, MacDonald and Mack Partnership.)

specifications developed by the Ordnance Department for all bag-loading plants. The smokeless-powder loading buildings (3003-3017), for example, employed typical "blow-out" construction: "While walls and foundations are composed essentially of poured, steel-reinforced concrete, cinder blocks are so placed that in event of an explosion, they will blow outward preventing the demolition of the entire building. For the same reason, roofing is made of readily shatterable transite."[13] The only major design innovation involved the large Bag-Manufacturing Building (Building 1001) (Figure 8):

> In the planning of this building, considerable pioneering was necessary since no data were available pertinent to a building of this size and type. This pioneering was stamped successful by the approval of the Chief of Ordnance, [and] the usage of these plans at the Radford (Va.) Ordnance Works. . . . Several requirements peculiar to the project were taken into consideration. Not only did the building have to be functionally efficient, but it had to be capable of speedy erection. In view of these considerations, a one story building was planned. This permits the flow of materials through the various stages of manufacture on a single level and permits a logical arrangement and sequence of steps. It minimizes distances between these steps and also eliminates the necessity of elevators. . . . Further, the fact that the building is of one story construction permits the utilization of the maximum amount of natural light [in the bag-manufacturing operation.] Consequently, the roof is of saw tooth construction. This arrangement is supplemented by approximately 900 3-tube, 240 watt fluorescent lights. To further protect the health of the operators, the building is adequately ventillated by a system consisting of fans constantly intaking fresh air and making a complete change every 6 minutes. For fire protection, not only is there an automatic sprinkler system, but also enough exits so that the entire building may be vacated within 15 seconds. The construction of the building itself is such that it is practically fireproof except for the roof. For reasons of economy and speed in construction, the building itself is constructed of concrete blocks.[14]

The third, and last, major construction project at INAAP was a new rocket-propellant plant, which got underway in December 1944, with du Pont serving as architect and general contractor. This project was never carried to

Figure 8: Bag-Manufacturing Building (Building 1001). (Source: Field inventory photograph, 1983, Jeffrey A. Hess, MacDonald and Mack Partnership.)

completion. On August 12, 1945, two days before V-J Day, all construction activities were suspended. Several of the buildings erected before the termination date were subsequently demolished, and the remainder were removed from IAAP jurisdiction when approximately half the rocket-plant site was sold as surplus property shortly after World War II.[15]

Technology

The term smokeless powder is a double misnomer. The material is actually a granulated substance, smokeless chiefly in comparison to black powder, which it replaced as the standard military propellant during the late nineteenth-century. Smokeless powder is categorized, according to the number of its active ingredients, as single-, double-, or multiple-base. Single-base powder, adopted by the American military for cannon and small arms during both World Wars, derives its propellant qualities from nitrocellulose. The modern manufacture of single-base powder still resembles the pioneering method developed by the French chemist Vielle in 1886. Vielle treated cotton with nitric acid to form nitrocellulose, gellatinized it with ether or alcohol, and then dried and cut the resulting material into "grains." Subsequent improvements on Vielle's method led to the perforation of powder grains to increase surface area and burning rate, and the use of chemical additives as stabilizers and flash retardants. In the summer of 1940, the Ordnance Department codified production methods for smokeless powder in a technical manual that dictated operating procedures at INAAP and most other World-War-II plants.16

Under the contract supervision of du Pont, INAAP began smokeless-

powder production in April 1941, and remained in operation until October 1945. The smokeless-powder area consisted of six parallel lines, designated (north to south) as "A" through "F" (Figure 9). The first four lines (A-D) produced multi-perforated cannon powder; the last two lines (E-F) single-perforated rifle powder.[17] Both types of propellant were manufactured by essentially the same process, summarized in the following description of the INAAP's operation:

> Smokeless powder is . . . made by nitrating cellulose. Wood or cotton can be used as the source of celluose; but as wood contains lignin, which must be eliminated, cotton is employed at this plant as the source for cellulose.[18] Cotton linters are used, since long staple cotton . . . plugs slurry lines and valves. . . . In the nitrating process the cotton . . . is sent to the third floor of the nitrating houses [105-series buildings] where there are several groups of charging hoppers. These supply the dipping pots suspended below the floor. Four pots are included in one nitrating unit. Cotton and nitrating acids are charged into the dipping pots. Beneath these pots and on the second floor are several wringers, one serving each of four dipping pots. Suspended under the wringers are immersion basins serviced with water. . . . In operation the pots are dipped in order, properly timed so that by the time the fourth pot is dipped, the first charge is ready to be dropped into the wringer. Nitrocellulose is discharged from the wringer into the immersion basin, drowned with water, and flushed into slurry tanks. . . .
>
> Impurities remain to be washed out in the next buildings in the line [108-series buildings]. This operation is known as the boiling tub procedure or stabilization. . . . After the boil is complete the material is run out of the tubs and put into another intermediate slurry tank. Any free acid is neutralized with sodium carbonate, but the nitrocellulose must be broken up to get at the acid held between the . . . fibers. This is accomplished . . . in the pulping houses [109-series buildings]. To accomplish the pulping the alkaline slurry is passed through a series of three Jordan refiners and pumped to the poacher houses [112-series buildings]. The final neutralization is accomplished here by the addition of more sodium carbonate. Heat and agitation insures the reaction between the acid and sodium carbonate. Boilings, settlings, decantations, and rewaterings follow, and the residual sodium carbonate and salts are removed by cold water washes. . . . Each [nitrocellulose] charge is analyzed and then pumped to huge vats with umbrella baffles and agitators in the blending and wringer house [113-series buildings] where blending produces the desired nitrogen content. After a sample of the blend has been approved by the laboratory, nitrocellulose is dewatered as much

Figure 9: Aerial photograph of the smokeless-powder lines, looking south, c. 1942. The three-story, gabled structures in the foreground are Nitrating Houses (105-series Buildings). (Source: INAAP Administrative Archives.)

as possible [by] centrifuging. . . .

Production [continues in the] dehydration press house [202-series buildings]. Here water present in the nitrocellulose is removed and alcohol is substituted. The nitrocellulose is charged into a hydraulic press and compressed by a low-pressure ram. Alcohol is forced in at the bottom of the press under a higher pressure, displacing the water. This process is aided by a partial vacuum applied through perforatons in the ramhead. The pressure exerted by this ram is then increased and some of the alcohol forced out of the cake. Enough alcohol is left in the block so that all alcohol requirements will be satisfied for the colloidizing [operation].

Actual colloidizing is accomplished in the mixer house [206-series buildings] where the dehydrated alcohol-containing blocks are charged into mixers. In a few minutes the action breaks up the blocks and partially mixes the nitrocellulose and insoluble compounding agents. Then ether containing a stabilizer and plasticizer is added . . . . The colloidal formation is completed in mixers . . . known as macerators; then [the material] is blocked in presses for convenience in handling. The next building in line is the screening and graining house [211-series buildings]. Here the powder is put through screens in a press in order to remove lumps and impurities. This is called a macaroni press [Figure 10] as the powder comes out in string or rope-like form. The powder is blocked once more and then sent to graining presses which extrude the powder through screens [and] a perforated die [Figure 11]. Strings or ropes of powder so obtained are then sent to a cutter where powder grain lengths are regulated.

