CHAPTER VI

THE MUNITIONS PRODUCTION BASE MODERNIZATION AND EXPANSION PROGRAM

On 20 November 1973 an official directive to Col. Lochlin W. Caffey, Huntsville Division Engineer, from Maj. Gen. D.A. Raymond, Deputy Chief of Engineers, OCE, formally assigned Huntsville Division a major new military construction mission. Effective immediately, the Division was officially designated as the Corps' central management agency for the huge Munitions Production Base Support Construction Program (MPBSCP). The MPBSCP, then three years old, was a high priority effort on the part of the Army Materiel Command (AMC) to modernize, expand, and maintain the Army's munitions manufacturing base for the last quarter of this century. Because of inflationary factors and political vagaries, nobody knew exactly what the ultimate cost would be, but 1973 estimates were in the vicinity of $3.5 billion. Because of the immense dollar value of the program, and because certain aspects of modernized technology had yet to be worked out, the MPBSCP was spread out over twelve years.

General Raymond's tasking letter marked the genesis of Huntsville Division's third activity after SAFEGUARD and its first new military engineering assignment since BMD. Like its predecessors, the new mission was technologically challenging, geographically extensive, and highly demanding of contractual and managerial expertise. Taken alone, these factors plus the heavy budgetary investment and lengthy programming of the MPBSCP would have made it a notable task for the Division. From the time of its assumption in 1973, however, the MPBSCP's importance for Huntsville Division was magnified even further by the concurrent phase-down in SAFEGUARD, by a general contraction in the BMD mission as a whole, and by well-defined limits on the duration and extent of the recent Postal and NASA missions then achieving maturity. Since 1973 the initial indications that the munitions program would become a large part of the Division's workload have been borne out. Annual appropriations for the MPBSCP have been somewhat reduced from original planning, but the overall length of the program has been stretched out to FY 1999. Hence, in the post-ABM Treaty era the MPBSCP was, and promises to remain for sometime, a most important mission for Huntsville Division.

The origins of the MPBSCP are easy to identify: the munitions program of the 1970's is rooted in the age of the United States' munitions production facilities and in the march of military and industrial technology since World War II. Most Army ammunition plants operating in the decade of the 1970's were built during a remarkable wave of construction during the first years of World War II that helped make America the "arsenal of democracy." But it was an arsenal built in great haste under wartime exigencies, and to create it, drastic corners had to be cut in the quality of construction materials and operator safety. As early as February 1941 it was decided to switch to a type of temporary construction for munitions plants having a **five-year** life expectancy; as Corps historians Fine and Remington have vividly written, those plants built during actual hostilities admitted even greater compromises:

> As has been shown, until Pearl Harbor the Army had built Ordnance and Chemical Warfare facilities largely of durable materials and had exercised great care to minimize the dangers of explosion. But once the country was at war, the need for conserving materials prompted consideration of drastic changes in design. Early in 1942 DuPont advised General Campbell that it could develop a plan for stripped down TNT plants. Although these plants would be more expensive to operate and maintain. DuPont was confident they would be more satisfactory in every other way. The West Virginia Ordnance Works, one of the first plants built on the new model, included such features as process buildings with asbestos siding; wooden shops, dormitories, and administration buildings; utilities with five-to-ten year life; concrete water tanks; barbed wire fencing; and duckboard sidewalks. West Virginia took 7 months to build as compared with 21 months for some of the earlier TNT plants. The DuPont typical became the wartime standard for explosives projects and started a trend which accelerated as shortages became more and more acute.[1]

It was munitions plants of this type that carried the nation to victory in 1945 and, in fact, sustained the next thirty years of Army ammunition demand.

The post-World War II years found the U.S. with a munitions base quite adequate for its peacetime forces, so new construction was minimal. The most decrepit and least efficient plants were disposed of, abandoned in place, or deactivated, while the remainder soldiered on through the Korean buildup. The uneasy peace of

the late 1950's and early 1960's saw little change in the nation's munitions facilities; expenditure was confined almost exclusively to routine maintenance.Worn-out motors, bearings, shafts, tanks, piping, and utilities were replaced item-for-item; roofs were repaired; fresh coats of paint were applied. The most crying deficiencies were corrected, but the equipment and processes of the 1960's were still 1940-vintage batch type, with human labor providing most of the materials handling. The intervention in Southeast Asia was undertaken with what were originally temporary World War II facilities still in operation--not a single new AAP had been built since 1945. The costs in dollars and human hazards were high.

Heavy munitions demands of the Vietnam War, along with two decades of technological progress and evolving attitudes towards the environment, helped expose the need for modernization of the country's munitions production base. Since World War II, the use of ammunition-gobbling automatic weapons and improved artillery increased ammunition demands enormously; so also did the proliferation of exotic munitions types such as cluster bomb units (CBU), special armor-piercing projectiles, delayed-action mines, and tube-launched missiles. The chemistry of blasting, too, had moved beyond the World War II era with the development of RDX and Composition B explosives as supplements to TNT. Equipment twenty-five years old made the production of either traditional or innovative types of munitions slow, inefficient, costly, and unreliable. In the case of nitroguanidine, a key ingredient in RDX and other new explosives, a lack of domestic facilities made the nation dependent upon Canadian exports. Amazingly, even in the late 1960's, TNT batches were still being mixed by hand with wooden paddles in wooden tubs, and shells and powder bags were being filled by manual means. Not suprisingly, accidents were often catastrophic because of the lack of blast suppressive shielding. Explosive plants, too, were notorious polluters of air and water; their emissions had formerly been casually dismissed as the inevitable by-products of the explosives business, but federal and state cleanup legislation of the 1960's mandated a change in this attitude. Again, the existing facilities were often not amenable to such change.[2]

Prodded by the high costs of reactivation for Vietnam and new pollution regulations, the Army acted to set its munitions house in order. In early 1968 a full scale modernization plan was presented to the Assistant Secretary of the Army for Installations and Logistics and the Office of the Secretary of Defense. Both agreed to support an aggressive modernization effort starting in FY 1970. It was initially estimated that it would cost $2.4 billion to modernize the plants and take five years. The program was later revised to seven years and then to ten years. Finally, in July 1970, the program was extended to twelve years through FY 1981 at a cost estimated at $4.2 billion. Of this total, $233 million was tabbed for expansion. The first improvements were sought in small calibre ammunition production (SCAMP), where an effort to replace batch-type operation with continuous automated line production of 5.56-mm rifle cartridges was started at the Frankfort Arsenal in 1968. A little later, in 1970, the Army commenced modernization of its propellant and explosives plants (P&E) with nine "turnkey" (combined design and construction contract) acid plant projects and two TNT projects. Initial contract awards on these were made on 30 June 1970.[3]

Within two years, however, the munitions modernization program was mired in various troubles. A General Accounting Office report of 31 May 1972 criticized the Army's management of the program, and some corrective measures ensued. A comprehensive 168 page Army Audit Agency report of 31 May 1973 entitled "Audit of the Army's Production Base Support Program," however, deemed the corrections inadequate and excoriated program management practices as a whole. In particular, the audit noted, the Army had instituted an omnibus design fund in February 1971, but on 30 November 1972, eighteen months after its start, only 20 percent of FY 1972 design funds had been spent. On 21 August 1972, the Commanding General, AMC, had established a Project Manager for the MPBME, but the Project Manager's Office did not begin to be staffed until December 1972 and no Project Manager had been appointed at the time the audit report was compiled. A Mechanized Milestone Reporting System that was supposed to be implemented by 1 July 1972 still was not operational on 15 January 1973. The audit was especially cognizant of embarrassing, costly tendencies to start-up projects before the requisite engineering and design were done or even before prototypes had proven successful. Early difficulties with 5.56-mm modularized SCAMP lines for the Twin Cities and Lake City AAP's were examples of this. There was also a deplorable tendency to hold onto funds and to request more funds, along with a singular reluctance to turn back unspent or unspendable monies. In Part II, "SUMMARY," the auditors wrote:

In our opinion, the Army needs to take a

hard look at its planned modernization and expansion program. Funding to date has exceeded the Army's ability to execute the program. But planned funding levels are even larger for future years of the 12-year program. Action is needed to match funding levels with execution capabilities before more problems generate. We can see two altenative courses of action the Army can take:

Either - Assign the management and engineering resources needed to provide the capability to execute the modernization and expansion program at planned funding levels.

