Flexible Pipe Shop Fabrication System

U.S. DEPARTMENT OF THE NAVY
DAVID TAYLOR RESEARCH CENTER

in cooperation with

National Steel and Shipbuilding Company
San Diego, California

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"FLEXIBLE PIPE SHOP FABRICATION SYSTEM"

TASK N1-90-1

PREPARED BY

NATIONAL STEEL & SHIPBUILDING COMPANY

TO

SNAME/SHIP PRODUCTION

PANEL SP-1

May 30, 1993

This project was managed by National Steel & Shipbuilding Company for the National Shipbuilding Research Program. This project and final report were only possible by the cooperative efforts of the following shipyards and pipe fabricators: Avondale Shipyard, Ingalls Shipyard, Bath Iron Works & International Piping Systems.

EXECUTIVE SUMMARY

The shipbuilding industry in the United States has become postured to increased competitiveness within America & with the Foreign shipyards. With an expected decline in Navy work availability due to a decrease in the United States defense budgets and an expected increase in commercial work availability, competition is challenging the industry to reduce schedule time and lower construction costs while maintaining a standard of high quality. To make these objectives reality, through-put must increase by maximizing efficiency, thus saving time, material and money. Piping system is one of the biggest components in the outfitting cost of a ship's fabrication.

This project reevaluates the concepts of a flexible pipe shop fabrication system as presented in earlier studies performed in the late 1970's and early 1980's. These studies were based on steel pipe as the norm: however, with the increased use of copper-nickel (CUNi) and stainless steel pipe within the industry, evaluation of how the industry is adjusting to this increase in pipe mix was performed. The emphasis of this project was to investigate and implement pipe fabrication and material handling systems that are designed for the mix of materials currently exhibited in Navy and commercial shipbuilding. The intention of this project was to do the following:

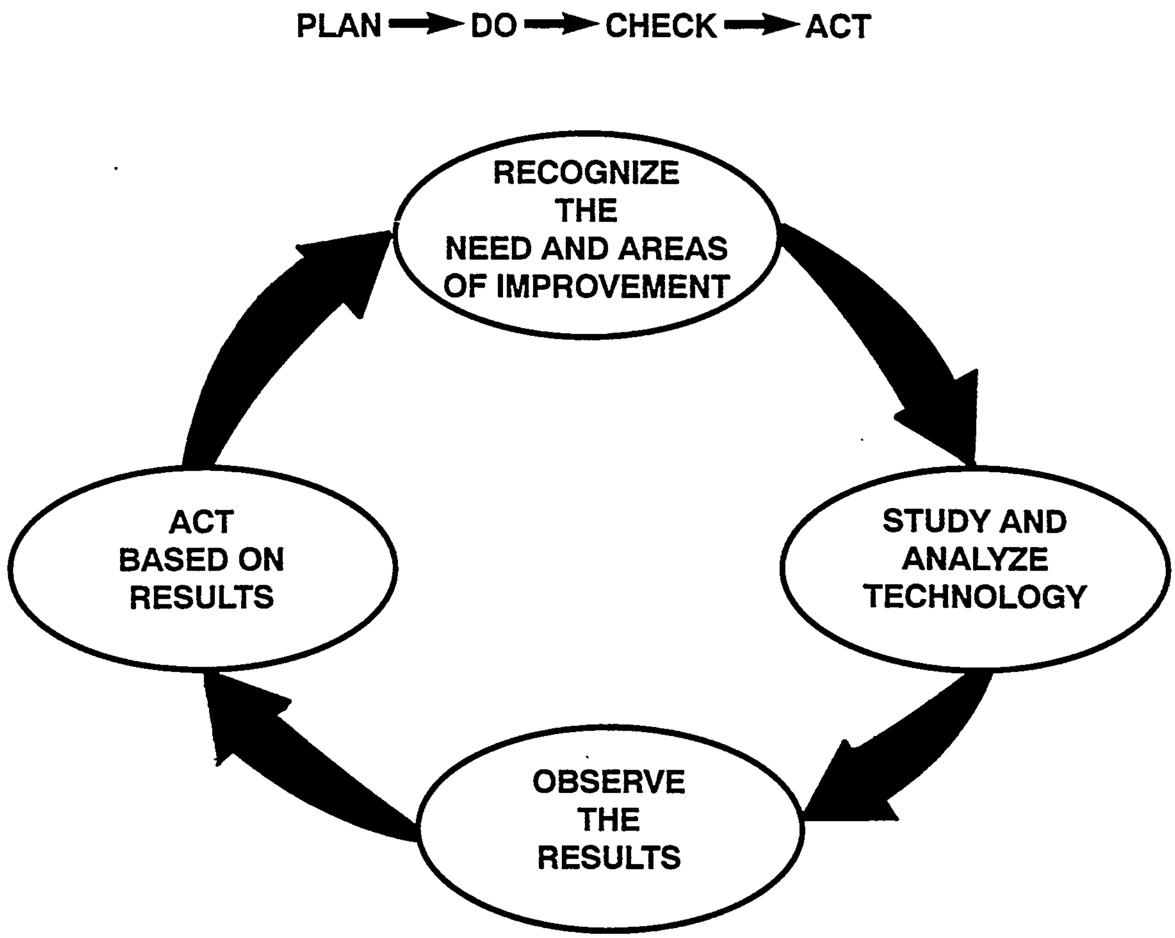
- Identify constraints imposed on the pipe shops surveyed due to the mix.
- Identify overall constraints imposed on the NASSCO pipe shop due to the mix and current layout.
- Identify implemented alternatives to relieving the constraints.
- Identify planned or possible alternatives for the NASSCO pipe shop.

This report identifies and describes currently available technology, processes, methods and equipment utilized to eliminate constraints imposed on the overall pipe fabrication process.

Continuous Improvement in Pipe Fabrication is possible thru: recognizing areas of improvement - studying and analyzing technology - observing the results and then acting based on results (See Diagram # 1).

This has been accomplished and it is concluded that there are distinct methods and alternative approaches for handling and fabricating the multiple mix of piping requirements. The mix can vary in the amount of impact on the shop and is a direct result of schedule impacts resulted from various ship construction scenarios. The solutions applied by each of the shops surveyed were based on the degree of mix experienced by the shops, constraints due to layout, and the degree of considered importance to their overall processes. This report examines how the NASSCO pipe shop is currently in the process of applying this concept of a Inflexible pipe shop fabrication system" to improving its: fabrication methods, overall layout of shop, material flow, material control, and quality. The conclusion we at NASSCO made was that in order for a pipe shop to maintain lower production costs and increase its efficiency and through-put, it must remain a "Flexible pipe Shop Fabrication System" able to handle the multiple types of fabrication demands throughout the entire shop.

CONTINUOUS IMPROVEMENT IN PIPE FABRICATION



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**All technical product information provided in the report is for information purpose only and is not intended to support one product over other possible competitors.

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DIAGRAM

1.0. INTRODUCTION

The following report presents an ideal approach to a semi-automated pipe shop capable of handling the multi-mix of pipe fabrication as found in both commercial and Navy work. The approach pursued by the NASSCO pipe shop were developed out of a recognized need to improve its fabrication methods, capacity and material control within the shop .

The approach NASSCO's pipe shop utilized was more or less the same as the objectives set forth for this report. To summarize NASSCO’S approach, the pipe shop performed the following:

1. Suneyed several other pipe shops through out the country and compared their lay outs and structure with theirs (Diagram # 2).

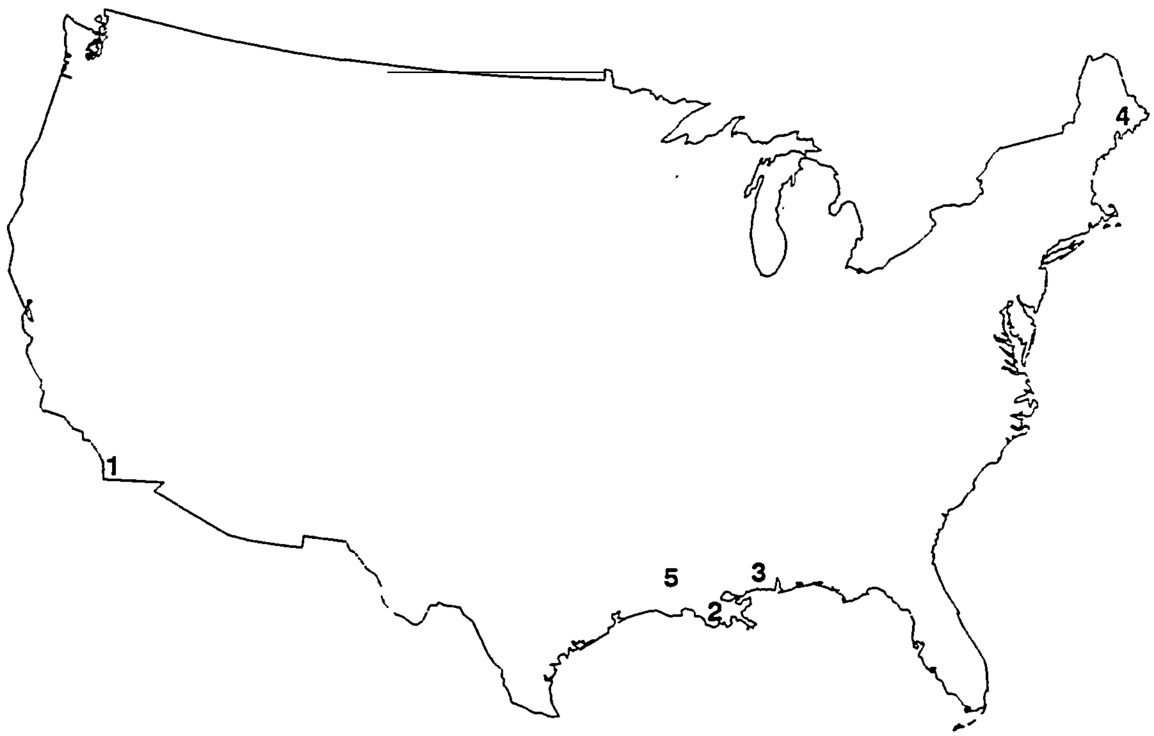
2. Held weekly brainstorming meetings with the shop personnel (both labor & management) to identify areas of direct concern to the floor personnel as well as identifying any fabrication constraints.

3. Reviewed the market for new technology, equipment, and\or methods of fabrication which would improve the shop's flexibility and overall through put.

4. Analyzed all the information received from the above three (3) tasks and formulated a plan that utilized those input which warranted the most return on investment.

What follows in this report is NASSCO’S results from the survey of the other shops and a comparison of those with NASSCO's shop. The report also discusses NASSCO’S current and proposed pipe shop layouts as well as description of all the new methods and equipment NASSCO is utilizing for the pipe fabrication process.

U.S. SHIPYARDS AND PIPE SHOPS VISITED AND SURVEYED



1. **NATIONAL STEEL AND SHIPBUILDING COMPANY — SAN DIEGO, CALIFORNIA**

2. **AVONDALE INDUSTRIES INC. — AVONDALE, LOUISIANA**

3. **INGALLS SHIPBUILDING — PASCAGOULA, MISSISSIPPI**

4. **BATH IRON WORKS — BATH, MAINE**

5. **INTERNATIONAL PIPING SYSTEMS — PORT ALLEN, LOUISIANA**

DIAGRAM 2

2.0. PROJECT OBJECTIVES

The project task objectives were as follows:

1) Research and review current systems and industries both internal and external to NASSCO.

2) Analyze and define processes utilized by these systems with differing constraints imposed due to an increase of pipe material mix.

3) Identify alternative solutions to receiving constraints imposed on the pipe shop and evaluate alternative methods for handling, end preparation, cutting, bending, and assembly of CuNi and Stainless Steel pipe. Then pursue vendor quotes for equipment to optimize flow and increase overall quality and productivity.

4) Procure equipment during on-site preparation work, including rearrangement of current NASSCO Pipe Shop.

5) Measure and finalize accounts of cost reductions, quality and productivity improvements.

6) Prepare and submit a Final NSRP Report.

3.0. YARDS AND PIPE SHOPS SURVEYED

3.1. PIPE SHOP COMPARISON MATRIX (Similarities & Constraints) (See Diagram # 3)

3.2. AVONDALE PIPE SHOP

3.2.1. GENERAL HISTORICAL INFORMATION

Avondale Shipyard's primary construction has centered around Navy amphibious and auxiliary vessels, i.e. fleet oilers (TA'S) and dock landing ships (LSD’s), a floating detention facility for the state of New York and most recently a contract for a governmental survey vessel (TAGS). On the commercial side, in the early 1980's, Avondale built 42,500 DWT product carriers for Exxon.

3.2.2. LOCATION

Avondale Shipyard is located on the west bank of the Mississippi River approximately 20 miles west and up river from the city of New Orleans, Louisiana. The pipe shop we visited runs length wise adjacent to the Mississippi River in the south west side of Avondale's Shipyard.

3.2.3. CUNI VS. STEEL

Copper nickel (CuNi) pipe comprises approximately fifty percent (50%) of the total fabricated pipe details built in the Avondale pipe shop.