Removal of alcohol and ether is accomplished by distilling the solvent out of the grains with hot air. . . . The powder is put into covered cars which are sent to the solvent recovery building [214-series buildings]. Here air heated by steam coils is passed through the cars and then partially by-passed through a condenser where much of the picked-up solvent is condensed. . . . After passing through the dump shed house [218-series buildings], the uniform powder is . . . put into storage tanks in the water-dry-house [219-series buildings]. Here the remaining solvent is removed. Water preheated by steam is pumped through the tanks so that the solvent may be quite rapidly dissolved out of the powder grains. . . . The removal of the water is left to the c. c. [control circulation] dry-house [220-series buildings]. Here the mass is dumped into a bin and hot air, obtained by passing air over a steam coil, is passed through the powder . . . to bring the moisture content down to an average value to be expected under normal conditions of termperature and humidity. The powder is now finished as far as the actual manufacturing processes are concerned.[19]

In addition to manufacturing finished propellant, INAAP also produced two

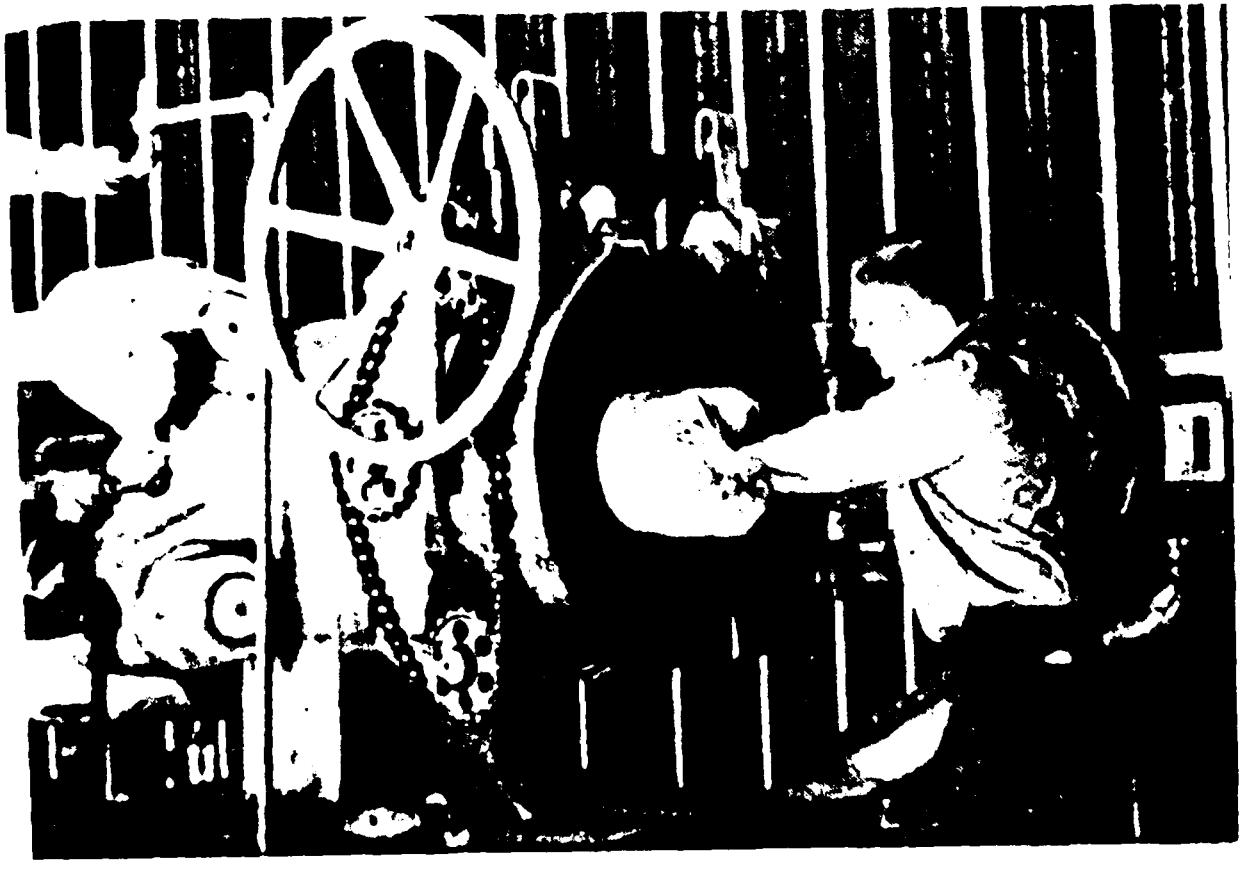


Figure 10: Operator loading block of colloided powder into a "macaroni" press. (Source: R. E. Hardy, "Producing Smokeless Powder by 1942 Methods," Chemical & Metallurgical Engineering, 49 [April 1942], 77.)

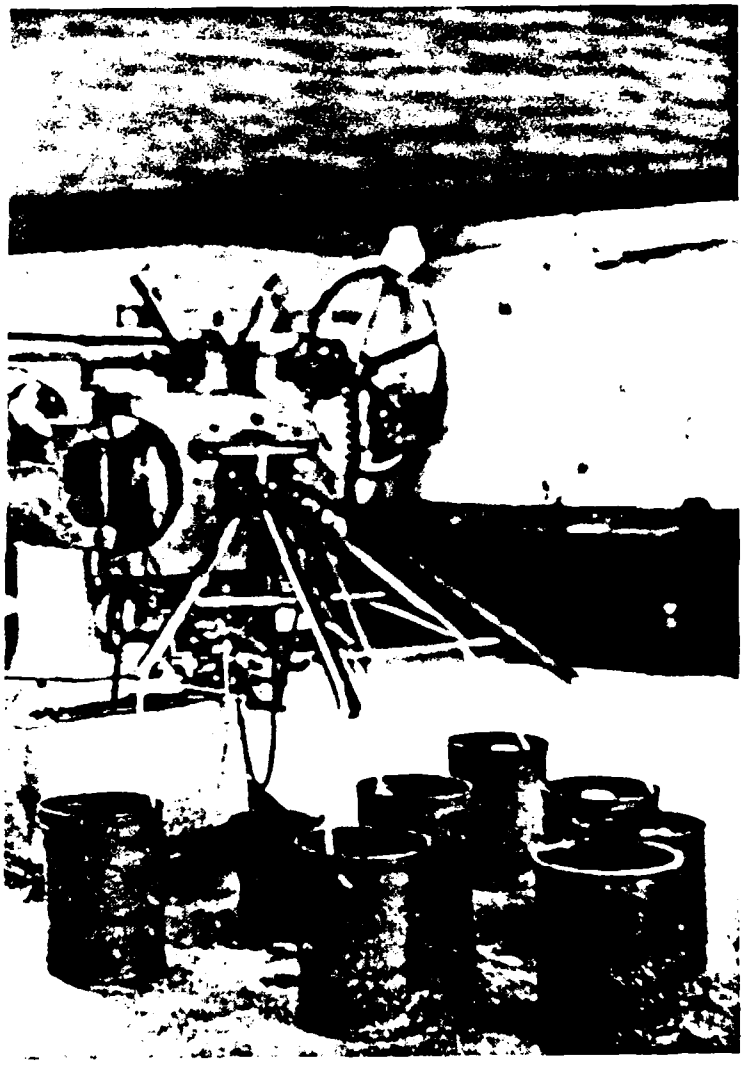


Figure 11: Powder being extruded in perforated strands from a graining press. (Source; "Smokeless Powder," Chemical & Metallurgical Engineering, 49 [April 1942], 112.)