Or - Limit the modernization and expansion program to funding levels that are commensurate with the Army's capability to execute the program.[4]

A little further along, the auditors specifically suggested that the Army should accelerate the engineering of munitions process technology and design; schedule follow-on projects only after successful testing of prototypes; implement a workable priority system for project selection and execution; set up a system to correlate the new manufacturing technology with the modernization program; and strengthen management procedures and controls to make sure that milestone dates for concept design, final design, and contract award would be met for all projects included in budget submissions for a given fiscal year.[5]

Almost immediately after issuance of the Army Audit Agency report, the Army took several steps to rectify managerial deficiencies in the munitions program. On 18 June 1973, Brig. Gen. Robert J. Malley was appointed Project Manager for the Munition Production Base Modernization and Expansion program (MPBME) which constituted by far the largest portion of the total MPBSCP. General Malley's Project Office was located at Picatinny Arsenal, Dover, New Jersey, with a small initial staff that grew during the remainder of the year towards a June 1974 target level of 160. As defined by the "Project Manager Charter" of 8 September 1973, "The Project Manager is the Army focal point for operational control of the MPBME program." The same document delineated the Project Manager's mission:

> He will exercise centralized management authority over the planning, direction, control, and execution of the MPBME program at all US Army Ammunition Plants and Arsenals and for government equipment located at contractor owned and operated facilities included in the MPBME program. The MPBME program assigned to the Project Manager includes modernization and expansion and Production Engineering Measures (PEM) directly associated with the MPBME.

Following his appointment, General Malley was to report directly to the Commanding General, U.S. Army Materiel Command (AMC), the "boss" of the entire MPBSCP. In late 1975, AMC became the U.S. Army Materiel Development and Readiness Command (DARCOM) but without significant change in function as supervisor of the MPBSCP as a whole.

The mainstream within General Malley's MPBME was, and is, modernization and expansion work at the twenty-five Government-owned, contractor-operated (GOCO) plants that comprise the present backbone of the Army's munitions production base. These GOCO plants generally manufacture high demand items ranging from 5.56-mm small arms rounds to 8-inch artillery shells. MPBME project areas at various GOCO plants include propellants and explosives (P&E), together with related acid plant facilities; small (5.56-mm through 30-mm) ammunition facilities; load assemble, and pack (LAP) facilities; metal parts facilites; and pilot plants. Additionally, the MPBME includes modernization and expansion of 125 Government-owned plant equipment packages (PEP) containing 345 production lines situated in private industry. The PEP's generally manufacture specialty items such as small metal parts, fuses, and rockets. Finally, the MPBME includes the Manufacturing Methods and Technology (MM&T) effort which develops the advanced process technology needed to back up modernization and expansion. The MPBME is funded with Procurement of Ammunition Army (PAA) funds (formerly PEMA) channeled through Armament Command (ARMCOM) financial controls to the Project Manager.

The MPBME was, and is, a large program, but it is not quite synonymous with the still wider MPBSCP. Related to the MPBME and integrated with it in the MPBSCP are two other programs for improvement of the munitions manufacturing base. Annual Support, or the Production Support and Equipment Replacement (PS&ER) program, supports annual maintenance that sometimes borders on modernization. The PS&ER is funded with PAA funds but is directed by ARMCOM, a command subordinate to AMC/DARCOM, from Rock Island, Illinois. A Pollution Abatement Program for control of emissions at munitions plants is funded with Military Construction, Army (MCA) monies and

executed under direction of the Chief of Engineers. In addition to these, there is a minor miscellany of MCA, MCA Minor, and Operation and Maintenance funded projects that are part of the MPBSCP. As will be seen shortly, the Corps of Engineers and Huntsville Division have had heavy design and construction responsibilities in all these MPBSCP areas.

Besides the appointment of General Malley as Project Manager for MPBME and the staffing of his Picatinny office, the Army took other measures to see that the MPBSCP was put back on track for FY 1974. During the remainder of calendar year 1973 steps were taken within the munitions community to improve coordination among AMC, ARMCOM, MPBME Project Manager, and Office of Secretary of Defense to insure that available appropriations for the MPBSCP were applied to the highest priority work. At the same time, overall funding for the MPBME was reduced from about $500 million per annum to about $300 million for FY 1974, and the program was stretched out even further to FY 1999.[7]

One of the most important managerial decisions made for the MPBSCP in 1973, however, was the introduction of Huntsville Division into the program as the central managerial agency for the Corps of Engineers which was engineering and constructing MPBSCP facilities. Since the inception of the MPBSCP in 1970, the Construction Division, Directorate of Military Construction, OCE had provided such central management. At this time (Before the establishment of the MPBME Project Manager's Office) individual munitions projects were directly allocated by ARMCOM to Corps geographic divisions and districts for design and construction. There was no central agency other than OCE interfacing with all Corps divisions and districts that could function on a day-in-day-out basis as a repository of technical information and milestone reporting. The single exception was Mobile District's management of acid plant design.

Immediately after his appointment as MPBME Project Manager, General Malley discussed the problems of facility design and construction with Generals Clarke, Gribble, and Wray at OCE. General Clarke suggested that General Malley should consider Huntsville Division for design of the facilities; General Gribble agreed but indicated that construction should be accomplished by the appropriate districts. This formula was to become the basis of Huntsville Division's participation in the MPBSCP. On 22 June 1973 General Malley telephoned Brig. Gen. Bates. C. Burnell to broach the idea of Division support in accomplishing the design for munitions plant modernization and expansion. General Burnell concurred, indicating "that the type of support desired by General Malley should fit very closely with the capabilities of Huntsville Division."[8] At the conclusion of this conversation, General Burnell summoned Deputy Division Engineer Col. Peter Grosz, Jr., and Lee Garrett, Chief of the Engineering Division, and briefed them to begin planning for the MPBME support mission. One of their first objectives was a working plan for the Division's role in the munitions program; a second was securing the concurrence of General Gribble, the Chief of Engineers.[9]

By early September a preliminary draft of ideas for Huntsville's participation in the MPBSCP had been generated by the Division's staff, and on 10 September 1973 Maj. Gen. George A. Rebh, Acting Deputy Chief of Engineers, telephoned the tentative approval of OCE.[10] An official follow-on message from OCE on 14 September notified divisions and districts of an impending change in the management of Corps activities in support of PEMA construction. By 25 September a final ten page "Plan for Corps of Engineers Support to Army Materiel Command for Ammunition Production Base Construction Program" with several bulky appendices had been prepared in conjunction with OCE. This plan outlined essential provisions whereby Huntsville Division would become the central operating agent of the Corps in managing MPBSCP design and construction. The plan embodied the principle of central program control and provided for continuity of engineering from advanced planning through concept design, final design, and construction with configuration management at each stage as appropriate.[11]

Two letters from OCE, one dated 16 October 1973, the other 20 November 1973, completed the official assignment of the MPBSCP support mission. The letter of 16 October presented the basic mission assignment and asserted that further details would be provided by 19 November. In the meanwhile, a number of ground-breaking conferences with other elements of the MPBSCP infrastructure--Corps geographic divisions and districts, ARMCOM, and the Project Manager--were scheduled to actually get the mission underway. Now gathering headway, the MPBSCP was proudly heralded in the 15 October issue of the Division's "Information Bulletin."[12]

The OCE letter of 20 November may be considered the definitive mission assignment, since appended to it was a detailed eleven page implementation directive entitled "Instructions for Corps of Engineers Support to Army Materiel Command Munition Production