Avondale Shipyard performed studies in both 1978 and 1983 on an integrated semi-automatic pipe shop. Extensive capital investment went into the former facility in order to upgrade it to a semi-automated pipe shop. The pipe shop experienced a great change in pipe material type and mix.

3.2.4. CONSTRAINTS AND IMPLEMENTED SOLUTIONS

In the late 1980’s Avondale increased its overall pipe assembly and fabrication area by taking over an adjacent building. The new pipe fabrication is dedicated entirely to fabricating (CuNi) pipe details. The new shop is divided into four separate areas:

1) Covered palletization bay - for large and small pipe

details (approximately 2,400 Sq. Ft.).

2) High rack storage bay - material and fitting storage (is serviced by a 5 ton overhead and is approximately 2,400 Sq. Ft.).

3) Middle fabrication bay - (is serviced by a 10 ton overhead gantry and is approximately 4,800 Sq. Ft.) .

The pipe is bent either on a 2-inch to 8-inch IPS Pipe Bender, or sent past the bender to (2) off load racks, one for small pipes and the other for large pipes. The bends are stored in an adjacent area. Small CuNi pipe details are fabricated in the middle fabrication bay along with some silver soldering.

4) Side fabrication bay - (is serviced by a 5 ton overhead gantry and is approximately 4,800 Sq. Ft.). This bay is used for fitting and weld out. Larger CuNi pipe and fittings are stored at the back end of this bay and the pipe details are fabricated at subsequent fit-up and weld out stations.

3.2.4.1 ADVANTAGES

1) Addition of the new fabrication area opened up the main pipe shop for increased through-put. The main shop appeared less congested with an increased flexibility in the overall material flow.

2) Less tooling change-out required for bender: because it is dedicated to only CuNi. The wiper dies and fixed dies for the 2-inch to 8-inch bender required less change-out because the bender is only being used for CuNi bends.

3) Lowered risk of damaging CuNi pipe - by separating the CuNi pipe from the steel pipe during handling, transporting, pelletizing, etc. It is assumed that the risk of damaging the CuNi pipe details would be reduced. Most of the shops visited, however, did not appear to have additional area in or around their shops to designate exclusively for CuNi fabrication.

3.2.4.2. ADDITIONAL CONSIDERATIONS

The CuNi pipe is delivered from the main pipe shop storage silos. CuNi travels through the main pipe shop which could contribute to possible undue congestion. This constraint could be reduced or eliminated by off loading and storing CuNi pipe adjacent to the CuNi pipe shop. Since CuNi doesn't require blasting, and with the CuNi facility designed to provide the cutting and bending functions, the main shop could be by-passed altogether by the CuNi pipe.

3.3. INGALLS PIPE SHOP

3.3.1. GENERAL HISTORICAL INFORMATION

Ingalls has been the leading builder of surface combatants (non nuclear) in the U.S.A., i.e. Destroyers (DD's), AEGIS Cruisers (CG'S), Multi-Purpose Amphibious Assault Ships (LHD's), & Class Guided Missile Destroyers (DDG's). Ingalls also was recently awarded three (SAAR 5) class fast attack crafts for Israel.

3.3.2. LOCATION

Ingalls Shipyard is located on the Gulf of Mexico at the mouth of the Pascagoula River in Pascagoula, Mississippi which is approximately 120 miles east of New Orleans. The Pascagoula River separates Ingalls into two yards: the east bank yard (primarily ship repair) and the newer west bank yard (primarily new construction). The west bank yard was completed in the early 1970's. The newly constructed pipe shop was visited in this yard.

3.3.3. CUNI VS. STEEL

At Ingalls pipe shop, copper nickel (CuNi) pipe comprises approximately 50 percent of the current total fabricated pipe details. This percentage represents an increase from 35 percent to 50 percent within the last five years.

The Ingalls pipe shop was built in the early 1970's when the west bank yard was built. The pipe shop is approximately 86,100 Sq. Ft. in an enclosed subdivided warehouse which also houses an electric shop, sheetmetal shop and adjacent machine shop. All pipe is delivered from the main storage area (approximately 120,000 Sq. Ft.) and onto a pipe conveyer system into the east end of the pipe shop. Pipe is then cut on an automatic bandsaw and sent to a pre-bend / pre-tray storage area. Pipe is then picked up by overhead cranes and moved through the bending operation. If no bending is required then the cut lengths are placed into 3-foot by lo-foot kit boxes. The boxes are placed with the pre-kitted fittings at each work station. Five sub-assembly lanes split up the entire pipe shop with approximately 52 total work stations throughout. Each station comprises of two (2) work benches and one (1) welding positioner with fitters and welders dedicated to each area. The lanes are set-up with either fit-up or weld-out or silver brazing as their primary function.

After the sub-assembly lanes, pipe is either moved to a testing or flushing area or through the blast and paint building adjacent to the pipe shop. Then, the pipe details are placed in a large in-progress storage (IPS) area or sent directly to the next stage of construction.

3.3.4. CONSTRAINTS AND IMPLEMENTED SOLUTIONS

Ingalls has experienced a larger mix of CuNi and considered a different approach to dealing with the greater influx. Each work station is set up with the welding equipment to perform all the variety of welds required for all the varieties of materials and schedules. The majority of welding performed was with the TIG process for both the root and fill passes. For steel pipe the pulse MIG was the primary method. The size of the shop allowed for fully outfitted work stations thus providing a set-up for a multiple variety of weld types to be performed at each station. CuNi pipe was moved down the same sub-assembly lanes as the steel, stainless steel and copper pipe. However, several of the lanes had specific equipment such as hot wire automatic TIG welding machines which were used for the Class 1 (X-ray / critical pipe details). One of the lanes also handled the silver brazing requirements. However, each of the sub-assembly lanes were capable of handling all of the mix of pipe materials and their welding requirements.

3.3.4.1. ADVANTAGES

There were no apparent problems in keeping the CuNi and steel pipe separate during the storage and material handling stages. All of the pipe was stored in the main pipe storage area and delivered as required for the pipe details, thus maintaining a flexible pipe fabrication system.

3.4. BATH PIPE SHOP

3.4.1. GENERAL HISTORICAL INFORMATION

Bath Iron Works has been a leading yard in the production of Navy destroyers. Its' programs over the years have included the following: Class Guided Missile Frigate Program (FFG's), Class Cruisers (CG'S) and lead shipyard for the Arleigh Burket Class Guided Missile Destroyer Program (DDG's). Baths' projects included many commercial ships such as container ships, RO/RO's and tankers.

3.4.2. LOCATION

Bath Iron Works is comprised of three (3) large facilities. The new ship construction facility, Bath Shipyard and the ship overhaul and repair facility at Portland are both located on the west bank of the Kennebec River, 15 miles from the Gulf of Maine. A newly built modern fabrication facility is located eight (8) miles west of the main bath facility in East Brunswick, Maine.

3.4.3. CUNI VS. STEEL

Currently 70 percent of all welded pipe systems are CuNi. The CuNi and steel pipe is moved down the same welded pipe process lane. The CuNi systems are produced in series with the steel and stainless steel systems. The sequence is driven by the main schedule demand.

3.4.4. CONSTRAINTS AND IMPLEMENTED SOLUTIONS

The new East Brunswick facility was completed in late January 1990. This new facility was built out of Baths' recognized need to increase its' fabrication capacities and improve material flow. The expansion included plans for both the pipe shop and sheet metal shop. The new facility was designed and planned with both management and floor level employee participation. (4) Key design criteria were: work station design, heating systems, overall building design and material flow.

Bath set out to improve the quality and through-put of fabricated components. The new facility design incorporated significant facility layout and equipment upgrades. Some of the areas of improvement were identified as follows:

- o Storage of raw pipe and sheet metal at the facility

- o Efficient inflow of materials from storage and improved crane service

- In-process material storage areas
- Improved work station design and layout
- Material kitting areas for finished kits
- Storage areas for finished kits
- Blast and paint support
- Q.A. support and X-ray facility on site

3.4.4.1. PROCESS IMPROVEMENT

The facility is subdivided with approximately half the area dedicated to pipe fabrication and the other half dedicated to sheet metal fabrication. The pipe shop is estimated to be approximately 25,000 Sq. Ft. All pipe is stored in a large pipe yard north of the building. Pipe is brought into the pipe shop on a conveyor system and advanced through a guillotine bandsaw. It is then cut and advanced to three roll-off tables, then bent on the benders if required. Then the pipe is placed on a series of rolling A-frame racks. The fittings, valves, and other pipe components are then pre-kitted in a separate warehouse and delivered in square 4-foot by 2-foot plastic kit boxes (holding 25-30 pieces). The material chaser / handler then matches the kits up with their pipe and delivers them together to the fitters.

3.4.4.2. MATERIAL CONTROL

Scheduling identifies daily pipe kits sent over from the consolidated warehouse per schedule demand - the pipe shop material handler inspects the kits at the warehouse comparing the planning package sketch to the physical kits (including flanges, fittings, etc.). Upon receipt, the shop, material handler again verifies the correctness of the kits, thus assuring errors are corrected on the spot. The kits are then stored in a secure storage area until issued for fabrication on the floor. No cutting or bending is started on a specific pipe assembly until all kit material is received. Once all material once released to the floor is delivered to the work benches by the pipe shop material handler. The pipe pieces

that go into the pipe assemblies are tracked by bench and shift. The material handlers then retrieve completed fabricated pipe assemblies from the benches, for tagging and storage.

3.4.4.3. Flow Lanes

The lanes are divided into a welded pipe lane and a brazed pipe lane. Approximately 25 work stations are on each side separated by an open lane for pipe movement. Sixty percent of all the pipe fabricated in the shop requires silver brazing. This pipe flows down the welded pipe lane. The ratio of fitters to welders is 3 to 1, respectively, and fitters to brazer is 6 to 1. Copper nickel pipe is used for all salt water systems. The fitters weld up the pipe assemblies and then each assembly is either moved through blast and paint storage, or to the other two yards for installation into the ships.

3.4.4.4. Advantages

Not only did Bath improve its through-put by 15 percent compared to its prior performance, but their overall fabrication rates dropped by 20 percent. Several quality checklists were implemented involving the floor worker, supervision and the customer (requester). All errors were returned to the mechanic for correction and error trends tracked. Through this system of checks it was identified that 20 percent of the benches caused 80 percent of the errors. Lack of training with engineering on a new pipe sketch format was just one of the problems identified and corrected. Additional training and follow-up dropped the shop's overall quarterly rejection rate from 12 percent to 2.2 percent for the first quarter of 1992. These improvements were a direct result of the tooling and process improvements incorporated which included:

- o Increased use of automatic welding equipment
- o New use of end prep equipment
- o Increased material support from material handlers

3.5. INTERNATIONAL PIPING SYSTEMS

3.5.1. GENERAL HISTORICAL INFORMATION / LOCATION

International piping systems (IPS) - is located in Port Allen, Louisiana, just outside of Baton Rouge. IPS implements the latest in computer technology in its modern approach to pipe bending and fabrication. IPS specializes in induction bending and fabricates pipe for petrochemical plants, power plants and refineries, etc. They have also supported shipbuilding companies with pipe fabrication support. This pipe shop is comprised of a 90,000 square foot warehouse building and a new facility approximately 24,000 for fabricating heavy wall power plant pipe. The main shop is subdivided into (4) separate bays with overhead gantry crane support to each. Pipe is moved from a large outside storage area or a pipe silo into the shop. Pipe enters the first bay from the silo and is blasted in a steel abrasive wheelabrator, cut to length on an automatic-positioning bandsaw and then beveled. The beveling station is an Oxtechnik design and a two step operation (one end at a time). The beveling time for each end takes approximately 1 minute. An extra 3 minutes is also required for clamping and positioning. The silo and shot blaster were designed as a one operator system. The cut to length and fully automatic beveling station were also designed as a one operator system. All conveyors are powered with a travel rate of 3 feet per minute. The transfer tables are also of the oxytechnik design utilizing gravitational flow.

The pipe continues down the first bay if requiring cold bending. Then, it follows to the other two (2) flow lane bays.

The second bay is set up for component storage, fitting stations (small and medium pipe) and welding. The third bay is set up for cutting on a pantograph (large pipe usually 12 inch and up), fitting area (large pipe) and welding.

The fourth and final bay is set up with a staging area for induction bending, with two (2) large induction benders with heat bending capacity from 2 inch through 34 inch IPS.

Pipe moves through each of these stations to a staging area at the end of the shop. The pipe spools are then packaged, placed on trailers and shipped to the construction site.

3.5.2. CUNI VS. STEEL

Discussions were held with several of the floor personnel and project managers about the effects of the increase of CUNI in the process shop and on the flow lanes. The CUNI pipe is normally scheduled down the middle two (2) bays in batches. This method seemed to have worked for the shop without much complexity.

3.5.3. ADVANTAGES

Due to the large size of this facility, it is able to handle the multiple mix of pipe through its entire facility. By batching the pipe types for fabrication on the floor, change over of tooling becomes less of a concern and, subsequently, capacity of material flowing more smoothly through the shop is increased.