basic raw materials: ether and nitric acid. The ether operation (207-series buildings) produced the solvent by dehydrating alcohol with strong sulfuric acid, which was "the conventional method of manufacture."[20] The nitric-acid facilities were also of standard industrial design, embodying a technology developed by du Pont in the mid-1920s. In the du Pont process, liquid ammonia was vaporized and mixed with heated compressed air in the presence of a platinum catalyst to form nitrogen oxides. The nitrogen compounds were then further oxidized with air and fed into an absorption tower, where they combined with water to form 60% nitric acid (Buildings 302-1, 302-2).[21] Like most industrial uses of nitric acid, the manufacture of nitrocellulose required an almost pure grade of the ingredient. To achieve this level of purity, INAAP used the time-honored technique of concentrating the 60% nitric acid by dehydrating it with strong sulfuric acid (Buildings 303-1, 303-2). The spent sulfuric acid, now diluted with water, was brought back to strength in an evaporator known as a "falling film concentrator" (Buildings 303-1, 303-2), which accomplished the removal of water by "dropping a thin film of acid over the inner surfaces of hot tubes."[22] The reconcentrated sulfuric acid was then ready for recycling in the nitric-acid operation.

INAAP also constructed and operated its own utilities. Two power houses (Buildings 400-1, 400-2) contained a total of eleven power units, each "composed of a [coal-fired] furnace, boiler, turbine, generators, and auxiliaries" to produce comfort-and-process heating and electricity.[23] Although the power houses were of standard industrial design, the plant's water-supply system required innovative engineering to furnish the vast quantities of water used in the smokeless-powder lines. To achieve the

necessary volume, INAAP constructed "the largest single groundwater project in the world," consisting of seven wells (Buildings 404-1 through 404-7) with a combined pumping capacity of approximately 70 million gallons per day (Figure 12).[24] The technology for the wells had been developed in the 1920s by a Canadian engineer named Leo Ranney, who initially applied it to the recovery of petroleum from oil-bearing sand and shale. By the mid-1930s, Ranney had modified his system for water-recovery purposes, founded the Ranney Water Collector Corporation of New York, and installed his first well in London, England. INAAP project was Ranney's eighth and largest contract in the United States. The hallmark of the Ranney system was the use of lateral collection pipes, which branched from the main caisson into the surrounding aquifer. This innovative design maximized the surface area of the subsoil collection system and allowed the "fullest utilization of the available groundwater."[25]

As was true for other propellant plants, the INAAP's smokeless-powder lines were in close proximity to bag-manufacturing-and-loading facilities, which produced finished propellant charges for artillery, cannon, and mortar projectiles. The INAAP's loading plant was supervised on a contract basis by Goodyear Engineering Corporation of Akron, Ohio. Production commenced in the fall of 1941, and continued until V-J Day. The INAAP's Bag-Manufacturing Building (Building 1001), closely resembled a garment-industry operation, employing conventional cutting and sewing machines to fabricate cotton and silk bags, which were then distributed to the loading, or charging, lines (Figure 13). INAAP was constructed with eight identical lines (3000-series buildings) for loading smokeless

Figure 12: Building 404-2 is typical of the Ranney water wells at the INAAP. (Source: Field inventory photograph, 1983, Jeffrey A. Hess, MacDonald and Mack Partnership.)

Figure 13: The Bag-Manufacturing Building (Building 1001) in full production during World War II. (Source: Charlestown Township Library, Charlestown, Indiana.)

powder and four identical lines (4000-series buildings) for black powder, which was manufactured at other munitions works. The black powder charges served as "igniters" for "certain propellant charges in order to insure complete, rapid, combustion." In its basic details, black-powder loading conformed to the following description of smokeless-powder loading:

> Approximately one day's supply of smokeless powder in filled containers is trucked from the igloo area [5000-series buildings] to the loading area and stored in the Smokeless Powder Service Magazines [Buildings 3101 through 3017] until immediately prior to loading . . . . Smokeless powder is handtrucked from service magazines to loading buildings [Buildings 3001 through 3017] over concrete connecting walks, 6-feet wide, covered by frame roofing, permitting all-weather transportation. Reaching the loading buildings, smokeless powder is hoisted by elevator to the second floor, thence handtrucked to non-sparking copper hoppers, each of which extends downward to a separate loading room [where operators measure and seal the propellant into bags].[27]

Although there were no major alterations to either the bag-manufacturing-and-loading or smokeless-powder facilities during World War II, INAAP did experience technological expansion with the construction of a rocket-propellant plant in 1944-1945. Du Pont was selected to serve as contract operator. According to original specifications, the plant was to contain three production lines for double-base, solventless, extruded propellant: "basic operations were to have been the manufacture of nitroglycerine, the mixing with nitrocellulose into a paste and the rolling of the paste into various forms for rocket propellant."[28] Only one line was completed. Entering production in July 1945, it was deactivated a month later. In the fall of 1945, the rocket plant, along with all other manufacturing facilities at INAAP, was placed in standby condition under government supervision.

KOREAN WAR

Portions of the INAAP's bag-manufacturing-and-loading facilities were reactivated by government personnel in 1948, but the installation did not resume large-scale military production until 1952, when Goodyear and du Pont returned to their respective World-War-II roles in supervising the loading and smokeless-powder operations. After the suspension of manufacturing activities in 1957, INAAP once more became a standby plant, with du Pont and Goodyear remaining as contract caretakers. This arrangement continued until 1959, when maintenance of all production facilities was taken over by Liberty Powder Defense Corporation, a wholly owned subsidiary of Olin Mathieson Chemical Corporation. During the Korean War reactivation, there were no significant technological developments at the installation. Approximately fifty new buildings were constructed; the majority were minor maintenance and storage facilities.[29]

VIETNAM WAR TO THE PRESENT

Although portions of INAAP remained in standby condition throughout the 1960s and 1970s, the plant played a significant role in manufacturing munitions for the Vietnam War. Reactivation commenced in November 1961, when Liberty Powder Defense Corporation started up the Bag-Manufacturing Building (Building 1001) to produce cloth bags for 105-mm artillery charges. Two months later, Olin dissolved its subsidiary firm and directly took charge of the INAAP's operation. This administrative reorganization coincided with the reactivation of the plant's igniter- and propellant-loading lines, which were supplied with black powder and smokeless powder

from other munitions works.[30]