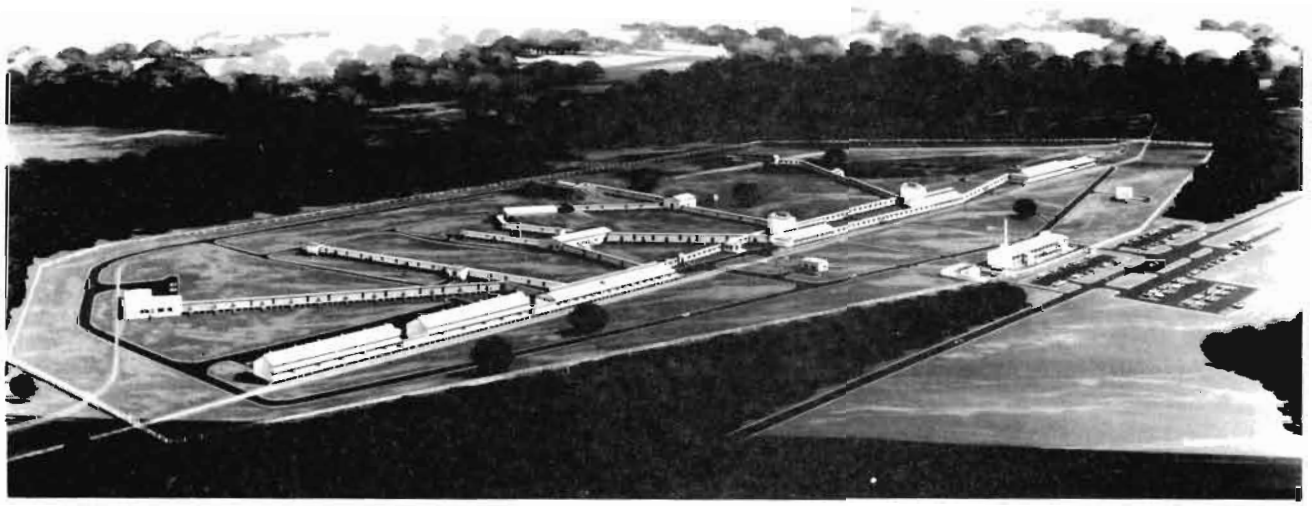
Base Support Construction Program."[13] This key OCE document incorporated the Division plan of September almost verbatim, with the exception of some funding data unavailable earlier. The "Instructions" defined the working relationships among Corps of Engineers and AMC organizations, designated the general functional and task assignments, presented organizational structures, and outlined pivotal plans. Curiously enough, a formal "Memorandum of Understanding Between the Project Manager for Munitions Production Base Modernization and Expansion (MPBME) and the Corps of Engineers for Support of the MPBME Construction Program" was not signed until 15 January 1975, or about eighteen months after General Malley first broached the idea of using Huntsville Division to OCE. The first Huntsville Division ER 10-1-22 edition to acknowledge the MPBSCP mission was that of 20 January 1975. Both of these documents were further clarified in an "Operations Manual for Munitions Production Base Support Construction Program (MPBSCP)" issued by OCE on 13 September 1976.[14]

As prescribed by the 20 November tasking letter, the Huntsville Division was " responsible to the Chief of Engineers for techincal and fiscal management of all MPBSCP activities." Individual projects would be assigned on a case-by-case basis to districts through their parent divisions; districts would return reports, schedules, estimates, designs, and other data as required to Huntsville Division. Huntsville liaison with the Project Manager would be maintained through a Division-staffed Liaison Office collocated with the Project Manager at Picatinny Arsenal. Similar project management and control would be provided to ARMCOM, but because of the smaller volume of work, only a liaison representative would be sent to Rock Island. The practices for handling of design duties in the MPBSCP were commensurate with the complexity of this mission. Huntsville Division was responsible for overall management of the design effort for the MPBSCP. Generally, Huntsville was to accomplish design of all process systems common to two or more sites--this to keep duplication of effort and "re-invention of the wheel" to a minimum--while districts were tasked for the balance. Hunstville Division was to design all new sites. As a general rule, geographical districts were responsible for design of site peculiar facilities and site peculiar pollution abatement projects; site adaption of multisite designs; and designs of MCA, MCA Minor, and Annual Support projects. Construction in all cases was to be accomplished by the district having responsibility for military construction in the region in which the project was located.[15]

Reorganization of the Division's internal structure for the MPBSCP proceeded at a rather leisurely pace during 1974. The MPBSCP Project Liaison Office at Picatinny was in being by February 1974 with Harvey C. Aden as Chief and Maj. H.C. Watson as Project Engineer, while on 18 August 1974, A.J. Manassero was assigned to ARMCOM Headquarters at Rock Island, Illinois, as liaison officer. Within the Division proper, MPBSCP assignments experienced a rather checkered career from 1973 on as the Project Management Branch of Engineering Division shifted its orientation from BMD to a munitions focus. A hand-drawn map in Division files dating from about October 1973 shows that the first apportionment of munitions tasks in the Project Management Branch was on the basis of five geographic zones with a general Project Manager for the handful of AAPs in each region. This geographic arrangement, though, was not formalized for another eight to ten months while the office of Chief, Project Management Branch, remained vacant. By February 1975, Robert K. Sawyer had been made Chief of the Branch and the Branch reorganized with a Project Managers Section. Four project managers within the Section now handled AAPs in southeastern, southwestern, northeastern, and north-central regions, while a fifth project manager was responsible for the remaining BMD work. In a subsequent 1976 reshuffling, MPBME munitions tasks were delegated on a topical basis to a staff of nine under four project managers: James G. Winter, Propellants and Explosives; James T. Ammons, Load, Assemble, and Pack; Reginald L. McLeod, Metal Parts; and George Barter, Acid Plants. PS&ER projects supplemental to MPBME were divided among project managers according to the AAP where they were located. Assistance relating to technical specialities such as specifications, estimation, and electrical and mechanical items was furnished by other Engineering Division branches and sections.[16]

The staff of the Construction Division has also had a limited role in surveillance of MPBSCP construction and in the reprocurement of several FY 1971 and 1972 "turnkey" acid plant projects contracted to Chemical Construction Co. (Chemico) before Huntsville Division entered the munitions program. In November 1975, with construction work about 90 percent complete, the Army suspended its payments on these contracts because of funding shortages unrelated to contractor performance; Chemico then sued, claiming the Government breached their

Central X-Ray Facility, Milam, Tennessee



Melt-Pour Modernization Line "C" Milan Ammunition Plant, Miliam, Tennessee

contract, and withdrew from its acid plant construction work at Badger, Radford, and Sunflower AAPs. The Government countered by terminating for default. After the Army lifted the suspension of payments some time later, Ned Rizzardi of the Huntsville Division, along with staff from Omaha and Norfolk Districts, surveyed the remaining scope of work at the three AAPs| on behalf of ARMCOM. At Sunflower and Radford AAPs, the plant contractor-operator was eventually engaged to complete the job; at Badger AAP, the work remaining was awarded to an industrial contractor for completion. These three "wrap-up" jobs and a fourth similar one for a chemical waste treatment plant at Joliet AAP are now under the management of Huntsville's Construction Division staff.

After assignment of the MPBSCP mission to Huntsville Division and early in the program, the MPBSCP Project Office at Picatinny Arsenal suggested that Huntsville develop a GFP procurement plan for the acquisition of long-lead items for AAP construction. A GFP plan, it was thought, might reduce construction time and effect maximum economies of acquisition.The concept, however, never got beyond approved procurement plan status, so there exists no valid method of evaluating the benefits, if any, to be derived from Government acquisition of industrial plant equipment for AAPs.[17]

THE FIRST 3 of 6 Continuous Pour TNT Lines constructed at Volunteer AAP near Chattanooga, Tennessee.

A comprehensive description of all of the munitions projects under the Division's supervision is made both redundant and impracticable by the sheer number and variety of jobs. At any given time during 1974-1976, the Division staff was supervising several dozen projects of quite disparate nature and value scattered among twenty-five arsenals and AAPs across the United States. Furthermore, some of the Division's munitions projects have exhibited the "now-you-see-it, now-you-don't" properties of the magician's rabbit as shifting defense priorities and funding fluctuations slip projects from one fiscal year to another or suspend them altogether. Congressional actions, too, have had an impact on scheduling, particularly affecting the siting of projects with optional locations. For these reasons, this **History** will focus on several of the more important, interesting, or on-going MPBSCP projects illustrative of the Division's overall role in this area.

A high degree of historical significance in the MPBSCP must be given to the Division's work on the Army's first new AAP since World War II. A directive to commence criteria development for a new AAP dedicated to the manufacture of the ICM M483 155--

mm artillery round was sent to Huntsville Division in August 1974. Construction was to be funded in FY 1977. The site chosen was the federal reservation in southern Mississippi where the NSTL was located. The product of the new facility was to be a new projectile for 155-mm howitzers, the "Improved Conventional Munitions," or ICM, round made up of hollow artillery shell forty-two inches long acting as a carrying container for a "cargo" of eighty-eight M42 and M46 grenades. The round is fuzed to scatter the grenades at a predetermined height over an area about the size of a football field which would be saturated with mixed explosions of anti-personnel bomblets and anti-armor shaped charges.