PIPE SHOP COMPARISON MATRIX

PROCESS OR AREA	NASSCO	AVONDALE	INGALLS	BATH	INTERNATIONAL PIPING SYSTEMS
LOCATION	SAN DIEGO, CAUFORNIA	AVONDALE, LOUISIANA	PASCAGOUIA, MISSISSIPPI	EAST BRUNSWICK AND BATH, MAINE	PORT ALLEN, LOUISIANA
TYPE OF PIPE SHOP	SHIPYARD PIPE SHOP	SHIPYARD PIPE SHOP	SHIPYARD PIPE SHOP	PIPE SHOP IN SEPARATE FACIL-ITY FROM MAIN SHIPYARD	PIPE FABRICATOR
PRIMARY WORKLOAD	SUPPORTS NEW SHIP CON STRUCTION AND SHIP REPAIR BOTH NAVY AND COMMERCIAL WITH FABRICATED PIPE PIECE AND MODULAR UNIT ASSEM BLIES	SUPPORTS NEW SHIP CON-STRUCTION AND SHIP REPAIR-BOTH NAVY AND COMMERCIAL WITH FABRICATED PIPE PIECES AND MODULAR UNIT ASSEM-BLIES	SUPPORTS NEW SHIP CON-STRUCTION AND SHIP REPAIR-BOTH NAVY AND COMMERCIAL WITH FABRICATED PIPE PIECES AND MODULAR UNIT ASSEM-BLIES	SUPPORTS NEW SHIP CON STRUCTION AND SHIP REPAIR BOTH NAVY AND COMMERCIAL WITH FABRICATED PIPE PIECES AND LIMITED MODULAR UNIT ASSEMBLIES	BUILDS SOME PIPING SYSTEMS FOR SHIPBUILDING INDUSTRY BUT PRIMARY WORK IS OIL AND LAND BASED PIPING SYSTEMS
LOCATION OF PIPE SHOP IN YARD	SOUTH EAST SIDE OF MAIN YARD	SOUTH SIDE OF MAIN YARD	EAST SIDE OF MAIN YARD	SEPARATE WAREHOUSE (8) MILES EAST OF THE MAIN BATE SHIPYARD	WAREHOUSE LOCATED ON (10) ACRES
FABRICATION AREA (SQUARE FEET)	MAIN SHOP 20,900 PIPE ANNEX TOTAL	MAIN SHOP 30,000 (APPROX) CUNI SHOP 12,000 (APPROX) TOTAL 42,000	MAIN SHOP 86,000 (APPROX)	MAIN SHOP 25,000 (APPROX)	MAIN SHOP 90,000 (APPROX)
UNIT/MODULAR ASSEMBLY AREA	OPEN AREA IN FRONT OF THE MAIN PIPE SHOP AND TWO ADJACENT PLATENS	A SEPARATE ENCLOSED BUILD-ING WITH OVERHEAD CRANE SERVICE	A SEPARATE, ENCLOSED BUILD ING WITH OVERHEAD CRANE SERVICE. MOST OF THE PIPING IS BUILT DIRECTLY INTO THE STEEL ASSEMBLIES	NO DIRECT AREA DEDICATED TO UNIT OR MODUIAR ASSEM-BLIES. THE MAJORITY OF THE PIPING IS SHIPPED TO THE MAIN BATH FACILITY FOP DIRECT INSTALLATION	(10) ACRES AVAILABLE FOR ASSEMBLY
LAYOUT OF SHOP	DETAILED IN REPORT	THE BUILDING IS SEPARATED INTO FABRICATION AREAS, IN THE FIRST HALF PIPE IS MOVED FROM STORAGE THROUGH AUTOMATIC BLASTING, PAINT-ING, CUTTING, END PREP, AND WELDING TO THE BENOING OPERATION VIA AN AUTOMATIC CONVEYOR SYSTEM, THE FIT-UP AND WELD-OUT AREA COM-PRISES THE SECOND HALF OF THE BUILDING.	THE BUILDING IS SET UP WITH THE CUTTING AND BENDING OPERATIONS TO THE EAST END OF THE SHOP, THE NEXT AREA IS A STAGING FOR PIPE KIT BOXES AND A KITTING AREA FOR FITTINGS. THE NEXT AND LARGEST AREA COMPRISES THE WORKSTATIONS AND IS USED FOR FIT-UP AND WELD-OUT.	THE PIPE CUITING AND BEND-ING OPERATION IS LOCATED ON THE NORTH SIDE OF THE SHOP THE REMAINDER OF THE SHOP IS SEPARATED INTO TWO SEPA RATE LANES. (WELDING AND BRAZING) EACH LANE IS SEPA RATED INTO 25 WORKSTA TIONS,	THE PIPE CUITTING AND BEND-ING OPERATION IS DONE DOWN ONE OF FOUR SEPARATE LANES. ONE LANE IS FOR INDUCTION BENDING AND TWO LANES FOR FIT-UP AND WELD-OUT OF SMALL AND LARGE PIPES.
FLOW LANES	DETAILED IN REPORT	PIPE MOVES FROM THE SOUTH-WEST END OF THE SHOP TO THE NORTHEAST END VIA AUTOMATIC CONVEYOR SYS-TEMS. THE PIPE PIECES ARE THEN PLACED ON CARTS AND MOVED FROM FIT-UP AND WELD. OUT BENCHES. CUNI PIPE IS MOVED DIRECTLY THROUGH THE MAIN PIPE SHOP VIA A TRANSPORT CART AND Fabri-cated IN A SEPARATE CUNI PIPE SHOP ADJACENT TO THE MAIN PIPE SHOP.	PIPE MOVES FROM THE EAST END TO THE WEST END OF THE SHOP. PIPE ENTERS THROUGH AN AUTOMATIC CONVEYOR SYSTEM. PIPE IS THEN MOVED THROUGH THE CUTTING AND BENDING AREAS. THEN PIPE IS PUT INTO KIT BOXES AND MOVED DOWN ONE OF FIVE SEPARATE FIT-UP AND WELD. OUT LANES. EACH LANE CON-SISTS OF WORKSTATIONS. EACH LANE IS SET UP TO HAN-DLE ALL WELD TYPES	PIPE MOVES FROM NORTH TO THE SOUTH END OF THE SHOP. PIPE ENTERS THROUGH THE BUILDING INTO THE CUTTING STATIONS. THEN PLACED IN THE BENDERS OR ON PIPE A. FRAME RACKS. THE PIPE IS THEN MOVED DOWN ONE OF TWO SEPARATE LANES WITH APPROXIMATELY 25 WORKSTA-TIONS IN EACH. ONE LANE IS DEDICATED TO SILVER BRAZ. ING AND THE OTHER WELDING.	PIPE MOVES THROUGH FOUR SEPARATE LANES. PIPE ENTERS FROM THE MAIN STOR-AGE AREA AND TRAVELS THROUGH THE WORKSTATIONS ON CARTS. THE COLD BENDING AND INDUCTION BENDING ARE DONE ON THE TWO OUTSIDE LANES WITH FIT-UP AND WELD-OUT OF PIPE DOWN THE TWO REMAINING CENTER LANES.

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DIAGRAM 3.A

PIPE SHOP COMPARISON MATRIX

PROCESS OR AREA	NASSCO	AVONDALE	INGALLS	BATH	INTERNATIONAL PIPING SYSTEMS
WORKSTATIONS FIT-UP AND WELD-OUT	APPROXIMATELY 30 FIT-UP STATIONS AND 8 WELD-OUT STATIONS	MULTIPLE FIT-UP STATIONS ADJACENT TO THE WELD-OUT STATION	APPROXIMATELY 52 WORKSTATIONS COMPRISING TWO WORK BENCHES AND ONE WELDING POSITIONER EACH, WITH FITTERS AND WELDERS DEDICATED TO EACH WORKSTATION	APPROXIMATELY 50 WORKSTATIONS WITH HALF DEDICATED TO SILVER BRAZING AND HALF TO WELDING	MULTIPLE FIT-UP AND WELD-OUT STATIONS LOCATED IN THE CENTER TWO LANES.
WELDING	TIG, MIQ, AND PLUX CORE, Will USE OF POSITIONERS PRIMARILY MANUAL WELDING MACHINES	TIG, MIG WITH USE OF POSITIONERS AND AUTOMATIC MANIPULATORS. USE OF FULLY AUTOMATED SLEEVE FLANGE WELD MACHINE.	TIG, MIG, AND SOME FLUX CORE, WITH THE PRIMARY METHOD TIG FOR BOTH ROOT AND FILL PASSES. ALSO USE OF POSITIONERS AND THREE HOT WIRE MACHINES.	TIG, SILVER BRAZING, AND SOME FLUX CORE. ALSO USE OF POSITIONERS AND MANIPULATORS. MANUAL WELDING MACHINES.	TIG, MIQ, AND SOME FLUX CORE. AUTOMATIC POSITIONERS AND MANIPULATORS, MANUAL WELDING MACHINES.
FIELD RUN	3/4 INCHES IN DIAMETER AND BELOW		1-INCH IN DIAMETER AND BELOW	3/4 INCHES IN DIAMETER AND BELOW	
PLANNING	DETAILED IN REPORT		MAJOR PACKAGING/PALLET PLANNING ALL DONE BY THE PRODUCTION CONTROL DEPARTMENT (P. C.) PLANNING ALL WORK PALLETS AND SCHEDULE THIS PACKAGE IS THEN TURNED OVER TO THE FLOOR PLANNERS. BUDGETS DONE BY INDUSTRIAL ENGINEERING BRANCH. PACKAGES SET UP FOR ONE TO THREE WEEKS WORK OF WORK.	MAJOR PACKAGING PALLET AND PLANNING ALL DONE BY THE MASTER PLANNING ORGANIZATION. THIS PACKAGE AND A COPY OF THE MATERIAL LIST IS SENT TO WAREHOUSING FOR THE PRE-KITTNG OF FITTINGS. THE PLANNING PACKAGE INCLUDES: • FAB SKETCH • CUT AND BEND SHEET • IDENTIFICATION TAG	
MATERIAL ACQUISITION	DETAILED IN REPORT	THE PIPE SHOP RECEIVES DALLETS WITH TWO WEEKS WORTH OF SPOOLS TO THE MAIN SHOP FLOOR FROM FITTING STORAGE. FITTINGS KITTED WITH WIRE AND DELIVERED TO CARTS WITH PIPE FOR FIT-UP.	PIPE IS DELIVERED FROM THE MAIN STORAGE YARD. FIANGES AND FITTINGS ARE PRE-KITTED AND PALLETIZED. THESE PALLETS ARE THEN DELIVERED BY FORKLIFT WITH A KIT BOX TO THE FITTER AT HIS WORH BENCH. THE KIT BOXES CONTAIN THE PRECUT OR BENT PIPE.	COPIES OF THE PRE-PALLETIZATION PACKAGES AND SCHEDULE GO TO THE WAREHOUSE. THE ENTIRE PIPE ASSEMBLY IS PRE-KITTED AT THE WAREHOUSE (EXCLUDING THE RAW PIPE). A MATERIAL HANDLER (M16) FROM THE PIPE SHOP THEN VERIFIES ACCURACY OF THE KITS AND SIGNS FOR THEM BEFORE DELIVERY TO THE SHOP.	
MATERIAL HANDLER	MATERIAL SUPPORT TECHNICIAN (MST)	MATERIAL HANOLER	FLOOR PLANNER	MATERIAL HANOLER-CHASER (M16)	PIPE SPOOLS
PIPE ASSEMBLY	PIPE SPOOLS (APPROXIMATELY 15 FEET)	PIPE DETAIL	PIPE DETAIL (APPROXIMATELY 15 FEET)	PIPE ASSEMBLY	
PRODUCTION CONTROL	DETAILED IN REPORT		QA PEOPLE WORK ON SHOP FLOOR HAND-IN-HAND WITH PRODUCTION PERSONNEL TC ASSURE QUALITY AND FAST RESPONSE TIME WHEN CHANGES ARE REQUIRED.	THE SHOP HAS DEVELOPED A PIPE QUALITY CHECKLIST FOR BOTH THE SUPERVISORS AND QA TO VERIFY ACCURACY.	