During the early 1960s, production runs were plagued by problems involving "maladjusted sewing machines and scales, inexperienced quality assurance inspectors, short leadtimes, incomplete technical data packages and fluctuating requirements." These difficulties were eventually resolved, largely "due to the contractor's ability to hire former DuPont and Good[year] employees familiar with bagging, propellant loading, and igniter assembly."[31] Because of American troop buildup in Vietnam, the INAAP's production schedules dramatically increased during the late 1960s. The production of 81-mm mortar charges, for example, rose from 600 per month in September 1965 to 8,000,000 in June 1968. In 1969, Olin was also authorized to reactivate a portion of the INAAP's smokeless-powder manufacturing area, which had been idle for over a decade. Olin continued in its supervisory role at INAAP until 1972, when maintenance and production activities were taken over by ICA Americas, Inc., of Wilmington, Delaware. ICI has remained the plant's contract operator to the present time.[32]

After the resolution of the Vietnam War, the federal government embarked on an ambitious modernization program of its munitions-manufacturing facilities. Initial studies of INAAP pointed out several limitations in the plant's World-War-II design and technology:

> Intraplant materials handling and storage facilties need improvement. Structures in most prodution lines will not meet new safety criteria. . . . [Igniter and propellant load lines] have excessive manual operations, and hazardous working conditions. . . . Indiana has the single-base propellant . . . capability to meet mobilization requirements, but is deficient in the

manufacture of . . . black powder.[33]

To rectify some of these deficiencies, INAAP began constructing three major new facilities. The first, completed in 1978, was a highly automated, black-powder manufacturing operation (800-series buildings), erected on the site of the World-War-II, rocket-propellant plant. Designed by the Omaha District of the U. S. Corps of Engineers, the system consisted of approximately a dozen, metal-clad structures which, after an initial "prove-out" period, were placed in standby condition in the summer of 1983 (Figure 14). In the traditional method of black-powder manufacture, workers manually shoveled sulfur, potassium nitrate, and charcoal into a wheel mill, which moistened the ingredients with water and ground them into a meal. After this initial incorporation process, the meal was pressed into cakes, manually transferred to a corning mill for "graining" and then to a wooden glaze barrel for tumble-polishing with graphite. The INAAP's new black-powder system, was the first of its kind in the United States. It eliminated almost all manual operations by means of computer-monitored conveyors and metering stations, and replaced the conventional wheel mill by an innovative "jet mill," which ground and blended the black-powder meal by air-pressurized particle collision.[34]

The INAAP's two other new projects, both presently in progress, are a semi-automated loading line for 105-mm charges and a similar assembly for 155-mm charges. The 105-mm buildings (Buildings 3018 A-G) were completed in 1980 on the site of the INAAP's northeasternmost propellant-charge line, which was demolished just prior to the start of new construction. Although much of the operating equipment has been installed and tested, the

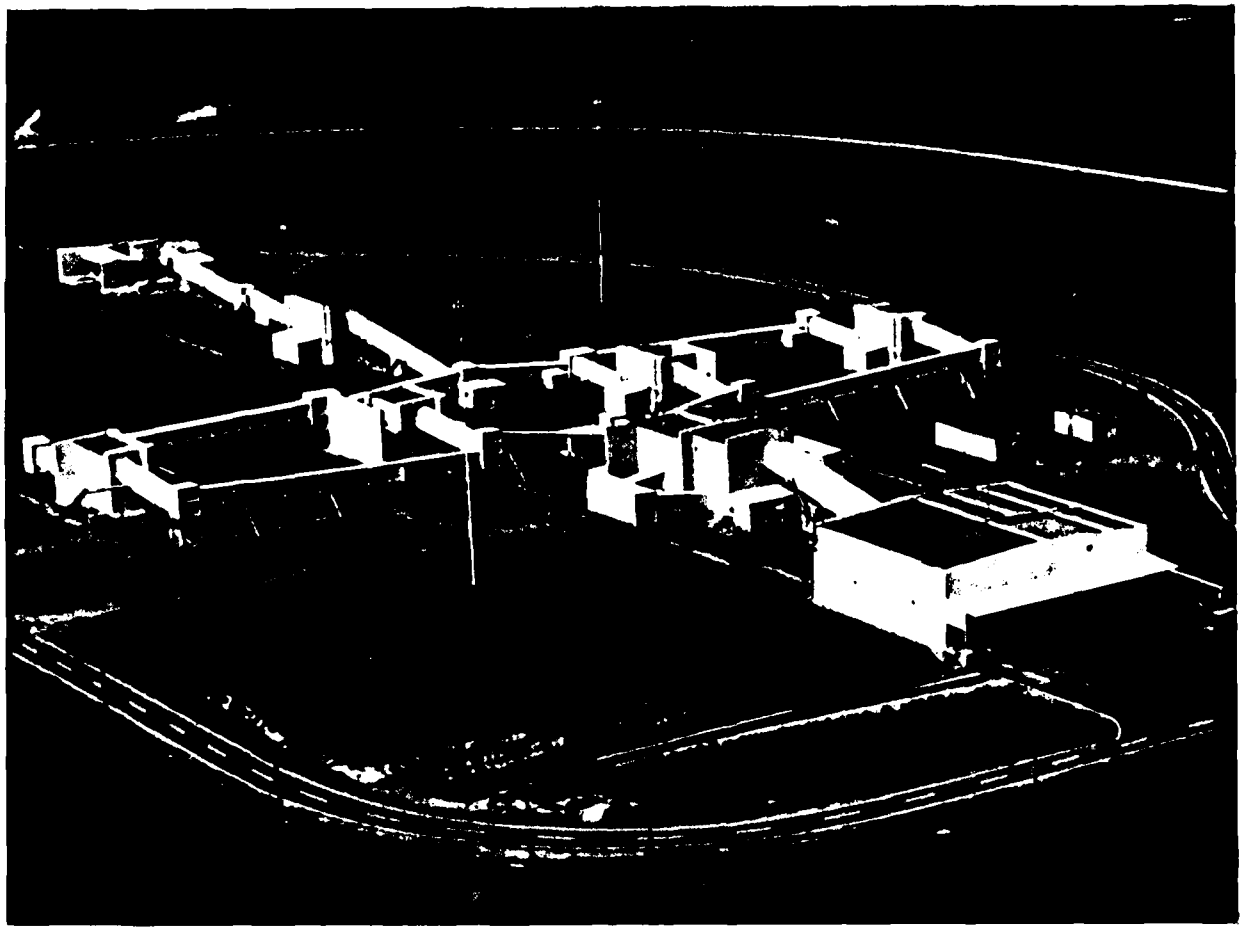


Figure 14: Aerial photograph of the new black-powder manufacturing area, looking south, c. 1980. (Source: INAAP Administrative Archives.)

system is not scheduled for completion until fiscal year 1986. The 155-mm operation (no building numbers assigned) was in its final phases of construction in 1981-1982. Erected on the site of the plant's northeasternmost igniter-charge line, the facility is currently awaiting final equipment installment, which should be completed about 1985.[35] Despite these various modernization projects, INAAP still retains most of its World-War-II architecture and technology. Currently, the bag-manufacturing-and-lines are in intermittent production; the smokeless-powder lines are in standby condition.