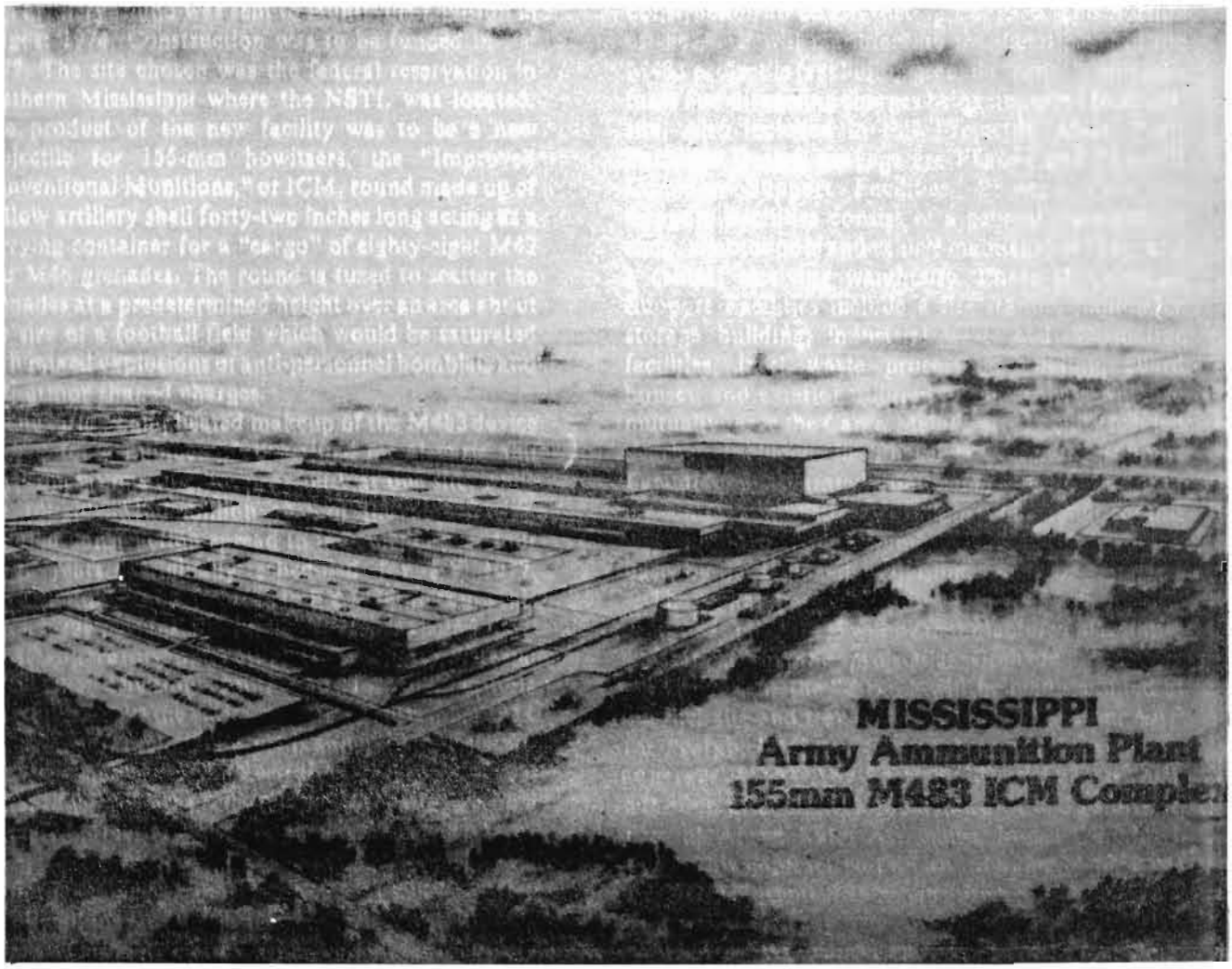
The rather complicated makeup of the M483 device argued for a number of diversified metal parts and LAP operations in close proximity at one site, while the roughly $180 million cost of the new facility dictated construction spread in increments over four fiscal years. Originally scheduled for FY 1977, construction is now to begin in FY 1978. Because this was a large new installation without an existing AAP plant operator-contractor to suggest criteria, Huntsville Division contracted for AE criteria development for the entire site. On 12 November 1974, a contract for preliminary plans and design studies for the Mississippi AAP was awarded to Kaiser Engineers for $91,000; this was followed on 2 April 1975 with a second contract to Kaiser Engineers (DACA87-75-C-0038) in the amount of $983,550 for criteria development. By the beginning of 1977, two modifications to the Kaiser criteria contract had boosted cumulative costs for criteria development to $1,777,846.

Once underway, however, the Mississippi AAP encountered a hiatus which has brought considerable delay and uncertainty in scheduling. Final site selection for the facility was deferred in 1975 by House of Representatives Appropriations Committee action which prohibited establishment of new AAPs while existing ones were being phased-down or mothballed. At the end of 1976 this restriction remained unaltered, rendering the ultimate location of the new facility indeterminate. Here, however, it will be referred to under its maiden name of Mississippi AAP.

Despite the setback of Congressional action, concept design commenced on the M483 Projectile Metal Parts Facilities portion of the AAP on 2 March 1976 under a United Engineers & Constructors, Inc., AE contract initially worth $772,507 (DACA87-76-C-0019). The current working estimates (30 September 1976) for construction costs were $65,600,000, with construction to be awarded in FY 1978. This portion of the AAP will manufacture the metal parts of the M483 projectile (excluding grenade "cargo") only, the fuzes and dispersing charges being imported from off-site. Also included in this Projectile Metal Parts Facilities Design package are Phase I and Phase II Common Support Facilities. Phase I Common Support Facilities consist of a general maintenance shop, a motor pool and vehicle maintenance shop, and a central receiving warehouse. Phase II Common Support Facilities include a fire station, flammable storage building, industrial waste and reclamation facilities, inert waste processing building, guard houses, and exterior utilities. Some of these will also mutually serve the Cargo Metal Parts Facility located nearby. Included in Phase I Common Support Facilities but separated from them for design purposes is a central administration building. The design for this was started in mid-November 1976 on an in-house basis by the Huntsville Division.

The metal parts of the M42 and M46 grenade "cargo" for the M483 will be manufactured in facilities separate from the projectile. Grenade fuzes and explosives for the "cargo" will be manufactured at another site and transported to the Mississippi AAP for "cargo" LAP operations. A general site design contract (DACA87-76-C-0020) requiring site adaption after site selection was awarded to the AE firm of Albert Kahn Associates, Inc., on 8 March 1976. This contract had an award value of $262,964 and by 29 November 1976 had grown to $576,239 after four modifications. The current working estimate of construction costs at the end of 1976 was $27 million.

Other major portions of the Mississippi AAP for which design had not been started in 1976 include the M483 LAP Facility with a programmed cost of $38 million; the Common Support Facilities, Phase III, programmed for FY 1982 at a cost of $1,975,000; the Sewage Treatment Plant, programmed for FY 1980 at a cost of $429,000; and a Power Plant for M483 Facilities, programmed for FY 1979 at a cost of $24,942,000. A DARCOM contract for plant operation of the facility was awarded in August 1976 to Mason Chamberlain, Inc., a joint venture of Mason Hanger-Silas Mason and Chamberlain Manufacturing Corporation. Final site selection for this project, however, was not expected before October 1977, and in the interim, Huntsville Division was proceeding on the Projectile Metal Parts and Cargo Metal Parts Facilities based on a hypothetical site with an option for later site adaption.[18]



Mississippi Army Ammunition Plant, Bay St. Louis, Mississippi

In August 1974, OCE formally directed Huntsville Division to assist the MPBME Project Manager in the development of criteria for a large new RDX/HMX explosives complex to be added to an undetermined AAP. The RDX/HMX project has since become a close rival to the Mississippi AAP in historical significance to the Division. This project was the first in the MPBSCP in which Huntsville Division developed both equipment design and facility design criteria. In the majority of other MPBME projects, criteria for modernization or expansion originate with the AAP plant operator-contractor concerned. In the case of the RDX/HMX project, however, the technology of the process was still in a formative stage, and the site for the new complex was undecided. Hence, the MPBME Project Office preferred to have Huntsville work up the design criteria through a specialist AE firm. An additional $75 million worth of process equipment will be designed and procured in parallel under direction of AMC/DARCOM for downstream delivery as GFE to the Corps of Engineers' construction contractors. In magnitude of costs, the RDX/HMX facilities' estimated $250 million construction cost (excluding AMC/DARCOM-procured process equipment) exceeds any other Huntsville Division munitions project. Design costs alone will amount to about $30 million.[19]

The RDX/HMX project entails design and constuction of two RDX/HMX production lines, together with their supporting chemical feedstock plants, recovery plants, a steam plant, utilities, support facilities, and waste treatment facilities. The production lines will be a new continuous and automated batch-type process patterned after an experimental line now operating at the Holston AAP at Kingsport, Tennessee. The Holston AAP, a GOCO plant operated by Holston Defense Corporation, a subsidiary of Eastman Kodak Corporation, has been developing basic RDX process technology on this

prototype line since 1969. This effort is part of the MM&T suport to modernization and expansion.