DIAGRAM 3.B

PIPE SHOP COMPARISON MATRIX

PROCESS OR AREA	NASSCO	AVONDALE	INGALLS	BATH	INTERNATIONAL PIPING SYSTEMS
PIPE STORAGE	TWO 12-CELL SILO, STORES SINGLE RANDOMS, 20-FOOT MAXIMUM LENGTHS, 1-1/2 INCH TO 12-INCH DIAMETER. SILO STOCKS AND REITRIEVES MORE THAN ONE PIPE ATA TIME.	ONE 11 -CELL SILOS (SAME TYPE AS NASSCOS)	MAIN STORAGE YARD APPROXI-MATELY 120,000 SQUARE FEET	MAIN STORAGE YARD APPROXI. MATELY 100,000 SQUARE FEET	ONE 12-CELL SILO (SAME TYPE AS NASSCO'S)
CUTTING	CNC COLD CUT SAW. (AUTO FEED). FOR PIPE BELOW 12 INCHES IN DIAMETER, THE PIPE 12 INCHES IN DIAMETER AND ABOVE IS CUT WITH A FIXED PLASMA PANTOGRAPH. BOTH SAWS ARE AUTO FEED.	CNC COLD CUT SAWS (AUTO FEED) FOR PIPE 2 TO 14 INCHES IN DIAMETER. THE PIPE 14 INCH-ES IN DIAMETER AND ABOVE IS CUT WITH A FIXED PLASMA PANTOGRAPH. BOTH SAWS ARE AUTO FEED.	COLD CUT SAWS FOR PIPE O TO 12 INCHES IN DIAMETER (AUTO FEED). ALSO HAND PLASMA PANTOGRAPH CUTTERS ARE USED REQUIRING MANUAL SET UP.	COLD CUT SAWS FOR PIPE 0 TO 14 INCHES IN DIAMETER. (MAN UAL FEED)	CNC AUTOMATIC COLD CUT SAWS FOR PIPE 0 TO 12 INCHES IN DIAMETER. ONE PLASMA PANTOGRAPH CUTTER (MANU-AL SET UP).
END PREPARATION	SEMI-AUTOMATIC END PREP STATION SUSPENDED TRI-TOOL BEVELING MACHINES AND PORTABLE SYSTEMS O TO 12 INCHES.	FULLY-AUTOMATIC END PREP STATION. OXYTECHNIK SYSTEM O TO 12 INCHES.	PORTABLE TRI-TOOL END PREP SYSTEMS MOVED FROM BENCH TO BENCH. ONE MAN DEDICAT. ED TO BEVELING PIPE FULL TIME. O TO 12 INCHES.	END PREP STATION COM-PRISED OF TWO TRI-TOOL SYS TEMS USED AS A DEDICATED WORKSTATION. PIPE DELIV-ERED TO THE STATION FOR BEVELING. O TO 12 INCHES.	FULLY-AUTOMATIC END PREP STATION. OXYTECHNIK SYS-TEM. 0 TO 12 INCHES.
BENDING	SIX TOTAL IN MAIN PIPE SHOP RANGING FROM 3/4 TO 12 INCH. ES IN DIAMETER WITH CNC CAPABILITY AND 2-D, 3-D AND 5-D CAPABILITY.	SIX TOTAL IN MAIN PIPE SHOP RANGING FROM 1/2 TO 8 INCH-ES IN DIAMETER WITH CNC CAPABILITY. ONE DEDICATED BENDER FOR CUNI IN A SEPA-RATE CUNI SHOP 2 TO 6 INCH-ES IN DIAMETER WITH 2-D, 3-D, AND 5-D CAPABILITY,	8 TOTAL BENDERS ALL 2-D, 3-D, AND 5-D CAPABLE OF RANGING FROM 1/2 TO 12 INCHES IN DIAMETER WITH CNC CAPABILI. TY.	4 TOTAL BENDERS IN MAIN PIPE SHOP RANGING FROM 1/2 TO 6 INCHES IN DIAMETER WITH 2-D, 3-D, AND 5-D CAPABILITY.	2 INDUCTION BENDERS RANG-ING FROM 2 TO 34 INCHES IN DIAMETER. ONE COLD BENDER 1/2 TO 4 INCHES DIAMETER WITH CNC CAPABILITY.
QUALITY ASSURANCE	DETAILED IN REPORT		FLOOR QUALITY CONTROL PEO. PLE RANDOMLY CHECK PIPE SYSTEMS FOR QUALITY OF PRODUCT. QUALITY CONTROL PERSONNEL REPORT TO PIPE SHOP MANAGER AND ACCURA-CY CONTROL PERFORMS FOL-LOW-UP CONTROL CHECKS.	DEVELOPED RECENTLY A SELF. GOVERNING QUALITY CHECK. LIST DEVELOPED BY THE PIPE SHOP AND ITS CUSTOMER, SUPERVISORS INSPECT 10% OF THROUGHPUT EVERY WEEK AND 50% OF THROUGHPUT ONE WEEK EVERY QUARTER, TRACKING ERROR TRENDS BACK TO THE MECHANIC.	
PALLETIZATION	PIPE IS MOVED IN PIPE BAS-KETS INTO STORAGE AREA OR NEXT STAGE OF CONSTRUC-TION.	PIPE IS SENT ON PALLETS TO NEXT STAGE OF CONSTRUC-TION.	PIPE IS MOVED IN KIT BOXES TO IN-PROCESS STORAGE (IPS) AREA.	PIPE IS MOVED IN KIT BOXES TO OTHER YARDS AND PLACED ADJACENT TO SHIPS, ON SHIPS, OR IN STORAGE.	
TREATMENT	NO GALVANIZING--ACID TREAT-ED AND PICKLED IN A TREAT-MENT AREA AFTER PIPE LEAVES THE SHOP.	NO TREATMENT FACILITY. SUB-CONTRACTS OUT THIS OPERA-TION.	NO GALVANIZING-ACID TREAT-ED AND PICKLED IN A SEPA-RATE NEW FACILITY ADJACENT TO THE PIPE SHOP.	NO GALVANIZING NO PICKLING PIPE JOINT ACID DIPPING TANKS USED WITHIN MAIN SHOP AMONG WORK BENCHES.	

PIPE SHOP COMPARISON MATRIX

PROCESS OR AREA	NASSCO	AVONDALE	INGALLS	BATH	INTERNATIONAL PIPING SYSTEMS
TESTING AND HYDROFLUSHING	HYDROFLUSH AND TEST STATION	NO PIPE HYDROFLUSHING OR TESTING	HYDROFLUSH STATION CITRIC AND SODIUM FLUSHING (PIPEFITTER RESPONSIBLE FOR HIS OWN FLUSH).	HOSE TESTING NO PIPE HYDROTESTING	
TRANSFER SYSTEMS	OVERHEAD CRANES MOVE PIPE THROUGH THE SHOP AND INTO TREATMENT LAYOUT AREA.	CARTS AND OVERHEAD CRANES MOVE PIPE THROUGH THE SHOP THEN ONTO PALLETS,	OVERHEAD CRANES MOVE THE KIT BOXES FROM WORKSTATION TO STATION THEN LOAD PIPE ONTO TRAILERS.	CARTS AND OVERHEAD CRANES MOVE PIPE THROUGH THE SHOP THEN PIPE IS PLACED INTO KIT BOXES AND LOADED ONTO TRAILERS OR STORED.	CARTS AND OVERHEAD CRANES.
UTILITIES	SMOKE EXTRACTION SYSTEM OVERHEAD. WELD LEADS ACROSS GROUND OR SUPPORTED AND DRAPED OVERHEAD.	SMOKE EXTRACTION SYSTEM OVERHEAD. SOME WELD LEADS RUN OVERHEAD FROM ELEVATED WELD MACHINES.	SMOKE EXTRACTION SYSTEM OVERHEAD. ALL UTILITIES EXCEPT SMOKE EXTRACTION AND WELD LEADS RUN UNDERGROUND STUBBING UP AT EACH BENCH. WELD LEADS RUN FROM HOSE REELS MOUNTED ON VERTICAL CENTER BEAM SUPPORTS,	SMOKE EXTRACTION SYSTEM, COMPRESSED AIR, AND ELECTRICAL RUN UNDERGROUND STUBBING UP AT EACH BENCH.	
PAINTING	PAINTING DONE IN A SEPARATE AREA OF THE YARD.	SOME PAINTING DONE IN-LINE WITH AUTOMATIC CONVEYING SYSTEM IN THE MAIN PIPE SHOP.	PAINTING DONE IN SAME BUILDING. THE TREATMENT TANKS ARE ADJACENT TO THE PIPE SHOP.	PAINTING DONE IN ENCLOSED ROOM AT THE END OF THE SHOP.	
CUNI vs. STEEL	52% OF ALL PIPE SPOOLS BUILT ARE CUNI.	50% OF ALL PIPE DETAILS BUILT ARE CUNI.	50% OF ALL PIPE DETAILS BUILT ARE CUNI.	70% OF ALL PIPE ASSEMBLIES BUILT ARE CUNI,	LESS OF A MIX EXISTS COMPARED TO SHIPYARD PIPE SHOPS.
GENERAL CONSTRAINTS DUI TO MIX	DETAILED INREPORT	CUNI PIPE REQUIRES TRANSPORT THROUGH MAIN SHOP. THE NEW CUNI SHOP ALLOWS FOR COMPLETE SEPARATION OF CUNI PIPE FROM STEEL PIPE. THIS IS AN IDEAL SOLUTION TO THE MIX. A FURTHER DETAILED EXPLANATION IS IN THE REPORT.	CUNI PIPE IS FABRICATED THROUGH THE MAIN SHOP WITH STEEL PIPE. NO MAJOR CONSTRAINTS IMPOSED DUE TO THE MIX BECAUSE OF THE LARGE SIZE AND OVERALL CAPACITY OF THE SHOP. A FURTHER DETAILED EXPLANATION IS IN THE REPORT.	CUNI PIPE IS FABRICATED THROUGH THE MAN SHOP WITH STEEL PIPE. NO MAJOR CONSTRAINTS IMPOSED DUE TO THE MIX. A LARGE PERCENTAGE OF THE SHOP IS USED FOR SILVER BRAZING AND THE WORKSTATIONS ARE SET UP TO FABRICATE AND WELD STEEL, CUNI, AND SILVER BRAZE..	CUNI PIPE IS FABRICATED THROUGH THE MAIN SHOP WITH STEEL PIPE. THE CUNI PIPE IS BATCHED TOGETHER AND RUN THROUGH THE SHOP ALL AT ONE TIME. ALL WORKSTATIONS ARE SET UP TO FABRICATE AND WELD STEEL AND CUNI PIPE.

* ALL INFORMATION WAS COMPILED BASED ON PUBLISHED OR PROVIDED DATA.
INFORMATION WITH AN ASTERISK WAS EITHER NOT AVAILABLE OR NOT APPLICABLE..

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DIAGRAM 3.D

4.0. NATIONAL STEEL & SHIPBUILDING COMPANY

4.1. GENERAL HISTORICAL INFORMATION

The NASSCO shipyard has been and is considered one of the dominant designers and builders of commercial tankers in the U.S. today. NASSCO constructed nearly half of all U.S. built tanker ships since the early 1970's. Navy ship construction and repair of non-combatant vessels both auxiliary and amphibious ships include the following fleet replenishment oiler (AOR7), tank landing ships (LST's), Combat Supply Ships (AFS 1), Destroyer Tenders (AD 41) and Cable Laying Repair Ship (TARC 7). Current construction includes the Fast Combat Support (AOE) Ships and a recently delivered cargo container ship for Matson.

4.2. LOCATION

The NASSCO shipyard is located on the bay waterfront of downtown San Diego. The pipe shop is located on the south-east side of the main yard (See Diagram #4). A full description of the pipeshop layout, flow lanes and constraints imposed on the shop are addressed in Section 5.0. of the report.

4.3. GENERAL PIPE SHOP INFORMATION

Through the evaluation of NASSCO'S overall pipe shop operation, the primary objectives were to simplify and streamline product flow and product sequence, reduce labor and material handling, integrate more automation with CNC capabilities while improving efficiency and quality.

4.4. GENERAL PIPE SHOP CONSTRAINTS

Several of the main constraints for the NASSCO pipe shop are its size, location, lay out, material control and fabrication methods. Currently only 20,900 SqFt. of fabrication area is available in the main shop. Since the shop is located in the middle of the overall ship fabrication process lane, any increase in the size of the shop is limited. Shop layout and material flow and handling were the key areas for potential improvement in reducing the delays in the fitting and welding sequence within the shop. Fabrication methods including pipe fitting, welding, and tooling were also evaluated and upgraded, where necessary.