NOTES

1. Sidney D. Kirkpatrick, "Mid-West Builds Biggest U. S. Powder Plant," Chemical & Metallurgical Engineering, 48 (April 1941), 74. The dismantling of the American munitions industry after World War I is discussed in Jules Bebie, "Making Explosives for World War II," Chemical & Metallurgical Engineering, 48 (October 1941), 76. As Secretary of War Henry L. Stimson noted in 1943, "We didn't have enough powder in the whole United States [in 1940] to last the men we now have overseas for anything like a day's fighting"; see Harry C. Thomson and Lida Mayo, The Ordnance Department: Procurement and Supply (Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1973), p. 104.

2. The other two powder plants were the Radford (Virginia) Ordnance Works, completed in 1941, and the Alabama Ordnance Works, completed in 1942; see Kirkpatrick, 73; Vincent B. Smith, "Ten-Month Time Limit Spurs 21,000 Construction Workers on $41,000,000 Powder Plant," Construction Methods, 23 (April 1941), 42-56; Lenore Fine and Jesse A. Remington, The Corps of Engineers: Construction in the United States (Washington, D.C.: Office of the Chief of Military History, United States Army, 1972), p. 340.

3. The conformance of INAAP site to general selection criteria is noted in Douglas M. Considine, "From the Ground Up," Scientific American, 166 (June 1942), 278-279; "Arsenal of Democracy," Heating, Piping and Air Conditioning (August 1941), 479.

4. Geoffrey Parsons Jr., "World's Biggest Powder Plant Turning Indiana Field Into City," New York Herald Tribune, January 26, 1941; Joeann

McManus, "Boom Town," p. 2, unpublished script for slide-tape program, 1979, in Charlestown Township Library, Charlestown, Indiana.

5. "Historical Report, Hoosier Ordnance Plant, from Beginning of Construction to December 31, 1942," p. 7, unpublished, n. d., in INAAP Administrativ°e Archives.

6. "Photographs, Plant #2, Real Estates," unpublished report, c. 1944, in INAAP Administrative Archives; "Jean Howerton Coady, "Once Popular, Rose Island Now Is Only Thorns," Louisville Courier-Journal, June 18, 1977; "Daily Log, Plant 2," unpublished report, 1945, in INAAP Administrative Archives.

7. "Historical Report, July 1940 thru December 31, 1942, Construction and Operations," unpublished, n.d., pp. 47-48, INAAP Administrative Archives; Vincent B. Smith, "$86,000,000 Powder Plant Matures in 10 Months Under Drive by 23,000 Construction Workers," Construction Methods, 23 (May 1941), 42-56; Indiana Army Ammunition Plant Real Property Inventory, unpublished computer printout, March 31, 1982. During World War II, Indiana Ordnance Works and Hoosier Ordnance Works were maintained as separate production plants with a shared government administrative staff. In October 1945, the two ordnance works were consolidated as Indiana Arsenal. Six years later, the installation was renamed Indiana Ordnance Plant and so remained until designated Indiana Army Ammunition Plant (INAAP) in July 1963. For purposes of brevity and clarity, this report will refer to the various production facilities as INAAP.

8. "Nation's Largest Powder Plant Built in 9 Months," Engineering News-Record, 127 (August 7, 1941), 188; Kirkpatrick, 73. "Brick is the favored material for exterior walls. . . . Availability and price in the Louisville area, as well as the established record of brick for durability in this location, determined the choice of this material for wall construction in many of the plant buildings"; Vincent, $86,000,000 Powder Plant," 54-55.

9. Ralph F. Armstrong, "Indiana Plays Guinea Pig for a War Boom," Nation's Business (May 1941), .

10. Mel Scott, American City Planning (Berkeley: University of California Press, 1969), p. 373.

11. William Voight, Jr., "The Ordnance Organization in World War II," p.144-145, unpublished report, c. 1945. For contemporary press coverage of the INAAP's pioneering role, see Karl Richert, "Charlestown to be 'Guinea Pig' for Nation," Louisville Times, October 4, 1940; "Big Business for Charlestown," Business Week (November 2, 1940), 26; "Army Building New du Pont Plant in Indiana," Life Magazine (January 20, 1941); "Boom Town Pains," Minneapolis Star Journal, February 16, 1941.

12. "Historical Report, Hoosier Ordnance Plant," pp. 7-9; "Historical Monograph of Indiana Army Ammunition Plant, Charlestown, Indiana, from 17 July 1940 to 1 July 1963," p. 16, unpublished, n.d., in INAAP

Administrative Archives.

13. "Historical Report, Hoosier Ordnance Plant," p. 27.

14. "History of Hoosier Ordnance Plant, Construction", n.p., unpublished, n.d., in INAAP Administrative Archives.

15. "Historical Summary, Indiana Arsenal, Charlestown, Indiana, 1 September 1945 - 1 July 1951, " pp. 5-6, unpublished, n.d., in INAAP Administrative Archives.

16. Chief of Ordnance, "Manufacture of Smokeless Powder," Military Explosives (Washington, D.C.: War Department, Technical Manual No. 9-2900, August 29, 1940), pp. 4-38. On the history of smokeless-powder manufacture, see E. I. du Pont de Nemours & Company, Inc., "Improvements in Single Base Propellant Manufacture," vol. 1, pp. 22-28, unpublished report prepared for Indiana Arsenal, 1958, in ICI Americas, Inc. Archives, INAAP; Robert G. Skerret, "Smokeless Powder for Our Navy," Compressed Air Magazine, 50 (February 1945), 39-45.

17. "Historical Report, July 1940 thru December 31, 1942," p. 60.

18. In 1942, INAAP modified lines A-D for using wood pulp as a cellulose base. This necessitated the construction of four new buildings, 122-1 through 122-4; see "Historical Report, July 1940 thru December 31, 1942," p. 65.

19. R. E. Hardy, "Producing Smokeless Powder by 1942 Methods," Chemical & Metallurgical Engineering, 49 (April 1942), 77-79.

20. "Historical Report, July 1940 thru December 31, 1942," p. 68.

21. Guy B. Taylor and others. "Manufacture of Nitric Acid by the Oxidation of Ammonia," Industrial and Engineering Chemistry, 23 (August 1, 1931), 860-865; "Historical Report, July 1940 thru December 31, 1942," p. 68.

22. "INAAP Chemical Division Manual," Section II (Acid), p. 4, unpublished, n.d., ICI Americas, Inc. Archives, INAAP.

23. E. C. Hardin, Jr. "Power," Powder Horn, 1 (Christmas Issue, 1942), 8, in Charlestown Township Library.

24. "Radial Wells for Powder Plant Water Supply," Engineering News-Record, 127 (July 31, 1941), 45.

25. "Radial Wells," 45. For the development of the Ranney system, see the following articles in Engineering News-Record: Ross Nebolsine, "London Water Supply Augmented by New Underground System," 117 (October 22, 1936), 576-577; C. M Maratta, "Industry Taps an Underground Lake," 120 (January 6, 1938), 25-28.

26. "Historical Report, Hoosier Ordnance Plant," p. 14.

27. "History of Hoosier Ordnance Plant, Construction," n.p.

28. "Historical Monograph of Indiana Army Ammunition Plant," p. 8; "Daily Log, Plant #2," entries for July - August, 1945, n.p.

29. "Historical Monograph of Indiana Army Ammunition Plant," pp. 12-14, 23-28.