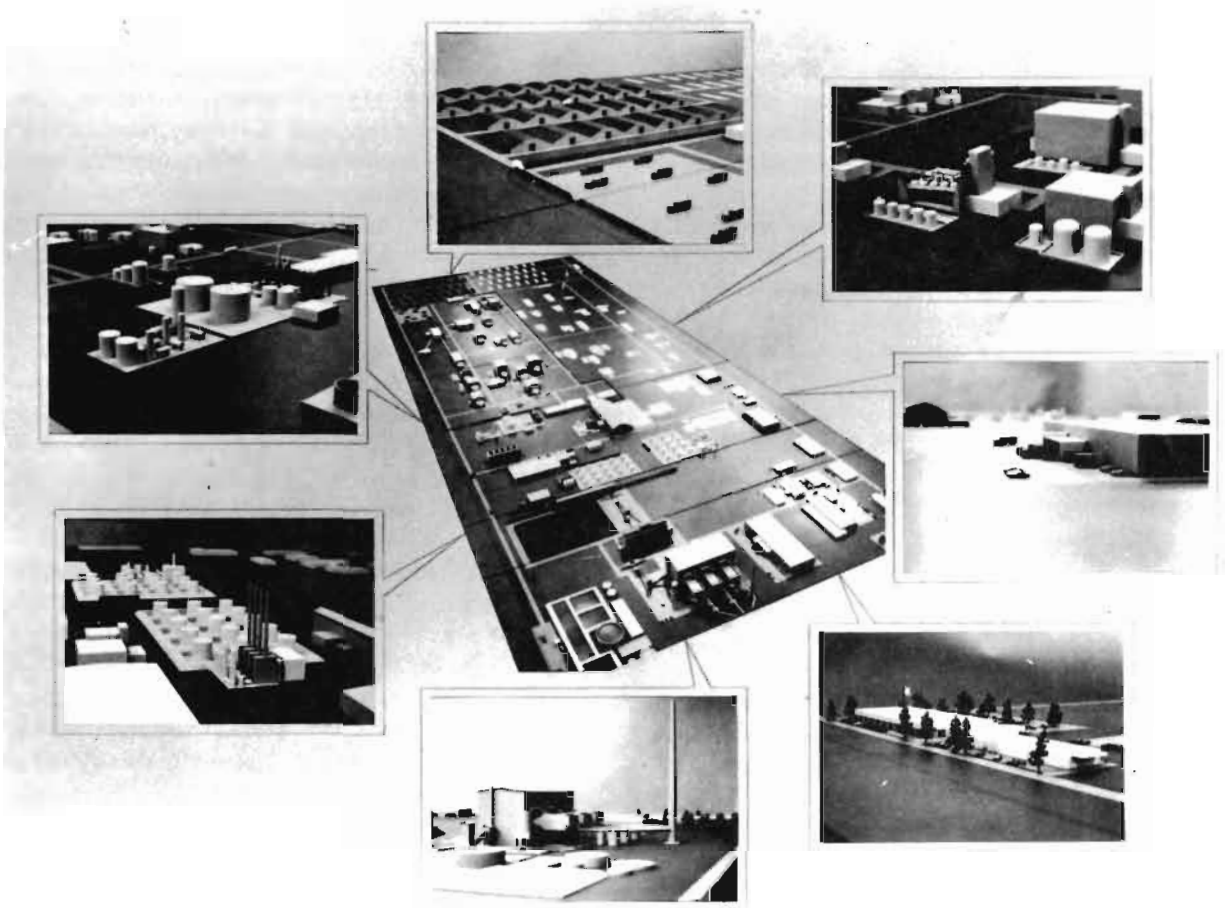
Nine other Holston conventional batch lines are currently the only source of RDX production for U.S. armed forces, even though the material is a base ingredient for the widely used Composition B and other modern explosive compounds. Composition B, a filler for artillery shells, mines, and grenades, is a compound of RDX plus TNT. The Holston facility was originally designed to make 40 million pounds of Composition B per month, but it is now required to make a host of other products also based on RDX and HMX. As a result, in 1973 Holston was scheduled at mobilization to make only 29 million pounds of Composition B, about one-third of projected need. To alleviate possible shortages, a new RDX/Composition B line is being planned for Holston AAP, and the RDX/HMX expansion project is being prepared for another AAP location. Prime candidates for location of the RDX/HMX expansion are Newport AAP, Newport, Indiana, which already has TNT production on-site, with Milan AAP and the McAlester Naval Ammunition Depot, which have no TNT facilities, also in contention.

The new facility will have two production lines with potential for expansion to four lines. Lines 1 and 2 differ slightly. Line 1 will produce 4.5 million pounds of RDX base per month which, when combined with TNT from other sources, will result in 7.5 million pounds of Composition B output per month. Line 1 will make RDX and Composition B only. Its major elements include buildings and equipment for nitrolysis, filtering, washing, recrystallization, dewatering, drying, and packaging.

Line 2 will feature variable production choices to make 4.5 million pounds per month of RDX as a base for either 7.5 million pounds per month of Composition B like Line 1, or lesser amounts of specialty products such as Composition C-4 and Composition PBX N-6. As an alternative to RDX, Line 2 will also be able to produce 0.5 million pounds per month of HMX base, an ingredient for the Octol explosive warheads of certain missiles. Except for additional facilities required for handling the product mix, facilities will be similar to Line 1. The control of product mix is to be computerized, and the operation of both lines will be fully automatic. All facilities producing explosives will be hardened for 7.5 p.s.i. of overpressure, and the complex must be capable of starting up from layaway in ninety days or less.

The chemical feedstocks for RDX production are acetic anhydribe, hexamine, glacial acetic acid, nitric acid, and nitric acid/ammonium nitrate. These ingredients will be prepared on-site and will require extensive preparation and recovery facilities of their own. The RDX/HMX project, therefore, also provides feedstock facilities producing 340 tons of 99 percent pure acetic anhydride per day and 200 tons of nitric acid/ammonium nitrate nitrolysis mixture per day. Steam is also a major manufacturing requirement, and part of the project package will be a pair of coal-fired steam boilers producing 500,000 pounds of steam per hour and a standby boiler producing 250,000 pounds per hour. Additional major elements in the facilities package include acid recovery facilities, chemical preparation facilities, waste treatment facilities, support facilities, and utilities.