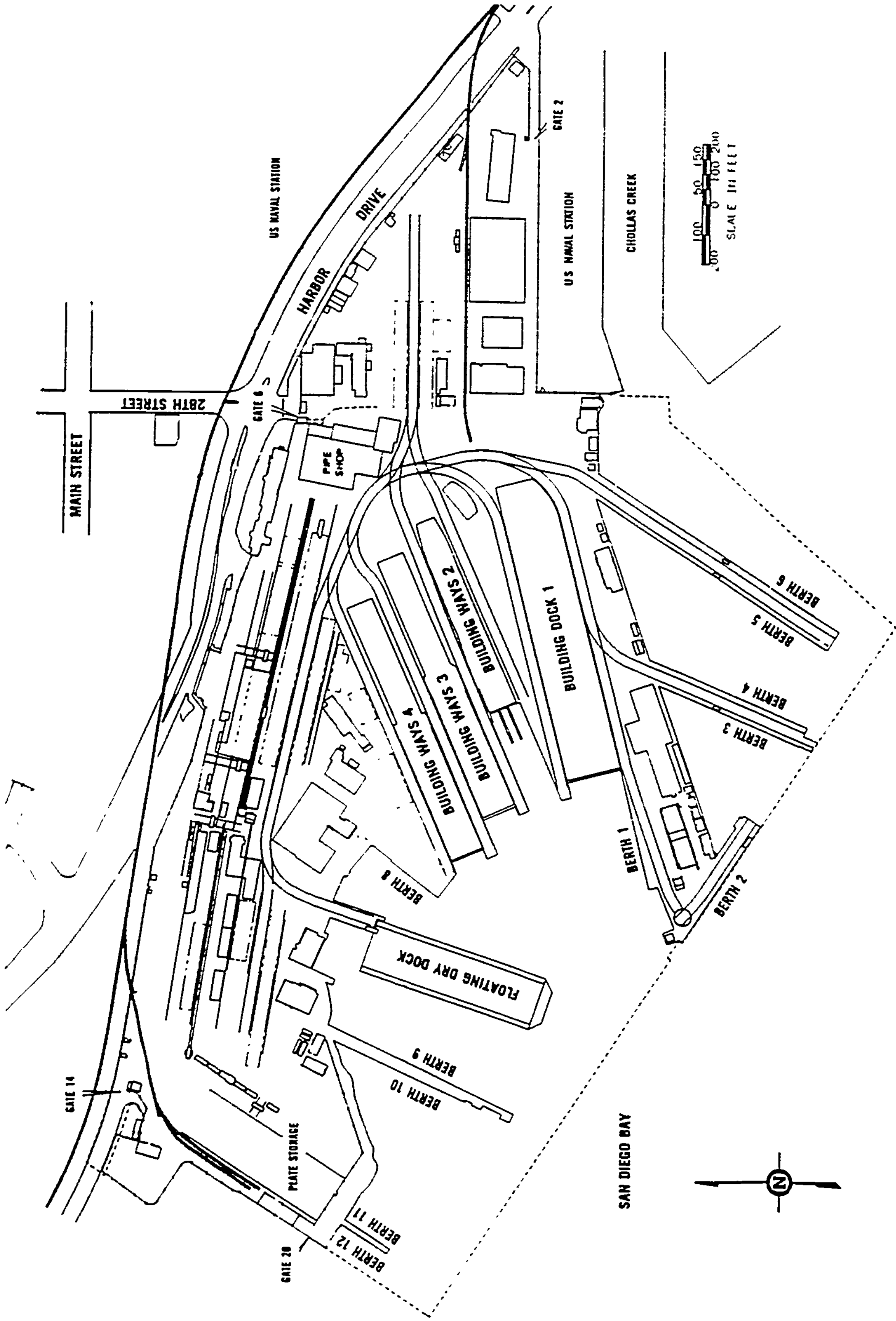

US NAVAL STATION
HARBOR DRIVE
GATE 2
US NAVAL STATION
CHOLLAS CREEK
SCALE IN FEET
28TH STREET
MAIN STREET
GATE 6
PIPE SHOP
BUILDING WAYS 2
BUILDING WAYS 3
BUILDING WAYS 4
BUILDING DOCK 1
BERTH 6
BERTH 5
BERTH 4
BERTH 3
BERTH 1
BERTH 2
BERTH 8
FLOATING DRY DOCK
BERTH 9
BERTH 10
PLATE STORAGE
GATE 14
BERTH 11
BERTH 12
GATE 20
SAN DIEGO BAY
N

DIAGRAM 4

4.5. CONSTRAINTS DUE TO MATERIAL MIX (CuNi Vs. Steel)

Through the surveys of other pipe fabrication facilities it was observed that each varied in its approach to the mix of CuNi and steel within the pipe fabrication system. To have a separate facility to exclusively build copper-nickel seemed ideal for some; however, depending on the type of construction, (Navy vs. Commercial) the percentage of CuNi vs. Steel can vary greatly.

Currently less Cuni pipe is used in commercial systems compared to that of Navy work. With an influx of commercial work, it seems important for a fabricating pipe shop to be flexible enough to build pipe systems of any material mix at almost any work station within the shop. All of the shipyards surveyed have increased in the amount of CuNi pipe and other alloy systems used for Navy ships contracts. Several of the other shops batch the CuNi pipe and send it down the floor in groups. This is the approach that NASSCO applies. However, NASSCO realized that the idea of dedicated process lanes would improve the overall efficiency and the through-put of the final product.

Through further study it was concluded that the most important segregating criteria was not as much the material type, since most cutting, bending, beveling and welding systems can handle any given metallic pipe for a given size range. Automatic machines usually are capable of handling any ferrous type metallic piping, and non-ferrous piping is usually joined through brazing. The most important factor for NASSCO to separate the fabrication process into sub-lanes was found to be the size or diameter of the pipe. Most of the tooling, and machinery, ie. (benders) are generally configured to handle either large or small pipes, but not the entire size range. The break-point in the process was considered at 3 inches and below. This constituted approximately 65 percent of the total workload through the shop based on current Navy and commercial contracts.

NASSCO's approach to adding an additional 3 inch and below fabrication area was to use an existing area adjacent to the main shop which is currently used for high rack storage of large fittings. Detailed discussion of the proposed pipe shop annex and main pipe shop rearrangement is further outlined in this section. It is expected that these proposed changes and the projects already implemented will be a significant factor in creating a true “Flexible Pipe Shop Fabrication System.”

5.0. NASSCO MAIN PIPE SHOP

Improving a shop’s layout, material flow and material handling is the key to minimizing through time, ie. the time required for a pipe spool to pass through shop and enter the next phase of construction.

5.1. CURRENT LAYOUT (See Diagram # 5)

Within the main pipe shop there are approximately 20,900 square feet of total area for supporting the fabrication of pipe. This does not include the additional areas which exist for storage, treatment, testing and palletizing. The unit modular assembly area is in front on the main pipe shop and at the ends of two adjacent platens. The storage facility and automatic cutting systems are at the north side of the shop with the bending operations at the east end. Approximately (30) work stations and (8) weld out stations comprise the center two lanes through the entire shop. An area set-up for the weld school and its classes is adjacent to the shop floor production offices. Adjacent to the main fabrication lane is also a specialty area for cutting gaskets and Class (1) pipe fabrication. Class (1) pipe refers to critical piping systems that require 100 percent weld assurance. The main fittings storage area and parts receiving is located in the center areas adjacent to the tool check out area. In a totally separated area adjacent to the main shop there. is an area primarily used for high pack storage, hose testing, pipe sub-assembly, and batch fabrication.

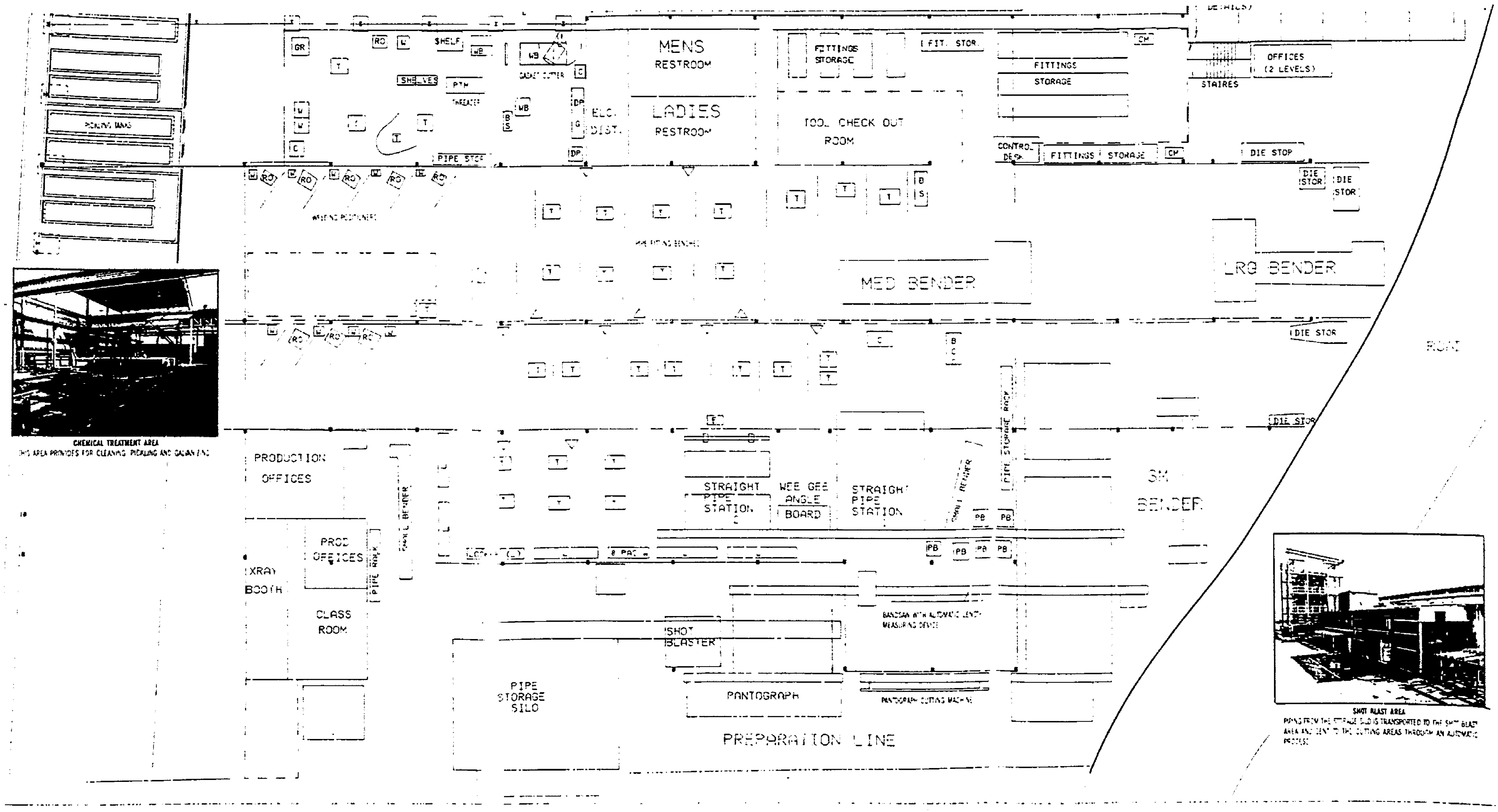
5.2. CURRENT MATERIAL FIOW THROUGH SHOP (See Diagrams # 6 & 7)

The current process flow lane for the NASSCO pipe shop is as follows:

Raw pipe material is delivered from the main steel yard via a flat bed trailer in batches and off loaded. It is stored either in the pipe silo system or in outside storage racks. This includes all pipe materials 3/4 inches and above. Pipe 3/4 inches and below is field run and stored in other areas outside of the shop. The pipe is then moved through an automatic conveyor system through the blasting, and manual \ flame cutting systems. Prior to the semi-automatic end prep station the pipe advances to a series of tables or is placed in baskets unbeveled. The fitters are then responsible for retrieving their own pipe from these tables, unless bending is required.

If bending is required then the fitter would retrieve his bent pipe from various bend storage areas after the bending operation.
The fitter then goes to the fittings storage control desk to pick-up the shop kitted fittings, again leaving his work station. The new process flow allows for the pre-kitted fittings and cut pipe to be delivered to the fitters' bench thus making it easier to control the work areas. The old process called for each fitter to bevel his own pipe through grinding.

Upon spool fit-up the pipe is then placed in a roll out station by the fitter, welded by the welder and in many cases retrieved by the same fitter for additional fit-up. This multi-handling is a major factor in "lost or unapplied" time on the job due to the delay between the fitters need and the welders availability. In an effort to decrease the non-value added tasks, the pipe shop proposed a new layout. The proposed layout points to creating a work center for the fitter, providing him with all the elements to fit piping systems with a minimal amount of movement outside of his area. Upon leaving final weld-out the pipe leaves the shop and then enters a series of operations, ie. treatment, blast and paint storage, on unit (modular assembly), on block or on board.



CHEMICAL TREATMENT AREA
THIS AREA PROVIDES FOR CLEANING, PICKLING AND GALVANIZING

SHOT BLAST AREA
PIPING FROM THE STORAGE SILO IS TRANSPORTED TO THE SHOT BLAST AREA AND SENT TO THE CUTTING AREAS THROUGH AN AUTOMATIC PROCESS