30. "Historical Monograph," pp. 15, 29.

31. R. J. Hammond, "Profile on Munitions, 1950-1977," p. 70, unpublished, n.d., microfiche, in AMCCOM Historical Office, Rock Island Arsenal.

32. Hammond, p. 70; "DARCOM Installation and Activity Brochure, Indiana Army Ammunition Plant," p. 3, unpublished, 1982, in INAAP Administrative Archives.

33. "Modernization Engineering Report for U. S. Army Ammunition Plants," Vol. 4, pp. 7-8, unpublished report prepared by Kaiser Engineers for U. S. Army Munitions Command, Dover, N. J., 1970, in AMCCOM Historical Office Archives, Rock Island Arsenal.

34. "Black Powder Manufacturing Facility, Indiana Army Ammunition Plant," unpublished report prepared by ICI Americas, Inc. for U. S. Army, AMCCOM, 1981; Jeffrey A. Hess, Interview with Richard Schultz, ICI Assistant Facility Project Manager for Black Powder Operation, August 4, 1983.

35. "Information Paper, Project 5802594, EXP 155/mm/8 Inch Center Core Prop Charge Lap," unpublished, Je. 17, 1983; "Information Paper, Project 5782500 Modernize 105mm M67 Prop Charge Production," unpublished, June 17, 1983, INAAP Administrative Archives.

Chapter 3

PRESERVATION RECOMMENDATIONS

BACKGROUND

Army Regulation 420-40 requires that an historic preservation plan be developed as an integral part of each installation's planning and long-range maintenance and development scheduling.[1] The purpose of such a program is to:

- Preserve historic properties to reflect the Army's role in history and its continuing concern for the protection of the nation's heritage.
- Implement historic preservation projects as an integral part of the installation's maintenance and construction programs.
- Find adaptive uses for historic properties in order to maintain them as actively used facilities on the installation.
- Eliminate damage or destruction due to improper maintenance, repair, or use that may alter or destroy the significant elements of any property.
- Enhance the most historically significant areas of the installation through appropriate landscaping and conservation.

To meet these overall preservation objectives, the general preservation recommendations set forth below have been developed:

Category I Historic Properties

All Category I historic properties not currently listed on or nominated to the National Register of Historic Places are assumed to be eligible for

nomination regardless of age. The following general preservation recommendations apply to these properties:

a) Each Category I historic property should be treated as if it were on the National Register, whether listed or not. Properties not currently listed should be nominated. Category I historic properties should not be altered or demolished. All work on such properties shall be performed in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation (ACHP) as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800).

b) An individual preservation plan should be developed and put into effect for each Category I historic property. This plan should delineate the appropriate restoration or preservation program to be carried out for the property. It should include a maintenance and repair schedule and estimated initial and annual costs. The preservation plan should be approved by the State Historic Preservation Officer and the Advisory Council in accordance with the above-referenced ACHP regulation. Until the historic preservation plan is put into effect, Category I historic properties should be maintained in accordance with the recommended approaches of the Secretary of Interior's Standards for Rehabilitation and

Revised Guidelines for Rehabilitating Historic Buildings[2] and in consultation with the State Historic Preservation Officer.

c) Each Category I historic property should be documented in accordance with Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) Documentation Level II, and the documentation submitted for inclusion in the HABS/HAER collections in the Library of Congress.[3] When no adequate architectural drawings exist for a Category I historic property, it should be documented in accordance with Documentation Level I of these standards. In cases where standard measured drawings are unable to record significant features of a property or technological process, interpretive drawings also should be prepared.

Category II Historic Properties

All Category II historic properties not currently listed on or nominated to the National Register of Historic Places are assumed to be eligible for nomination regardless of age. The following general preservation recommendations apply to these properties:

a) Each Category II historic property should be treated as if it were on the National Register, whether listed or not. Properties not currently listed should be nominated. Category II historic properties should not be altered or demolished. All work on such properties shall be performed

in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation (ACHP) as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800).

b) An individual preservation plan should be developed and put into effect for each Category II historic property. This plan should delineate the appropriate preservation or rehabilitation program to be carried out for the property or for those parts of the property which contribute to its historical, architectural, or technological importance. It should include a maintenance and repair schedule and estimated initial and annual costs. The preservation plan should be approved by the State Historic Preservation Officer and the Advisory Council in accordance with the above-referenced ACHP regulations. Until the historic preservation plan is put into effect, Category II historic properties should be maintained in accordance with the recommended approaches in the Secretary of the Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings[4] and in consultation with the State Historic Preservation Officer.

c) Each Category II historic property should be documented in accordance with Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) Documentation Level

II, and the documentation submitted for inclusion in the HABS/HAER collections in the Library of Congress.[5]

Category III Historic Properties

The following preservation recommendations apply to Category III historic properties:

a) Category III historic properties listed on or eligible for nomination to the National Register as part of a district or thematic group should be treated in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800). Such properties should not be demolished and their facades, or those parts of the property that contribute to the historical landscape, should be protected from major modifications. Preservation plans should be developed for groupings of Category III historic properties within a district or thematic group. The scope of these plans should be limited to those parts of each property that contribute to the district or group's importance. Until such plans are put into effect, these properties should be maintained in accordance with the recommended approaches in the Secretary of the Interior's Standards for Rehabilitation and Revised

Guidelines for Rehabilitating Historic Buildings[6] and in consultation with the State Historic Preservation Officer.

b) Category III historic properties not listed on or eligible for nomination to the National Register as part of a district or thematic group should receive routine maintenance. Such properties should not be demolished, and their facades, or those parts of the property that contribute to the historical landscape, should be protected from modification. If the properties are unoccupied, they should, as a minimum, be maintained in stable condition and prevented from deteriorating.

HABS/HAER Documentation Level IV has been completed for all Category III historic properties, and no additional documentation is required as long as they are not endangered. Category III historic properties that are endangered for operational or other reasons should be documented in accordance with HABS/HAER Documentation Level III, and submitted for inclusion in the HABS/HAER collections in the Library of Congress.[7] Similar structures need only be documented once.

CATEGORY I HISTORIC PROPERTIES

There are no Category I historic properties at the INAAP.

CATEGORY II HISTORIC PROPERTIES

Ranney Water Wells (Buildings 404-1 through 404-7)

. Background and significance. The seven wells (see page 37 and Figures 12, 15, 16) were built in 1941 to meet the substantial water requirements of the INAAP's smokeless-powder manufacturing operation. The structures are spaced at approximately one-quarter-mile intervals near the bank of the Ohio River on the INAAP's eastern boundary. Although individual units vary slightly in overall dimensions, each consists of a cyclindrical, reinforced-concrete caisson surmounted by a steel-framed, Transite-clad control house. The caissons are about 100 feet in length (from the floor of the control house to the bottom of the well) and measure thirteen feet in diameter with walls eighteen inches thick. The control houses are elevated about thirty feet above ground level; they are one-story structures of rectangular plan, measuring approximately thirty feet by twenty feet. Each control house is equipped with two pumping stations.