Design for the RDX/HMX complex actively started on 13 December 1974 with the award of a $96,647 contract for preliminary criteria development to The Ralph M. Parsons Co. This was followed by a second criteria development contract (DACA87-75-C-0041) worth $990,789 awarded to Parsons on 14 April 1975. By the beginning of 1977, this contract had acquired eleven modifications and had risen to a cumulative total worth of $3,841,387. All criteria had been completed by January 1977 with the exception of the nitric acid concentration plant and the Line 1 recrystallization building.[20]



RDX/HMX Production Facility. The Ralph M. Parsons Company

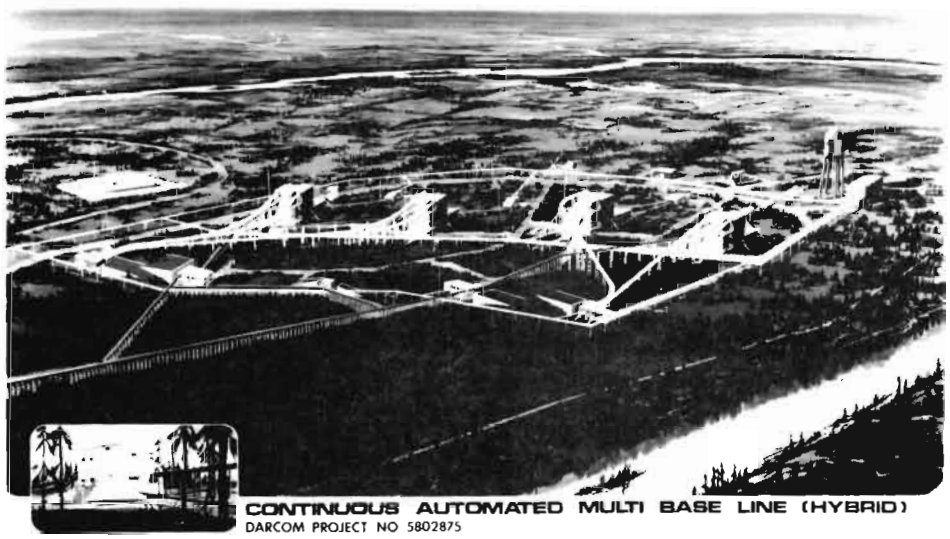
Groundwork for concept design and final design of the RDX/HMX facilities was just beginning as this **History** was being written (January 1977). During the next two years, several AE design contracts will probably be awarded, and construction for parts of the complex will begin in 1979. Certain constituent elements such as the nitric acid production plant and the acetic anhydride plant will be designed and constructed under single "turnkey" contracts. At the beginning of 1977, Division staff was drafting an AE advertisement for **Commerce Business Daily** for RDX/HMX Line 1. The only RDX/HMX AE contract that had been awarded was to J.E. Sirrine on 11 June 1976 for the preparation of Steam Plant Equipment detail specifications in advance of procurement. This project bears the MPBSCP number 5802668-01 and has a programmed cost of $18,200,000.[21]

As exemplified with the RDX/HMX expansion project above, the Army has been attracted to the possibilities of producing explosives on continuous and automated lines instead of by batch process. The Continuous Automated Multi-Base Line (CAMBL) hybrid now in the design development stage for Radford AAP, Radford, Virginia, and Sunflower AAP, De Soto, Kansas, is another example of the implementation of this concept. Current equipment at these plants is of World War II vintage, Radford having been built originally in eight months in 1942 and Sunflower AAP in about the same time. Now programmed for FY 1980 construction award, the Radford-Sunflower CAMBL hybrids will offer continuous and automated output of the high demand double-base and triple-base propellants ("cannon powder") used in large calibre artillery pieces. The advantages of the process over traditional batch production are several. Perhaps the most significant advantage is that operating personnel can be reduced by 80 percent which will substantially reduce the labor costs of the product and diminish operator exposure

to dangerous materials handling. Better product quality and uniformity should result, too, because the elimination of batching will also eliminate the customary need to blend batches to obtain uniform performance characteristics.[22]

Evolution of the CAMBL concept began at Radford AAP about 1970. Working in conjunction with Hercules Powder Co., the plant's operator, ARMCOM funded MM&T studies of a pilot line to prove out the equipment in full-size configuration. Ballistic tests on the first pilot lots of M26 double-base powder were nearing completion in November 1976 with triple-base tests to follow. With its entrance into the MPBME in 1974, Huntsville Division joined Hercules in developing criteria for production CAMBL facilities on an in-house basis. This was one of the first instances of Corps of Engineers participation in MPBME projects at the criteria stage. Formerly, Corps constructing organizations had not been privy to projects until the design phase, too late to incorporate earlier lessons learned or to jointly design two or more similar projects at different locations. The preliminary Huntsville-Hercules criteria were subjected to a $94,000 value engineering study conducted by Zurheide-Hermmann, Inc., beginning 27 June 1975, and topographic investigation into potential sites at Radford began about the same time. This study resulted in a savings of $3.5 million. Criteria development for the CAMBL concept was completed in mid-December 1976, and concept design was scheduled to begin at the first of March 1977.

Since the Radford and Sunflower CAMBL hybrids have identical processes and products with only minor site peculiarities, the criteria for both installations have gone forward concurrently. Both CAMBL facilities will utilize an alcohol and acetone solvent-type process to make M26 double-base propellant out of nitroglycerine and nitrocellulose feedstock originating on-site. Alternatively, the lines may be directed to produce triple-base M30 or M30A1 powders from nitroglycerine, nitrocellulose, and nitroguanidine. Nitroguanidine stock is currently wholly imported from exclusively Canadian sources, but a MPBME project is underway to provide for domestic manufacture at Sunflower AAP. The basic manufacturing for either double-base or triple-base powders is similar and may roughly be divided into three stages. In the CAMBL hybrid, the first two stages are automated, and existing conventional facilities will be used for the final stage, bringing construction cost savings of 50 percent over wholly new facilities.[23] In the first stage, the chemical ingredients and alcohol-acetone solvents are prepared in separate facilities. One chemicals preparation and one solvents preparation building each serve two "Green Lines." Each "Green Line" has two independent production channels. In the "Green Line" area, the heart of the process, the chemical ingredients are mixed under rigid computer control to emerge as a moist dough. The mixture is extruded through dies and cut to form "green" grains of powder. In the third or finishing stage, the uncured powder is loaded onto two-inch deep trays with perforated bottoms and conveyed to a forced air drying building to remove all traces of solvent. The dry powder is then glazed with powdered graphite and packed in fiber cans for distribution. The CAMBL will "sense" the level of volatiles and moisture so well that blending of powder batches will be superfluous.[24]



Continuous Automated Multi Base Line (Hybrid).

The Radford CAMBL hybrid is an expansion project currently programmed for FY 1980 construction award. When completed, this installation will have four "Green Lines," each with two independent process channels, amounting to a total of eight lines of independent primary manufacture. Two solvent preparation/chemical preparation buildings, a control house, tank farm, and miscellaneous support facilities are included in the project. Radford's CAMBL will generate an additional capacity of 2.4 million pounds of M30 powder per month to the plant's present capacity of 1.3 million pounds per month. The Radford CAMBL proper is being managed by Huntsville Division and has an anticipated construction cost of $52,774,000. Included in this figure is $2 million worth of rehabilitation for existing drying, finishing, pack-out facilities being designed by the Norfolk District.

The Sunflower CAMBL project will result in six new "Green Lines" (twelve independent production modules) to replace either existing "B" or "C" batch line, which will be scrapped. The new CAMBL will have a capacity of 3.6 million pounds per month of M 30.

The Sunflower CAMBL design is being managed by Huntsville Division in unison with the Radford project and has an estimated construction cost of $78,322,000. Out of this figure, $16 million will be directed toward a refurbishing of existing drying, finishing, and pack-out facilities being designed by Kansas City District.[25]

An important aspect of the modernization of the Sunflower AAP, as well as other P&E plants, is the improvement of acid plants which serve the preparation of chemical feedstock. Both nitric and sulfuric acids may be used in explosives manufacture, and in most operations these chemicals must be recovered and reconcentrated in facilities separate from the production line. In the MPBME the acid treatment facilities represent a special area of concern reflected in their high priority within the program. In a great many cases, the existing plants have patched up equipment based on antiquated technology that blocks further modernization or expansion. Inefficient and unreliable, these old acid plants are also sizeable facilities that are costly to replace. Their replacements, however, must not only be harmoniously integrated with the older existing facilities and with future planning but today must also meet stringent state and federal parameters regarding pollutant discharge. The design and construction of acid plants, therefore, represent particular challenges which are often met by solicitation and evaluation of technical proposals, followed by award of a unified ("turnkey") design-construction contract.

Generally typical of acid plant projects at all eleven GOCO P&E plants, the Nitroguanidine Sulfuric Acid Concentration System (SAC) at Sunflower AAP is also uniquely related to the overall munitions base and to the manufacture of triple-base cannon powder described earlier. The SAC is part of an urgently needed domestic complex that will replace the current Canadian source of nitroguanidine feeding Radford, Sunflower, and other multi-base propellant lines. The $92,700,000 (1975 estimate) complex was approved and funded on 30 June 1975, and design procedures were inaugurated immediately.