LEGEND FOR PIPE SHOP EQUIPMENT

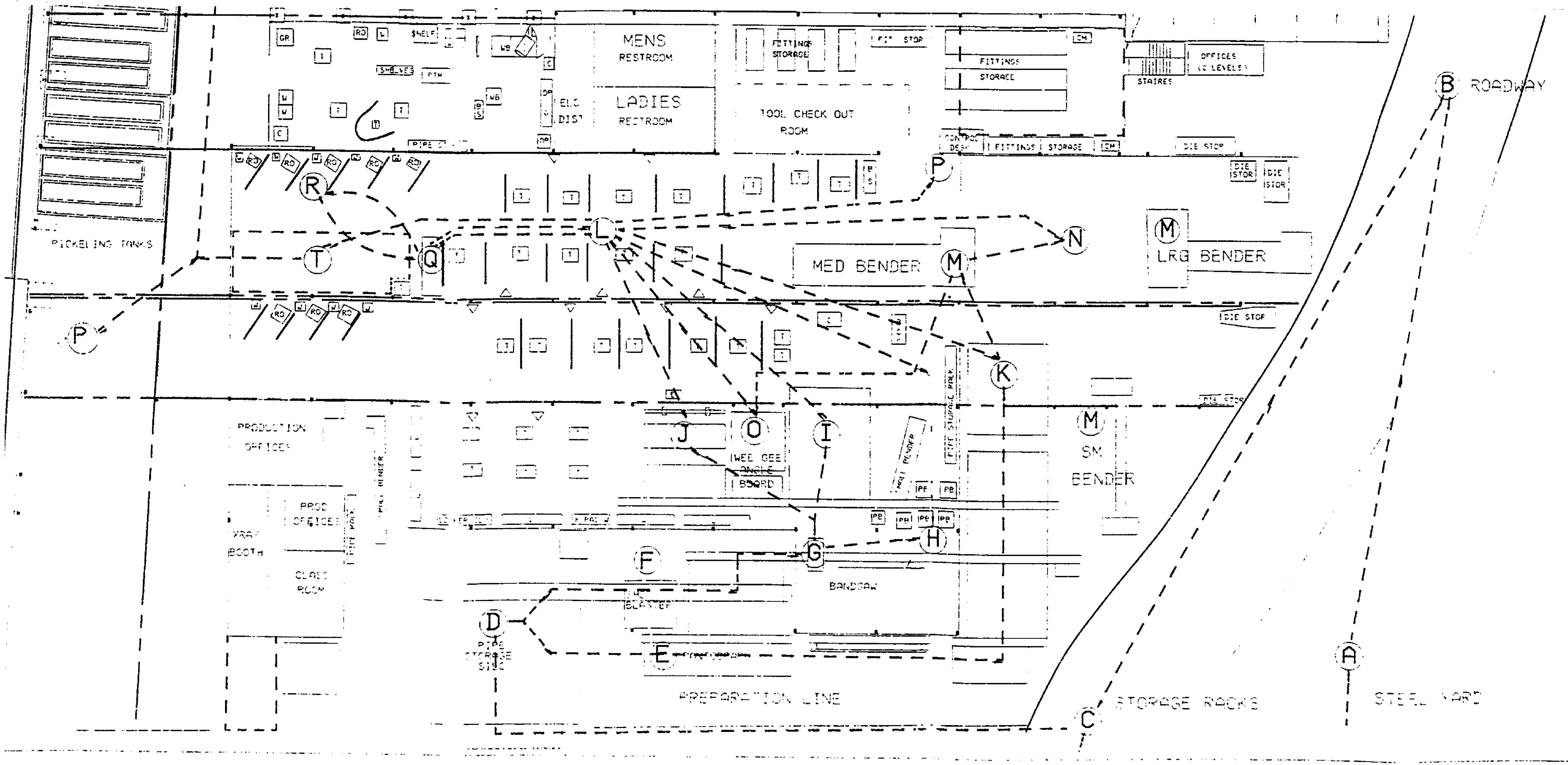
NOMENCLATURE	
BS	BANDSAW
C	CABINET
CM	COKE MACHINE & CANDY MACHINE
D	DRILL PRESS
E	EXTRUSION
G	GRINDER
PB	PIPE BINS
PTM	PIPE THREAD MACHINE
PSR	PIPE STORAGE RACK
RO	ROLL OUT MACHINE
S	SHELF
SR	STORAGE RACK
T	TABLE
W	WELDER
WB	WORK BENCH

PIPE SHOP LAYOUT

DRAWN BY: D. CLARKSON
DATE: 8/30/91
NO. DESCRIPTION
SCALE:

NATIONAL STEEL & SHIPBUIL
SAN DIEGO, CALF.

DIAGRAM 5



NOMENCLATURE		
BS	BANDSAW	
C	CABINET	
CM	COKE MACHINE & CANDY MACHINE	
D	DRILL PRESS	
E	EXTRUSION	
G	GRINDER	
PB	PIPE BINS	
PTM	PIPE THREAD MACHINE	
PSR	PIPE STORAGE RACK	
RC	ROLL OUT MACHINE	
S	SHELF	
SR	STORAGE RACK	
T	TABLE or BENCH	
W	WELDER	
WB	WORK BENCH	

PIPE SHOP LAYOUT

TYPICAL FLOW

DRAWN BY D. CLARKSON

DATE 2/30/91

NO. NSRP 05 DESCRIPTION

SCALE REVISIONS B

NATIONAL STEEL & SHIPBUIL
SAN DIEGO, CALF.

 DIAGRAM 6

CURRENT PROCESS FLOW LANES
FOR THE NASSCO PIPE SHOP

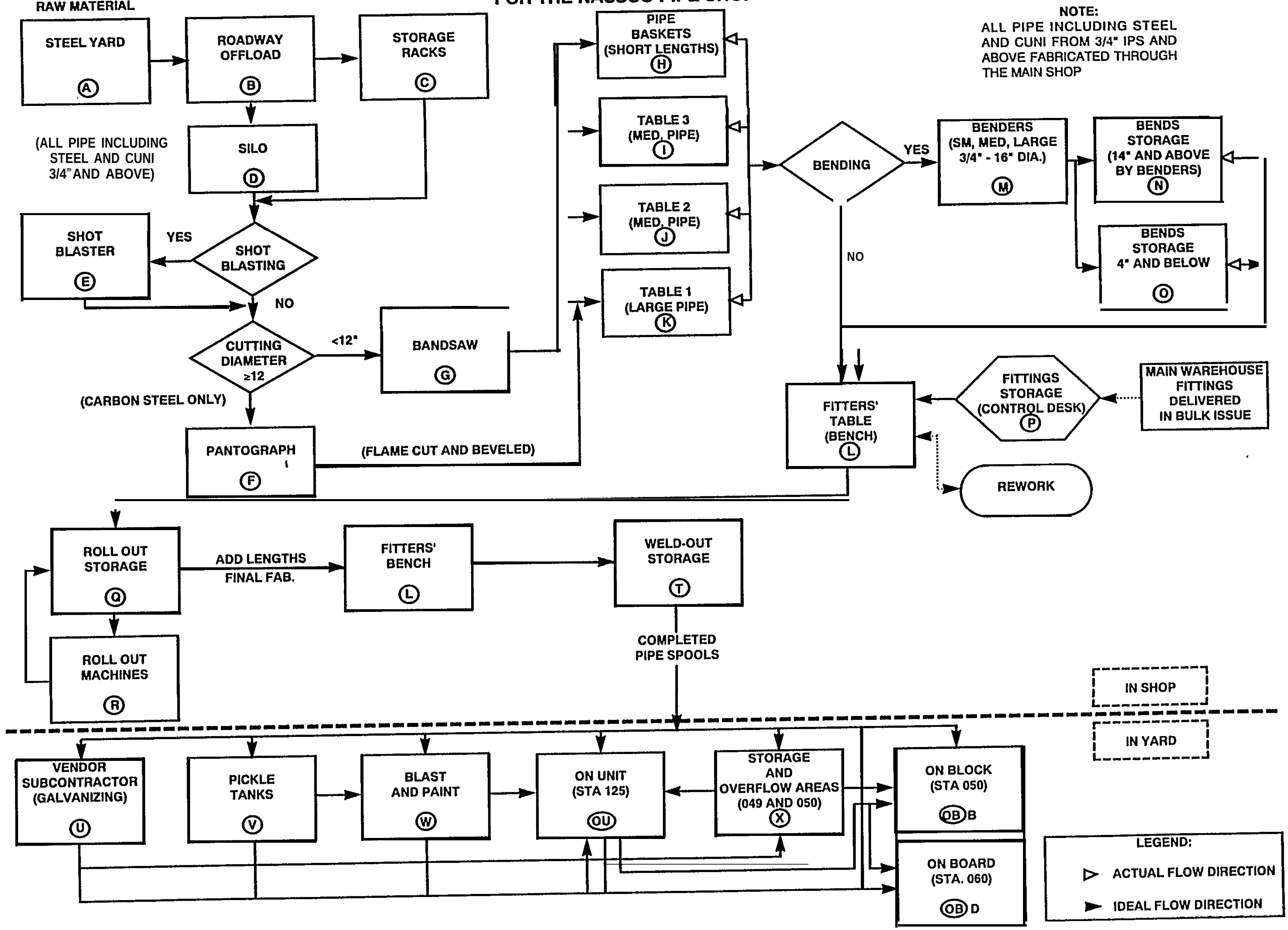


DIAGRAM 7

5.3. PROPOSED LAYOUT (Current and Proposed) (See Diagram # 8)

After studying the current layout in detail, several improvements were viewed as necessary. These areas of improvement included the following:

- o Creation of another process lane to improve the pipe shop’s flexibility and its overall through-put.
- 0 Increase planning efforts to organize and chart the complete process.
- 0 Reduction of in-house storage of material and fittings
- o Equipment movement-promoting single directional flow vs. the current multi-directional flow
- o Addition of areas dedicated to pipe end-preparation
- o Relocation of activities into areas of similar or like work
- o Reduce “non-value added” tasks to minimum.

5.4. PROPOSED MATERIAL FLOW

5.4.1. Dedicated Process Lane

NASSCO's approach to the creation of a dedicated process lane was to divide the process by the size of pipe. All the pipes equal to or less than 3" in size are to be routed to the storage annex area. The annex area will be developed to handle the complete process of storage / retrieval, cutting, preparation, bending, fitting, and welding for all pipes within the designated size range. This will also open up the main shop for a less congested operation to process all the pipes which are larger than 3" in size (See Diagram #9, Main Pipe Shop).

5.4.2. Increased Planning efforts

Diagram #10 shows a flow chart of N0ASSCO's planning efforts to reduce the “non-Value Added” tasks and create an organized system by which several departments join hands and coordinate to ensure the complete process can be accomplished as efficiently as is possible.

5.4.3. Reduction of in-house storage of materials and fittings

(See Diagram # 11, High Rack Storage). The reduction in storage can be accomplished by assuming a just-in-time delivery philosophy. This is achieved by pre-kitting spool fittings at the warehouse before they get to the shop. This eliminates the surplus fittings currently stored in the shop providing additional area to support pipe fabrication. The overall storage of fittings with this plan can be reduced by two thirds.

5.4.4. Equipment movement promoting single directional versus current multi-directional flow.

In order to reduce delays and multiple handling, the right equipment and tools need to be accessible and in the right location. Ey applying the work center approach of outfitting the citter and welder with everything required to accomplish the work, delays are reduced.

Additionally, creating the small pipe process lane as well as re-arranging some of the work stations in the main shop also assists in promoting the single directional flow.

5.4.5. Addition of areas dedicated to end-preparation

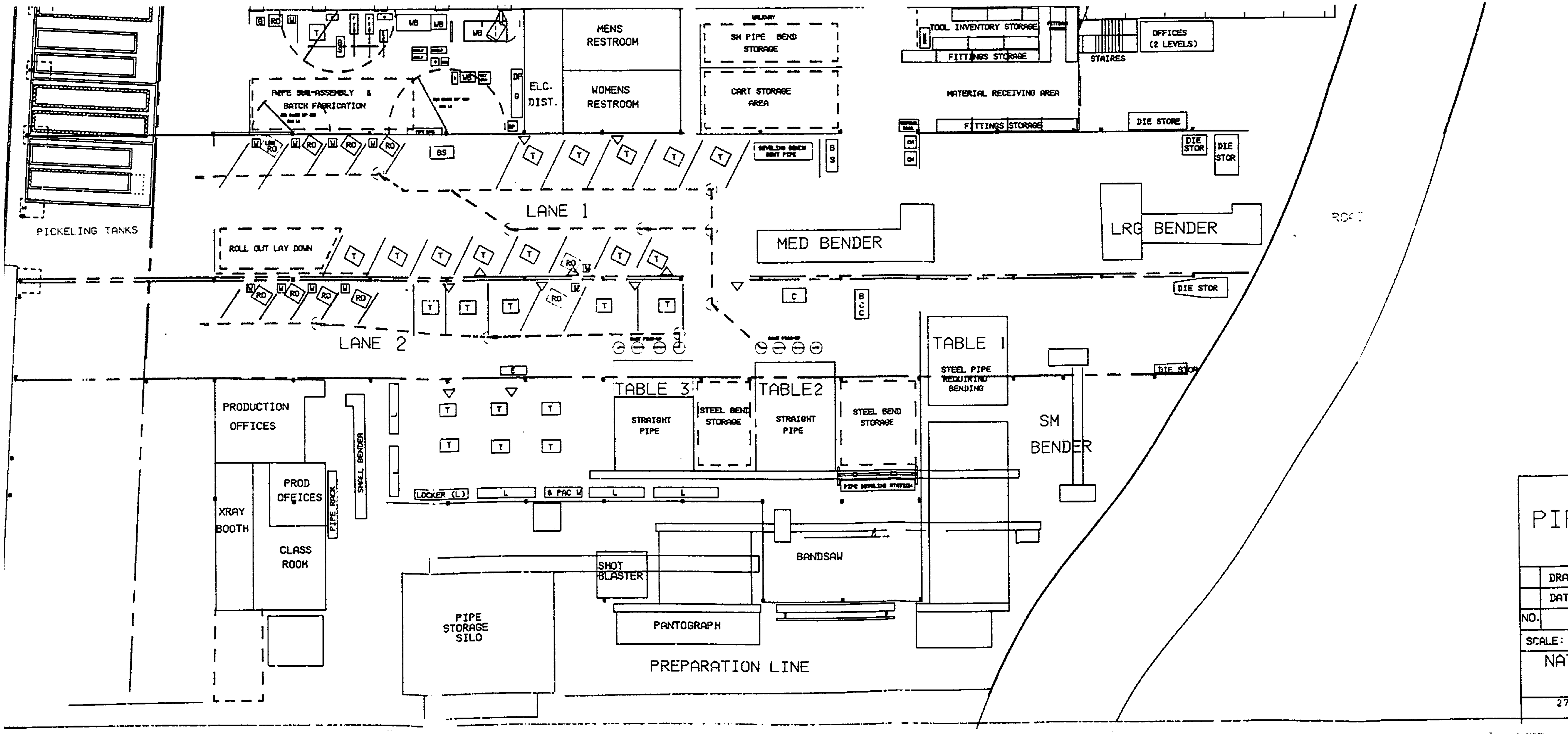
A new semi-automated end prep station has been installed between tables (1) and (2). The system uses two (2) portable end-prep machines which bevel, face and counter bore pipe. A second beveling station is proposed for installation to be used for bent pipe. The new station however, is capable of beveling bent pipe as well as fittings and flanges. This area was a primary focus and is more fully outlined in Section 7.2, Semi-Automatic End Prep Station.