The wells were designed by the Ranney Water Collector Corporation of New York, and embodied a distinctive technology developed by the company's founder, Canadian-born engineer Leo Ranney. Ranney's system utilized a network of screened, perforated collection pipes, which branched from the main caisson into the surrounding aquifer. The number and placement of the lateral collectors depended upon groundwater conditions and the pumping requirements of the system. In 1938, when Ranney installed his first American unit for the Timken

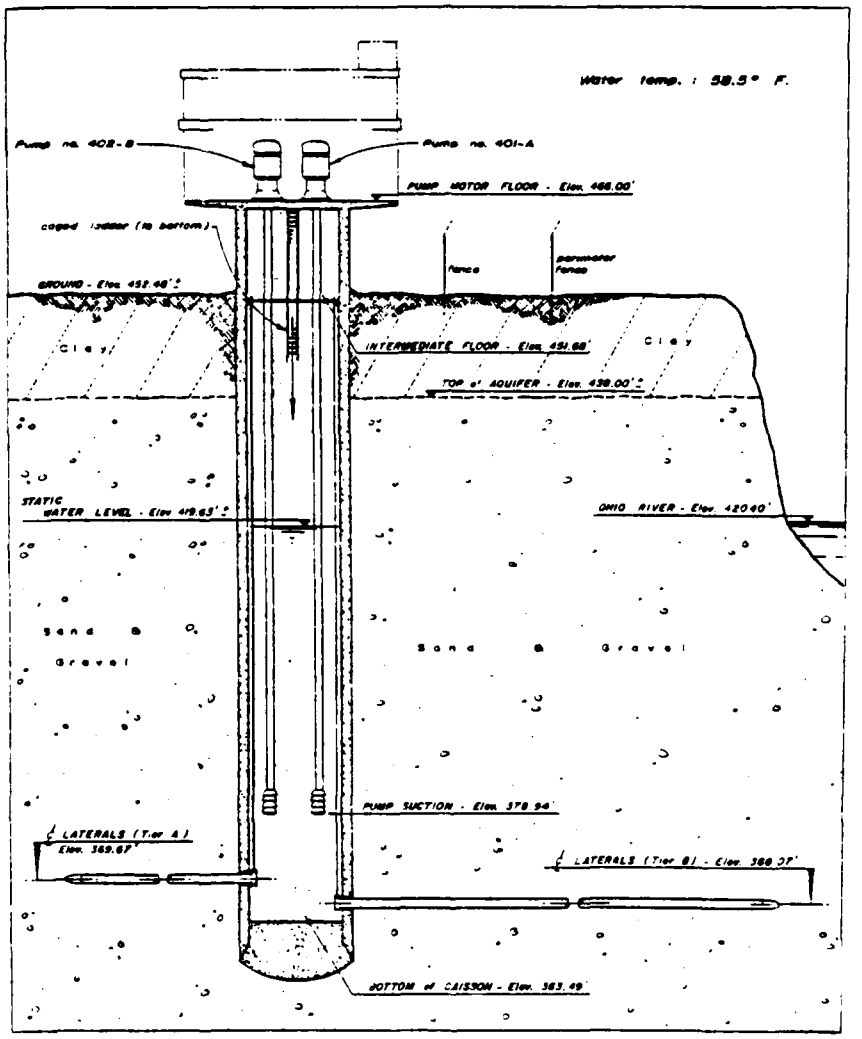


Figure 15: Cross-section view of Building 404-7, showing engineering features typical of all seven Ranney water wells at INAAP. (Source: "Ranney Well Inspections," unpublished report prepared by Ranney Company for ICI Americas, Inc., March 1979, p. 45, ICI Americas, Inc. Archives, INAAP.)

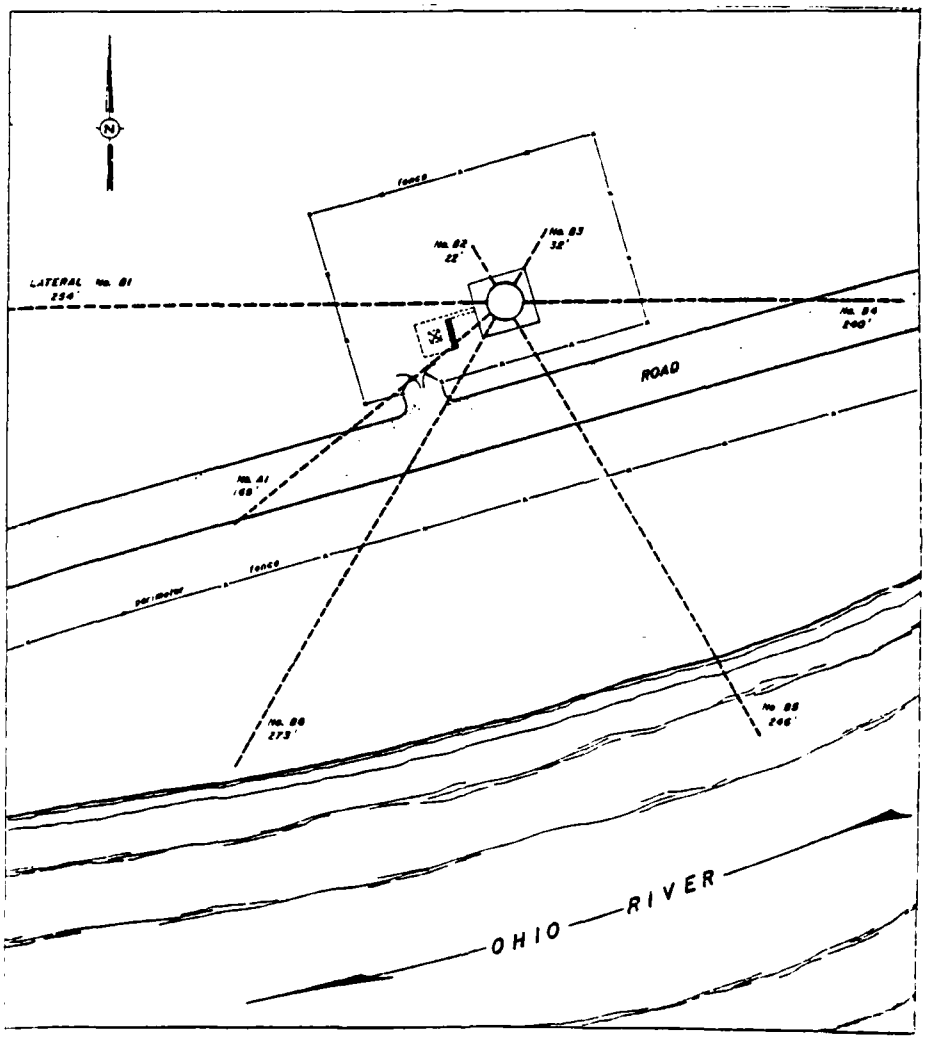


Figure 16: Plan view of Building 404-7, showing radial arrangement of lateral collectors. (Source: "Ranney Well Inspections," unpublished report prepared by Ranney Company for ICI Americas, Inc., March 1979, p. 46, ICI Americas, Inc. Archives, INAAP.)