The Nitroguanidine SAC project 5752632-04 provides for a sulfuric acid concentration facility capable of concentrating a weak 70 percent sulfuric acid feed solution containing water and chemical salts into a concentrated 93 percent acid product. The stream feeding the concentrator will be a waste stream leading from the nitroguanidine production facility and will return reconcentrated sulfuric acid to the nitroguanidine process line. Technically, the Nitroguanidine SAC amounts to a species of still in which incoming weak acid is directed into vacuum chambers. The atmosphere is then evacuated and the chambers heated through steam coils to drive off water in the acid. A major techincal problem is that the weak feed sulfuric acid has to be concentrated in the presence of by-products of the manufacturing process such as guanidine sulfate, guanidine nitrate, and nitroguanidine residues. It was desired that these compounds should remain unaffected by the concentration, yet the application of heat tends to decompose the guanidine compounds present with the acid. The contractor for the SAC "turnkey," therefore, has only to demonstrate that the plant will concentrate acid from 70 percent to 93 percent but not to show that the nitroguanidine salts would be unaffected.[26]

The formulation of design criteria, design, and construction in this project reflected the novelty of the nitroguanidine process and the intricacies of providing a smooth transition from the drawing board to prove-out of the finished plant. Decisions taken in the MPBME Project Office at the inception of the Sunflower Nitroguanidine SAC procurement in 1975 dictated that the facility should be designed, engineered, constructed, and performance proved by one firm under a single "turnkey" contract. In turn, the IFB for this contract had to contain an explicit technical proposal amounting to the criteria upon which bids could be offered. The first step for Huntsville Division, therefore, was to develop a Request for Technical Proposals (RFTP). To support this Request and later evaluation of the proposals submitted, the AE firm of H.K. Ferguson was engaged on 19 September 1975. Subsequent evaluation of

Ferguson's RFTP, plus resolution of differences with the Project Manager's Office, consumed all of 1976, and it was not until 26 December 1976 that the Division was able to issue its RFTP. During 1977 it is expected that the Technical Proposal will be chosen, to be included with the IFB to be issued later in the year.[27]

Metal parts projects in the MPBME are fewer in number than either P&E or LAP projects, and because metal parts plants present lesser pollution problems or operator hazards, they have generally received a lower priority than P&E or LAP AAPs. Nevertheless, modernization and expansion of metal parts plants are equally vital to the nation's munitions manufacturing base. Normally, metal parts that can be produced by private industry are procured from that sector, but there are many large items that industry does not manufacture in quantities sufficient to satisfy overall Army needs. These large, high demand items are now, or can be, manufactured at Burlington, Gateway, Hays, Riverbank, St. Louis, Scranton, Louisiana, and Twin City AAPs. The MPBME program will give these plants new material-handling equipment, furnaces, lathes, drill presses, and milling machines. Control of many of these will be automated with easy adaptation to new and different metals or innovative processing as these appear. Potential benefits to be derived from modernization will include a better quality product, greater productive output, diminution of the scrap rate, reduction of unit cost, reduction of operating staff, greater safety, better control of pollutants and waste products, and higher employee morale.

The 105-mm Projectile Metal Parts Manufacturing Facility 5762532T developed for Lone Star AAP was one of the more notable metal parts projects managed by Huntsville Division to date. Despite its exceptionally large $60,300,000 price tag (30 September 1976 current working estimate) and its uncertain future, the nature of the Lone Star project is quite typical of metal parts modernization and expansion everywhere. The genesis and evolution of project design are also typical of the way Huntsville Division has usually functioned in the MPBME, since the project criteria were generated by the AAP contractor-operator and design was carried out by the Division.

The Lone Star AAP at Texarkana, Texas, is a typical World War II vintage GOCO plant presently operated by Day and Zimmermann. Today it is not a metal parts plant per se but one of the Army's more important LAP facilities, producing loaded 105-mm artillery shells, 81-mm mortar rounds, grenades, mines, CBU, primers, and detonators. If the new 105-mm Projectile Production Facility is constructed--and this currently seems somewhat problematical--the installation will give Lone Star a metal parts function. The facility will provide an up-to-date source of one million projectiles per month for LAP lines on the premises and for supply to other LAP AAPs. Consideration has also been given to expansion to handle future generation medium calibre alloy steel (HF-1) projectiles.[28]

Project 5762532T comprises all the manufacturing elements necessary to convert 1000 pound rounded corner mild steel billets measuring four inches by four inches by twenty feet into finished 105-mm artillery projectiles ready for their explosive filling. For the Lone Star AAP, design calls for a billet storage yard measuring seventy-five feet by 1,000 feet served by a seventy-five ton crane and several smaller cranes. Up to a ninety days' supply of raw material may be stored in this yard. Adjoining the billet storage yard is the Projectile Building itself, approximately 300 feet wide, 1,500 feet long, and thirty feet high. The first part of the production line will be devoted to initial heating and forming operations. Cold steel billets removed from storage will first enter one of five identical independent electric induction heating tunnels where they will be heated into a red-hot softened state at 2,050°F. Upon emerging from the tunnel, a 350-ton shear blade will trim off hot slugs of predetermined length. These blanks will next travel to one of fire 2,000-ton capacity hydraulic presses. In two rapid operations these presses will form a "cabbage" tapered at one end and indented at the other. The projectile blank now taking shape will be further drawn through dies to reduce its diameter and increase its overall length, leaving enough outside material for machining and forming operations which follow. Press and drawing machines are to be fitted with automated controls which will both move the workpiece and sense its temperature to avoid damage to process equipment through excessive strain.

After emerging from initial forming operations, the shell forging will be cooled, shot-blasted to remove scale, and automatically chucked on duplex lathes. The first turning operation will give the slug body a rough contour turning; nose contours will then be developed by reheating and shaping in a 400-ton vertical press containing a nosing die. Final finishing operations include several further lathe treatments to give the shell its finished dimensions and a circumferential groove for the bore sealing band. Fuze threads in the nose are also cut at this stage. After washing, the projectile is completed by automatic welding of the

base plate, final bourrelet grinding, and application of the bore sealing band. Stamping of nomenclature, lot number, date of manufacture, contractor code, and protective painting result in a finished product ready for transmittal to LAP operations. Facility production rate will be 2,000 per hour, which on a three shift, 120 hour work week amounts to about one million projectiles per month.[29]

Active planning for a 105-mm facility like the one just described started in 1973 when the MPBME Project Manager's Office selected Lone Star AAP over the St. Louis AAP as facility site and notified plant operators Day and Zimmermann to initiate criteria development. The facility was to be funded with FY 1976 monies, meaning that construction would get underway sometime after July 1975. Day and Zimmermann released their baseline criteria to OCE on 13 August 1974. Huntsville Division actively assumed management of the project for design purposes in September 1974, and on 9 December 1974 Lockwood Greene Engineers, Inc., were awarded AE contract DACA87-75-C-0032 in the amount of $1,173,815 to produce a facilities design based on Day and Zimmermann criteria. Design passed smoothly through concept and final design phases with all milestones being met on time, despite several criteria revisions and seventeen modifications to the Lockwood Greene contract. Final design was completed on schedule in December 1975, but before the project could be advertised for construction in May 1976, Congressional action intervened. The House of Representatives Appropriations Committee recommended deferral of the project and requested a study of the feasibility of using or modifying facilites at St. Louis AAP. At the end of 1976 the Department of the Army was reviewing the St. Louis alternative, and no prediction could be made regarding the decision that would be made.[30]

In addition to the large MPBME modernization and expansion projects mentioned above, Huntsville Division has also exercised a managerial role in the area of PS&ER projects. While geographic districts prepare the criteria, design, and construct these projects, Huntsville Division maintains the milestone reporting on them and offers design review and assistance if required. The vast majority of PS&ER jobs are relatively modest in dollar value and usually do not reflect the kind of spectacular technology sometimes found in MPBME projects. A random selection from the Division's omnibus listing in the MPBSCP "Planning & Design Status Report" (30 September 1976 edition) reveals projects such as 5775314-14, a $21,000 telephone cable installation at Louisiana AAP; 5785317-17 for reroofing of buildings at Milan AAP worth $83,000; and 5785312-20, a $139,000 installation of guard station and truck scales at Volunteer AAP.[31]

CHAPTER VI FOOTNOTES

[1]Lenore Fine and Jesse A. Remington, **The Corps of Engineers: Construction in the United States** ("The United States Army in World War II," The Technical Services [Washington, 1972]), pp. 529-530.