5.4.6. Relocation of activities into areas of similar or like work

The pipe sub-assembly and batch fabrication area is to be relocated from the proposed annex area to the existing gasket cutting and pipe threading area. This will consolidate the batch fabricated components into the same area within the main shop.

The steel bend storage areas are to be relocated adjacent to tables (2) and (3) and placed on the carts for movement to each of the fit-up stations.

PROPOSED LAYOUT AND TYPICAL FLOW



NOMENCLATURE

BS	BANDSAW
C	CABINET
CM	COKE MACHINE & CANDY MACHINE
D	DRILL PRESS
E	EXTRUSION
G	GRINDER
PB	PIPE BINS
PTM	PIPE THREAD MACHINE
PSR	PIPE STORAGE RACK
RO	ROLL OUT MACHINE
S	SHELF
SR	STORAGE RACK
T	TABLE
W	WELDER
WB	WORK BENCH

PIPE SHOP LAYOUT
IDEAL LAYOUT

DRAWN BY: D. CLARKSON

DATE: 1/7/92

NO. | DESCRIPTION

SCALE: ______ REVISIONS: C

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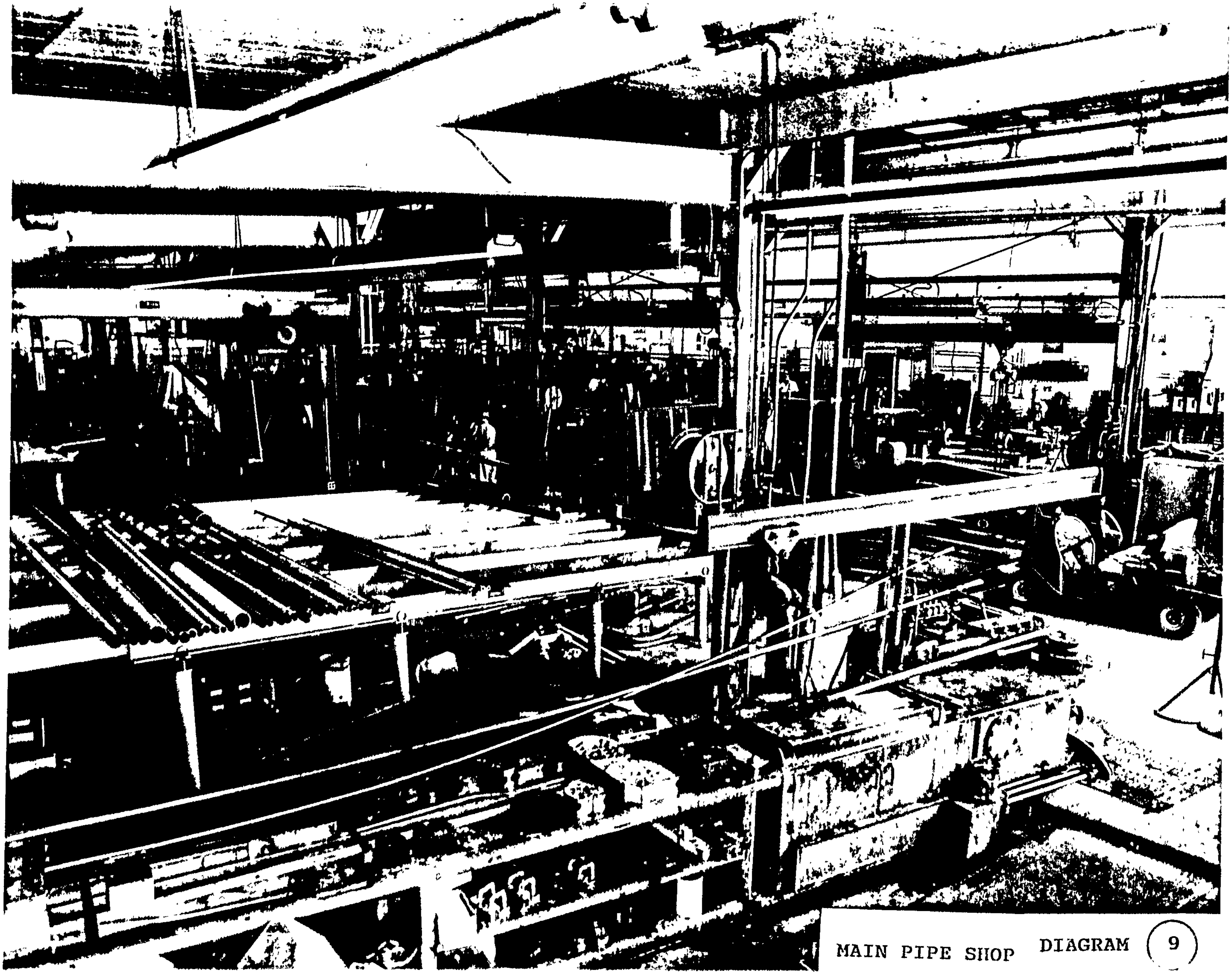
27 DIAGRAM 8



MAIN PIPE SHOP DIAGRAM (9)

6.0. NASSCO PIPE SHOP ANNEX (Current and Proposed)

6.1. GENERAL INFORMATION

Nesting is a method used to systematically classify pipe pieces into groups or families having similar design and manufacturing attributes. Nesting allows for batching these similar groups for fabrication. This process is known as Pipe Piece Family Manufacturing. These similarities for pipe include such factors as size, material type complexity of spool, joint designs, etc.

The goal for selecting these families and planning their routes is to utilize production line principles. A production line frees the workers from having to plan out their sequence for each pipe piece so they can instead concentrate on executing normal and consistent work methods and processes.

NASSCO'S extensive planning efforts also includes utilization of nesting technology to create a production line. This has improved the production rate tremendously. NASSCO'S plan for the new annex also includes a more computerized use of this technology.

6.2. CURRENT LAYOUT

The size of pipe and its fabrication was considered to be the most important factor requiring NASSCO to separate the fabrication process into separate sub-lanes for small and large pipes. Excluding field run pipe 3/4 inches and below, pipes 3 inches and below make up about 65 percent of the total workload through the shop. This is based on current Navy and Commercial contracts and is expected to be even greater with an increase in commercial contracts.

NASSCO's approach to adding an additional 3 inch and below fabrication area is to use an existing area adjacent to the main shop. The existing paint booth in that area will be removed and the area will be turned into a fabrication lane for all pipes 3 inches in diameter and below. (Excluding field run). This area will include (14) new work benches, (5) roll-out machines, and (17) portable multi process welding machines. A new 3 inch and below 2-D bender will also be placed in the annex with an existing relocated, small bender. This will free up the present flow lanes in the main shop for large pipe (See Diagram # 12 & 13).

Small carts will be used in the main shop and annex. The MST'S will provide the materials directly to the fitter, rather than having the fitter go to various places in the shop to get his material. This will also be important in increasing the production rate (spools/week) because a lot of time is spent by the fitter in trying to get all the material he requires to build a spool.
The new annex will improve the material flow in the main pipe shop

and will be fully equipped to handle the multiple mix of pipe (See Diagram # 14).

The proposed annex area however is currently used for high rack storage of fittings and is housed by an enclosed paint booth. Relocation of existing activities an-d consolidation of storage within this area are the first steps in preparing the new facility (See Diagram # 15 & 16).

6.3. REARRANGEMENT

Relocation of the existing activities and consolidation of storage areas include:

6.3.1. HOSE TESTING STATION

This station to be moved adjacent to the hydro test and flushing area to consolidate like processes.

400 SqFt

6.3.2. PIPE SUB ASSEMBLY AND BATCH FABRICATION

This activity which fabricates specialty components and assemblies to be relocated into the reorganized gasket and threading area in the main shop.

(a) Sub-assembly fabrication area	1,000 SqFt
(b) Sub-assembly storage	2,000 SqFt

6.3.3. HIGH RACK STORAGE

This area includes all storage of ship board items or large pipe fittings. Some of the storage of all weather items to be stored outside with the bulk sent back to the warehouse. Material would be delivered using the just-in-time approach. 2,000 SqFt

6.3.4. ADDITIONAL WELD UP AREA AND STORAGE 3,000 SqFt

THE TOTAL ARE AVAILABLE FOR ANNEX Total: 8,400 SqFt

PIPE FABRICATION AND MATERIAL ACQUISITION

ENGINEERING:

1) Draw Spool Sheets from Design Drawings
2) Spooler. with support of Pipe Shop Liaison make up Spool Take Off Books
3) Bill of Material inputs Material Requirements into Mainframe

MATERIAL CONTROL/PURCHASING:

1) Takes Information from Mainframe
2) Requisitions Material
3) Orders Material from Requisitions

PALLET PLANNING:

1) Issues Detailed Work Pallets or Packages which Specify Spools and Work Schedule for all Stages of Construction

RECEIVING/WAREHOUSE:

1) Inspects Material Received
2) Sends Material for Storage
3) Warehouse Pre-Kits Fittings and Flanges
4) Pipe Shop MST Inspects Kits before delivery to Shop
5) Inputs Information into Mainframe

PIPE SHOP:

1) Planners
   A) Input into System
   B) Route Spools through Shop
   C) Create Schedule Files
   D) Order Books by Date
   E) Make Spool Tags
2) MST matches Spool Sheets to Kits and Stores or Delivers with Pipe to Fitters' Benches
3) Shop Floor Foreman Assigns Spool Sheets and Kits to Floor
4) Operators
   A) Cut Pipe
   B) Bevel/End Prep Pipe
   C) Bend Pipe (2D, 3D, and 5D)
   D) Store Pipe in In-Process Storage Areas
5) Pipe Fitters/Welders
   A) Assemble Pipe Spools
   B) Weld-Out
   C) Final Assembly
   D) Final Weld-Out
6) Shop Foreman inspects Spools for Accuracy
7) MST delivers Pipe to Test and Flush Station
8) Operators
   A) Hydro Test Spools
   B) Flush Pipe Systems
   C) Pallets Spools into Bins or Storage
9) Planners Update System

DIAGRAM 10

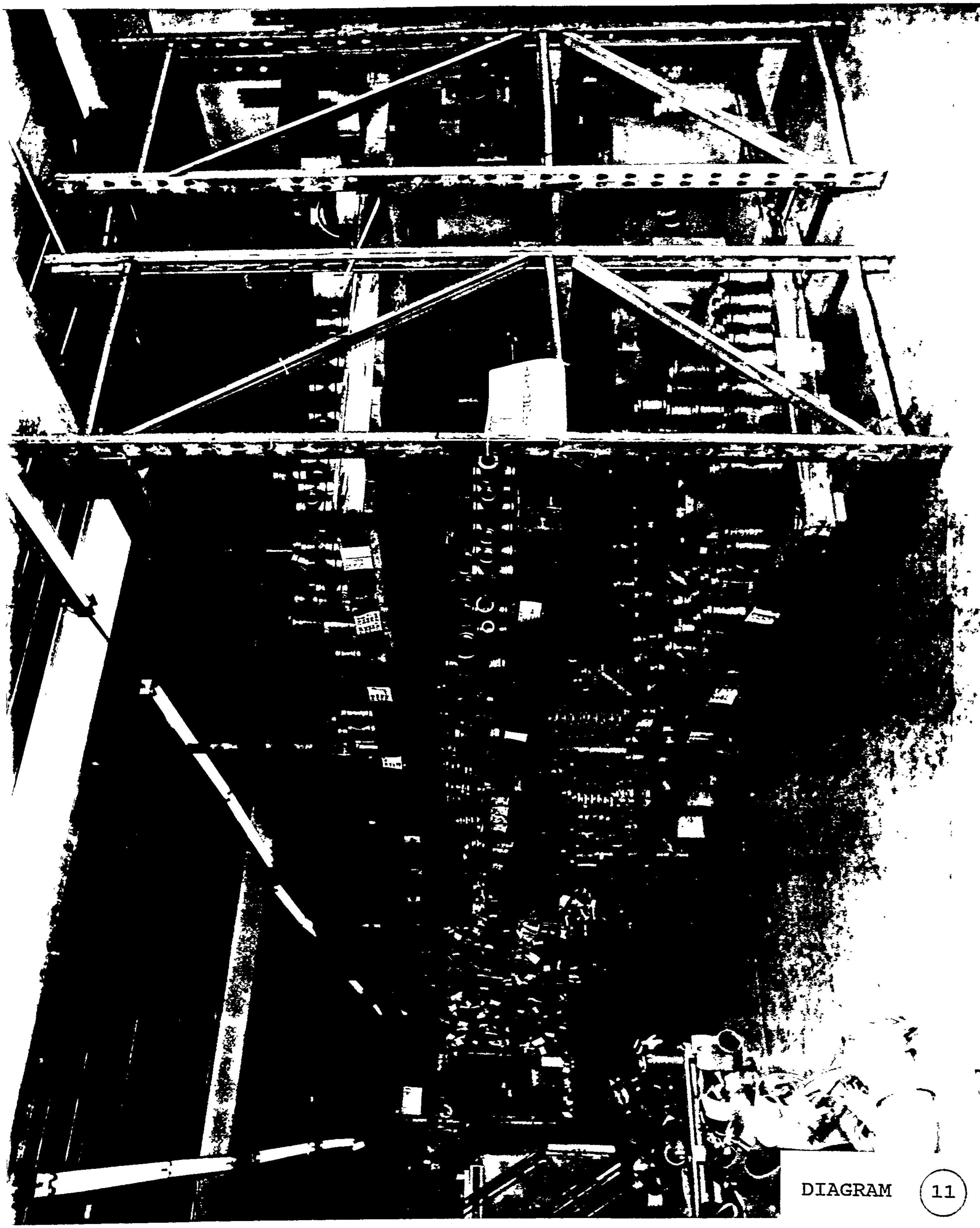


DIAGRAM (11)

6.4. PROPOSED LAYOUT and MATERIAL FLOW (See Diagram # 12)

The proposed layout for the pipe shop annex will be independent of the main shop. It will be fully outfitted with the equipment and tooling for storage, cutting, bending, beveling, fit-up, and welding of pipe spools 3 inches in diameter and below. However, the two process lanes will share one hydro test and flushing station which is located at the end of both process lanes. This station is not viewed as a bottle neck, and therefore, should not impact the overall capacity and through-put.