Roller Bearing Co. of Canton, Ohio, the Engineering News-Record described the system's "radical departure from the orthodox type of well construction":

> The principle on which the system is based involves the sinking of a shaft of suitable diameter down through the water bearing strata and projecting slotted screen pipes (collectors) radially and horizontally at selected levels into the water bearing formation. Each pipe has its outer end equipped with a special digging point by means of which fine material in its path is removed. Thus it is possible to develop a graded filtering medium surrounding the screen surface of the collector pipes. This digging point also permits the projection of the pipe to a considerable distance and the exposure of a large screen area into the water-bearing strata. The large area of screen exposed makes it possible to maintain a low velocity flow through the screen openings as well as in the adjacent ground. Consequently, there is only a relatively small drop in pressure between the water in the pipe and that in the nearby ground when withdrawals of water are made. Under these conditions it is believed that no substantial incrustation can take place and the permanency of supply will be assured.[8]

In 1940, when Congress authorized the construction of INAAP, the Ranney well system was a new and little-known technology with only four operating examples in the United States. In that year, however, du Pont commissioned three Ranney systems for its plants in New Jersey, and the company was so satisfied with the results that it recommended the new water-supply technology for the government's smokeless-powder plant in Indiana. Each Ranney well at INAAP was designed with two tiers of lateral collectors arranged in a radial configuration, which allowed a pumping capacity of approximately 10 million gallons per day, or a total field capacity of 70 million gallons. At the time of its completion, the INAAP's water-supply system was considered to be "the largest single groundwater project in

the world." Although over 250 Ranney systems have been installed in the United States since World War II, the INAAP's wells have not been exceeded in pumping capacity. The INAAP's system is the third oldest, active example of Ranney technology in the country.[9] Because the INAAP's wells are important examples of a highly intact engineering process, they are Category II historic properties.

- Condition and potential adverse impacts. Architecturally and technologically, the seven wells are in good condition. Three of the units (Buildings 404-1, 404-3, 404-4) are used on an intermittent basis, and the remainder are on standby status. Apart from the modernization of one pumping station in Building 404-1 in 1976, the wells retain the full complement of their original equipment. There are no current plans to alter or demolish any of the structures, but continued maintenance and repair of these facilities is needed to ensure their preservation.

- Preservation options. Since the seven wells are virtually identical, it would be redundant to document all of them in detail. In consultation with appropriate military personnel, one well should be selected on the basis of its location and condition for nomination to the National Register and for preservation as a Catgory II historic structure. Such preservation need not extend to the original pumping equipment (pumps, motors, switchgear, fuel tanks, etc.), which were of conventional design. If necessary, these components can be rehabilitated or replaced with modern equipment. Otherwise, the well's architecture and technology should be treated in conformance

with the general preservation recommendations for Category II historic properties, as outlined at the beginning of this chapter. The other six wells should be preserved as Category III historic structures. Their architecture and significant technology should be treated in conformance with the general preservation recommendations for Category III historic structures not eligible for the National Register, as outlined at the beginning of this chapter.

CATEGORY III HISTORIC PROPERTIES

Bag-Manufacturing Building (Building 1001)

- Background and significance. Designed by Shreve, Anderson & Walker of Detroit, the building was constructed in 1941 for manufacturing cloth bags for artillery, cannon, and mortar charges. Essentially, the building was a mass-production textile workshop, housing conventional industrial equipment for patterning, cutting, and sewing (See page 28 and Figures 8, 13). Covering nearly four acres of ground, the one-story structure is of rectangular plan, with steel framing and concrete-block walls. Its distinctive, saw-tooth monitor roof was selected to permit "the utilization of the maximum amount of natural light" in the bag-manufacturing process. The structure served as a model for similar, but smaller, facilities at other World-War-II munitions plants. Because of its unique scale and prototype qualities, the building is a Category III historic property.

- Condition and potential adverse impacts. Portions of the buildings

are currently used for production on an intermittent basis. The structure receives routine repair and maintenance, and is in good condition. There are no current plans to alter or demolish this building.

- Preservation options. See the general preservation recommendations at the beginning of this chapter for Category III historic properties not eligible for the National Register.

Main Administration Building (Building 703)

- Background and significance. The Main Administration Building (Figure 16) typifies the "permanent" steel-frame, brick-wall construction that set INAAP apart from other government-owned smokeless- powder plants built during World War II. Completed in 1941, the building was designed by E. I. du Pont de Nemours & Co., Inc. in a style reminiscent of simplified, late-WPA architecture. Of rectangular plan, the flat-roofed, two-story structure measures approximately 250 feet by 80 feet. Its projecting entrance bay on the west facade is adorned with linearly patterned cast-concrete accents. In terms of siting, scale, and detailing, the building dominates the INAAP's main administration area, and it was obviously intended to be the plant's most "public" architectural statement. Functionally and symbolically, the Main Administration Building presided over both INAAP and the neighboring community of Charlestown, which, under the plant's impact, was transformed from a small, unpaved, rural village into a modern city (see Chapter 2, World War II). Because of its local historic

Figure 17: Main Administration Building (Building 703). (Source: Field inventory photograph, 1983, Jeffrey A. Hess, MacDonald and Mack Partnership.)

importance, the Main Administration Building is a Category III historic property.

- Condition and potential adverse impacts. The building still houses the INAAP's main administrative offices. It receives routine maintenance and repair, and is in good condition. There are no current plans to alter or demolish the structure.

- Preservation options. See the general preservation recommendations at the beginning of this chapter for Category III historic properties not eligible for the National Register.

NOTES

1. Army Regulation 420-40, Historic Preservation (Headquarters, U.S. Army: Washington, D.C., 15 April 1984).

2. National Park Service, Secretary of Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings, 1983 (Washington, D.C.: Preservation Assistance Division, National Park Service, 1983).

3. National Park Service, "Archeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines," Federal Register, Part IV, 28 September 1983, pp. 44730-44734.

4. National Park Service, Secretary of the Interior's Standards.

5. National Park Service, "Archeology and Historic Preservation."

6. National Park Service, Secretary of the Interior's Standards.

7. National Park Service, "Archeology and Historic Preservation."

8. C. M. Maratta, "Industry Taps an Underground Lake," Engineering News-Record, 120 (January 6, 1938), 26. Although the idea of radiating, lateral collectors was not new, Ranney was the first to engineer a truly successful system: "For certain locations, engineers have long recognized the advantages of wells equipped

with a number of radiating collector pipes. In the oldest examples of Europe, horizontal radial screen pipes discharging into a central well were buried in trenches. The very limited depth to which this could be done excluded all locations where the groundwaetr was not perfectly stable and near the surface. Later, radial wells were built by simply forcing horizontal strainer pipes of small diameter into the ground through openings in the well of the shaft. . . . This procedure, however, result[ed] in compressing the ground around and ahead of the pipe so that the permeability of the adjacent soil [was] greatly reduced and silting . . . encouraged"; see Ross Nebolsin, "London Water Supply Augmented by New Underground System," Engineering News-Record, 117 (October 22, 1936), 576.

9. Information on the Ranney Corporation's first American contracts and surviving well systems was provided by James A. French, Director of Technical Services, Ranney Company, Westerville, Ohio, in a telephone interview with the author, November 14, 1983.

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