[2]Thomas H. Blunt, Sr., "Modernizing Our Munitions," **The National Defense,** Nov.-Dec. 1973, pp. 250-252.

[3]Ibid.

[4]U.S. Army Audit Agency [Audit] Report MW 73-62, "Report of Audit: Audit of the Army's Production Base Support Program," 31 May [1973, p. 5.

[5]Ibid., pp. 6-8.

[6]"Production Manager Charter, Munitions Production Base Modernization and Expansion," 8 Sep 73, p. 1. USAEDH-DE [file, Munitions Production Base Program 1501-07.

[7]Memo for Record, Col Peter Grosz, Jr., Dpty Div Engr, 25 Jun 73, sub: Army Munitions Plants Modernization and Expansion. USAEDH-DE file, Munitions Production Base Program 1501-07. Ltr, Lt Col John J. Cook, Assist Div Engr, to Col Lochlin Caffey, Div Engr, 6 Sep74, sub: Munitions Production Base Support Construction Program (MPSCP) Resources Management System. USAEDH-DE file, Munitions Production Base Program 1501-07.

[8]Memo for Record, Col Peter Grosz, Jr., Dpty Div Engr, 25 Jun 73, sub: Army Munitions Plants Modernization and Expansion. USAEDH-DE file, Muntions Production Base Program 1501-07.

[9]Ibid.

[10]Note, Col Lochlin Caffey to Gen Burnell, 10 Sep 73, sub: Assumption of Munitions Mission. USAEDH-DE file, Munitions Production Base Program 1501-07.

[11]USAEDH, "Plan for Corps of Engineers Support to Army Materiel Command for Ammunition Production Base Construction Program," Sep 73. USAEDH-DE file, Munitions Production Base Program 1501-07.

[12]USAEDH-PAO, "Information Bulletin," VI, No. 9 (15 Oct. 1973), p. 1.

[13]Ltr, Maj Gen D.A. Raymond, Dpty Chf of Engrs to Div Engr, Huntsville, 20 Nov 73, sub: Corps of Engrs Support to Army Materiel Command for Munitions Production Base Support Construction Program (MPBSCP), with inclusion "Instructions for Corps of Engineers Support to Army Materiel Command Munitions Production Base Support Construction Program," 20 Nov 73. USAEDH-DE file, Munitions Production Base Program 1501-07.

[14]Memorandum of Understanding Between the Project Manager for Munitions Production Base Modernization and Expansion (MPBME) and the Corps of Engineers for Support of the MPBME Construction Program," signed by Brig Gen Robert J. Malley, Project Manager, on 11 Dec 74, and by Maj Gen George A. Rebh, Director of Military Construction, on 15 Jan 75. USAEDH-DE file, Munitions Production Base Program 1501-07. OCE, "Operations Manual for Munitions Production Base Support Construction Program (MPBSCP)," 13 Sept. 1976.

[15]Ltr, Maj Gen D.A. Raymond, Dpty Chf of Engrs, to Div Engr, Huntsville, 20 Nov 73, sub: Corps of Engineers Support to Army Materiel Command for Munitions Production Base Support Construction Program (MPBSCP). USAEDH-DE file, Munitions Production Base Program 1501-07.

[16]The early map of project manager areas of responsibility is in USAEDH-DE file, Munitions Production Base Program 1501-07. For further reorganizations within the Engineering Division, see the tables of organization in USAEDH-PAO, "Historical Summary FY 1974," II, Documents, pp. 2-26, and USAEDH-PAO, "Historical Summary FY 1975," II, Documents, pp. 6-25.

[17]Memo to the author from Thor S. Anderson, Chief, Procurement and Supply Division, USAEDH, July 1978.

[18]The sources for the development of the Mississippi AAP include: personal interview with Carl Manley, Project Engineer, Project Management Branch, Engineering Division, USAED, May 1978; USAEDH-DB, "Planning & Design Status Report: Production Base Support Projects," 30 Sept. 1976, 4 Feb. 1977; Contract Records file, USAEDH AE Contracts Section, Engineering Division.

[19]The sources for the RDX/HMX project include: personal interview with William Little, Chief, Engineering Division, USAEDH, 7 April 1977; personal interview with Robert K. Sawyer, Chief, Project Management Branch, Engineering Division, USAEDH, 5 April 1977; personal interviews with Ray Segelhorst, Project Engineer, Project Management Branch, Engineering Division, USAEDH, May 1978; USAEDH-DB, "Planning & Design Status Report: Production Base Support Projects," 30 Sept. 1976, 4 Feb. 1977; MPBME Project Manager's Office, "Review and Command Assessment of the Munitions Production Base Modernization and Expansion (Recap)," 11 Sept. 1973, 18 Dec. 1973, 25 Apr. 1974, 19 Sept. 1974, 29 Jan. 1975, 8 Apr. 1975, 29 July 1975, 9 March 1976, 17 Aug. 1976, 16 Nov. 1976.

[20]Contract data for RDX/HMX may be found in the Contract Records file, USAEDH AE Contracts Section, and in USAEDH-

PAO, "Historical Summary FY 1974," II, Documents, pp. 101-102; USAEDH-PS raw input data for "Historical Summary FY 1976," in USAEDH-PAO "Historical Summary" file.

[21]USAEDH-DB, "Planning & Design Status Report: Production Base Support Projects," 30 Sept. 1976, 4 Feb. 1977.

[22]For information on the CAMBL project, I am deeply indebted to Kenneth Edmundson, Project Management Branch, Engineering Division, USAEDH, for very thorough and comprehensive briefing on 7 April 1977 and a further series of conversations during May 1978. Other information may be found in a briefing on the MPBSCP prepared by the MPBME Project Manager's Office entitled "Munitions Production Base Twelve Year Modernization and Expansion Program," 25 July 1973.

[23]The cost savings are figures estimated to the author by Kenneth Edmundson, Project Engineer, Project Management Branch, Engineering Division, USAEDH, in May 1978.

[24]Personal interviews with Kenneth Edmundson, Project Engineer, Project Management Branch, Engineereing Division, USAEDH, May 1978.

[25]Personal interviews with Kenneth Edmundson, Project Engineer, Project Management Branch, Engineering Division, USAEDH. May 1978; USAEDH-DB, "Planning & Design Status Report: Production Base Support Projects," 30 Sept. 1976, 4 Feb. 1977.

[26]Personal interviews with Henry O. Everitt, Project Engineer, Project Management Branch, Engineering Division, USAEDH, June 1978.

[27]Personal interviews with Henry O. Everitt, Project Engineer, Project Management Branch, Engineering Division, USAEDH, June 1978; USAEDH-DB, "Planning & Design Status Report: Production Base Support Projects," 30 Sept. 1976, 4 Feb. 1977.

[28]The information for the 105-mm Projectile Metal Parts Manufacturing Facility has been derived from personal interviews with Sam B. Presson, Project Engineer, Project Management Branch, Engineering Division, USAEDH, July 1978; "Design Criteria: 105-mm Projectile Manufacturing Facility Modernization Project AMC 5762532" prepared by Day and Zimmermann, Inc., plant contractor-operator for Lone Star Ammunition Plant; MPBME Project Manager's Office, "Status Report: 105-mm Projectile Facility, Lone Star Army Ammunition Plant Project No. 5762532T," No. 6 (4 Aug. 1975) and No. 7 (undated).

[29]"Design Criteria: 105mm Projectile Manufacturing Facility Modernization Project AMC 5762532" prepared by Day and Zimmermann, Inc., LSAAP, including all revisions.

[30]USAEDH-DB, "Planning & Design Status Report: Production Base Support Project," 30 Sept. 1976, 4 Feb. 1977; Contract Records file, AE Contracts Section, Engineering Division, USAEDH.

[31]USAEDH-DB, "Planning & Design Status Report: Production Base Support Projects," 30 Sept. 1976.