6.4.1. STORAGE

All raw pipes 3 inches and below is currently stored throughout the main pipe shop and at the steel yard on the opposite side of the yard. With the new annex, pipe would be stored in high racks both in and around the annex. The pipe is then delivered by overhead crane or forklift to the cutting station. A computerized pipe storage and retrieval station is also envisioned for the future.

6.4.2. CUTTING

A vertical bandsaw is to be located adjacent to the south wall. Its standard features include some of the following:

- Hydraulic auto conveyor feed
- Variable blade speed
- Twelve (12) inches capacity
- Multi index
- Piece counter
- Manual column tilt 45 degrees L and R with lock

After cutting, pipe is moved to the bending or beveling station.

6.4.3. BENDING

The bending operation will be comprised of an additional 2D bender and the relocation of an existing small pipe 3D, 5D bender.

The new 2D bender is computer controlled (CNC) with a pipe capacity of 3 inches and below. CuNi, copper, carbon steel, and stainless steel pipe can all be bent in 2-D. Because this machine has a smaller range, a minimal change out of tooling; ie. (wiper dies, fixed dies and mandrels) is required. The new bender is fully outlined in Section 7.3. After the pipe is bent, it moves on carts to the beveling station or to an in-process-storage area reserved for bends.

6.4.4. BEVELING (See Diagram # 17)

A new station is to be installed using an ID mount Tri-Tool end-prep machine with a capacity from 1 1/2 to 6 inches. For pipes smaller than 1 1/2 inches, a fixed OD clamping beveler is used. The 1 1/2 to 6 inch beveler is suspended overhead by a balancer which is adjusted in tension to just overcome the downward gravity pull. The bench at the station is set up with a chain pipe vise and removable catch basin for the shavings. The carts can be moved in place, wheels locked and jack adjusted to act as a support jack. The carts can be used throughout the process this way.

6.4.5. FIT-UP

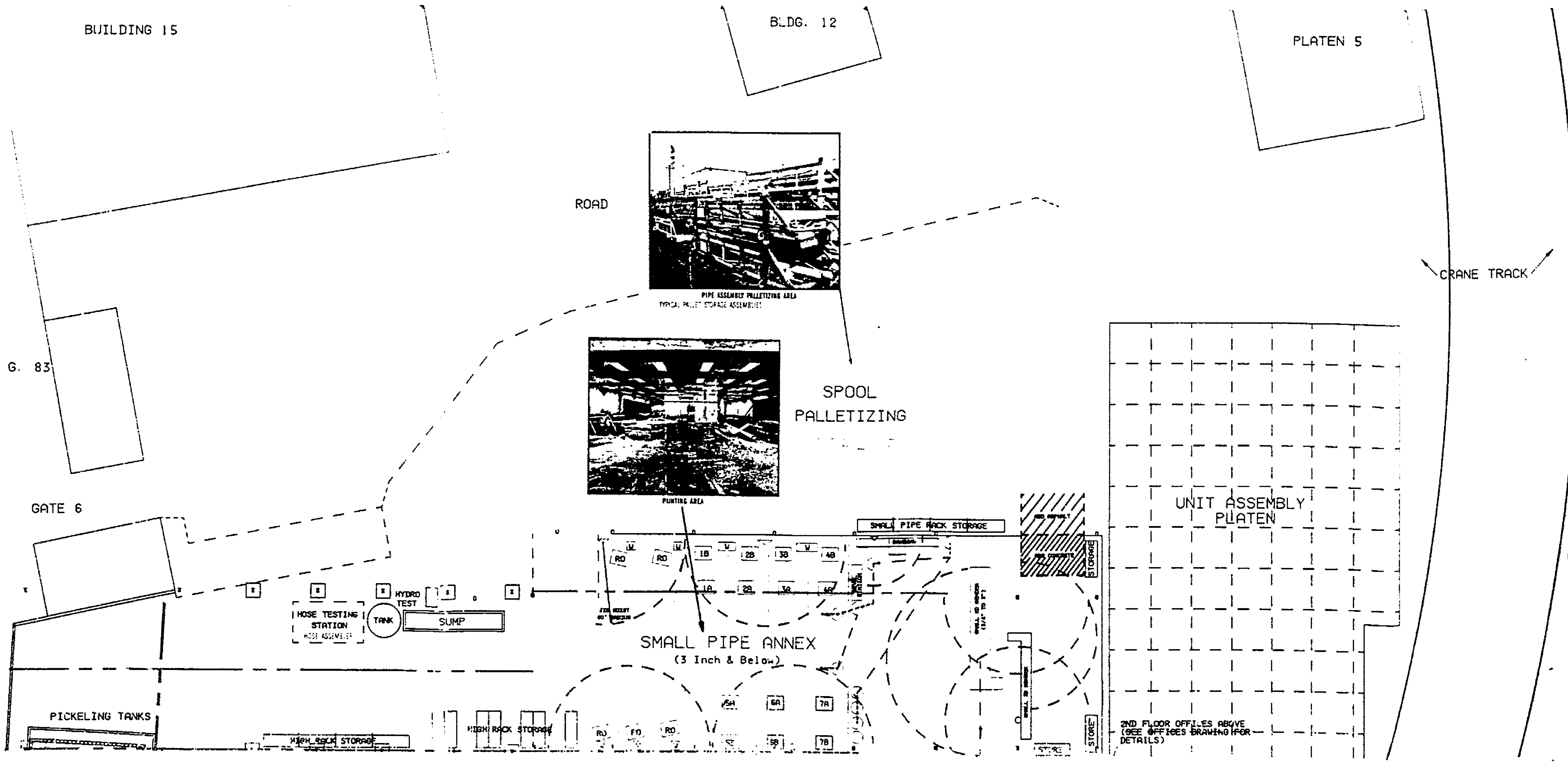
Once the pipe has been beveled it is moved to a series of (14) fit-up benches, each station is made up of (2) fit-up benches. Benches 1 (A and B) and 2 (A and B) are to be designated primarily for Class (1) critical piping systems. The other benches to be dedicated for all other systems. The pipe is then moved from the fit-up benches to the weld-out areas.

6.4.6. WELDING

The new annex is to be outfitted with two (2) 6-pack multi-ARC/multi process welding systems for the fit- up areas and five (5) individual welding units for the weld out areas. These units are small and portable. All welding leads are to be run underground. Currently the leads are run above ground and will not allow for the free movement of the carts thru the annex (See Diagram # 18). Five (5) gear driven welding positioners will also be added. Each positioner has a three (3)-jaw self-centering holding chuck with (1) to (12) inch gripping capacity and foot pedal for forward, reverse and speed control. Once through weld-Out, small pipe meets up with the large pipe from the main shop at the hydro testing and flushing station. The spools are then tested or flushed, and moved to the treatment area, and then palletized. Once palletized pipe is placed in baskets (See Diagram # 34). It is then either sent to storage, the unit area for installation into large modular pipe assemblies, or to other stages of construction.

Like the main pipe shop, material (pipe and pre-kit fittings) is delivered to the fitters bench and through the annex by the material support technicians (MST's).

The pipe shop annex material flow is shown in Diagram # 13.



PROPOSED LAYOUT AND TYPICAL FLOW

1	STORAGE
2	CUTTING STATION
3	BENDING
4	END PREP STATION
5	TRANSFER CARTS
6	FIT-UP STATIONS
7	WELDOUT STATIONS/ POSITIONERS
8	TREATMENT
9	HYDRO TEST/FLUSH STATION
10	PALLITIZATION
11	STORAGE
12	DELIVER next STAGE of CONST.

NATIONAL STEEL & SHIPBUILDING
SAN DIEGO, CALF.

PROPOSED PIPE SHOP
ANNEX
IDEAL LAYOUT

DRAWN BY: D. CLARKSON
DATE: 3/3/92
36 DIAGRAM 12 SHEET NO. A.1

IDEAL AND PROPOSED PROCESS FLOW LANES FOR THE NASSCO PIPE SHOP AND ANNEX

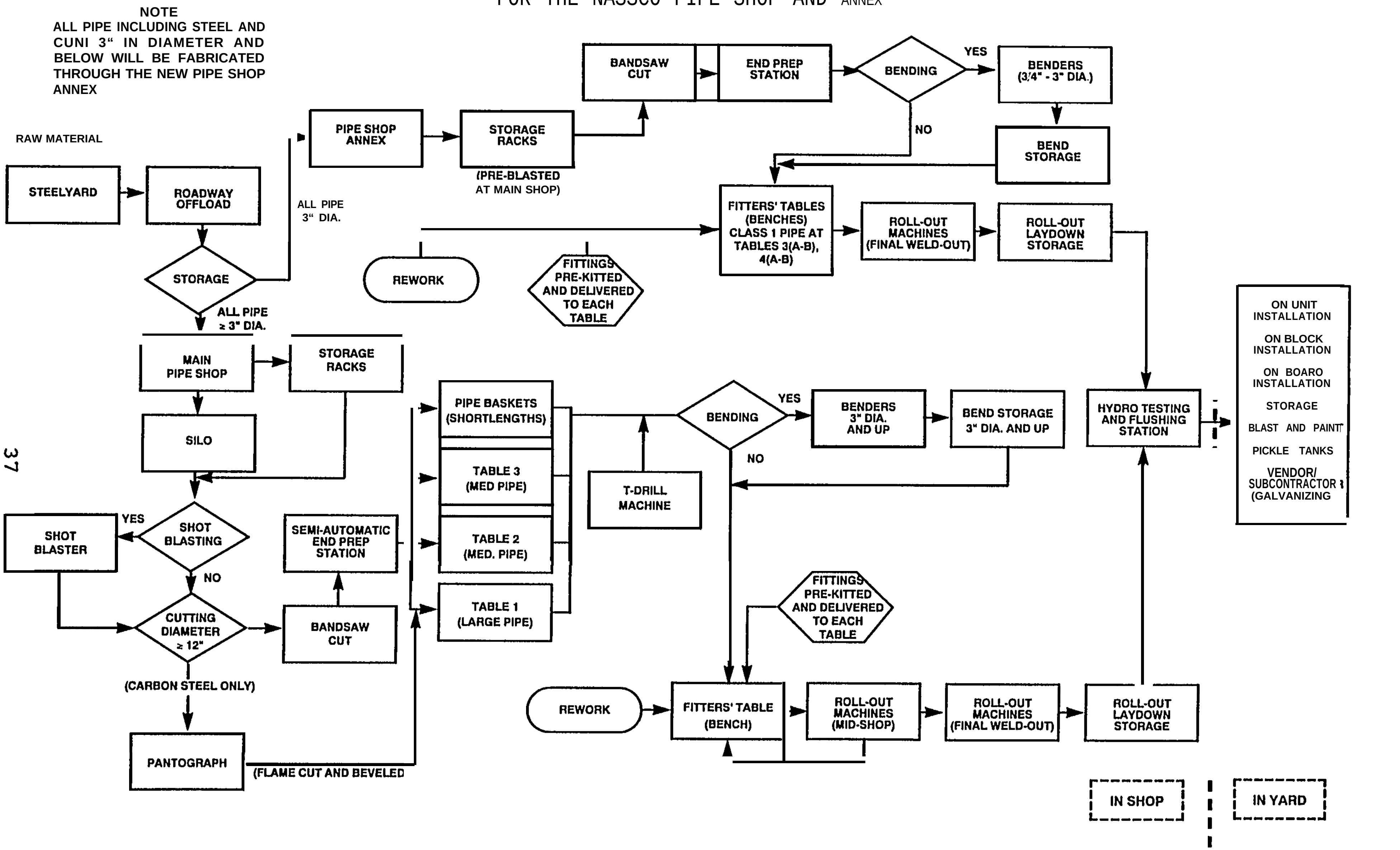


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DIAGRAM 13

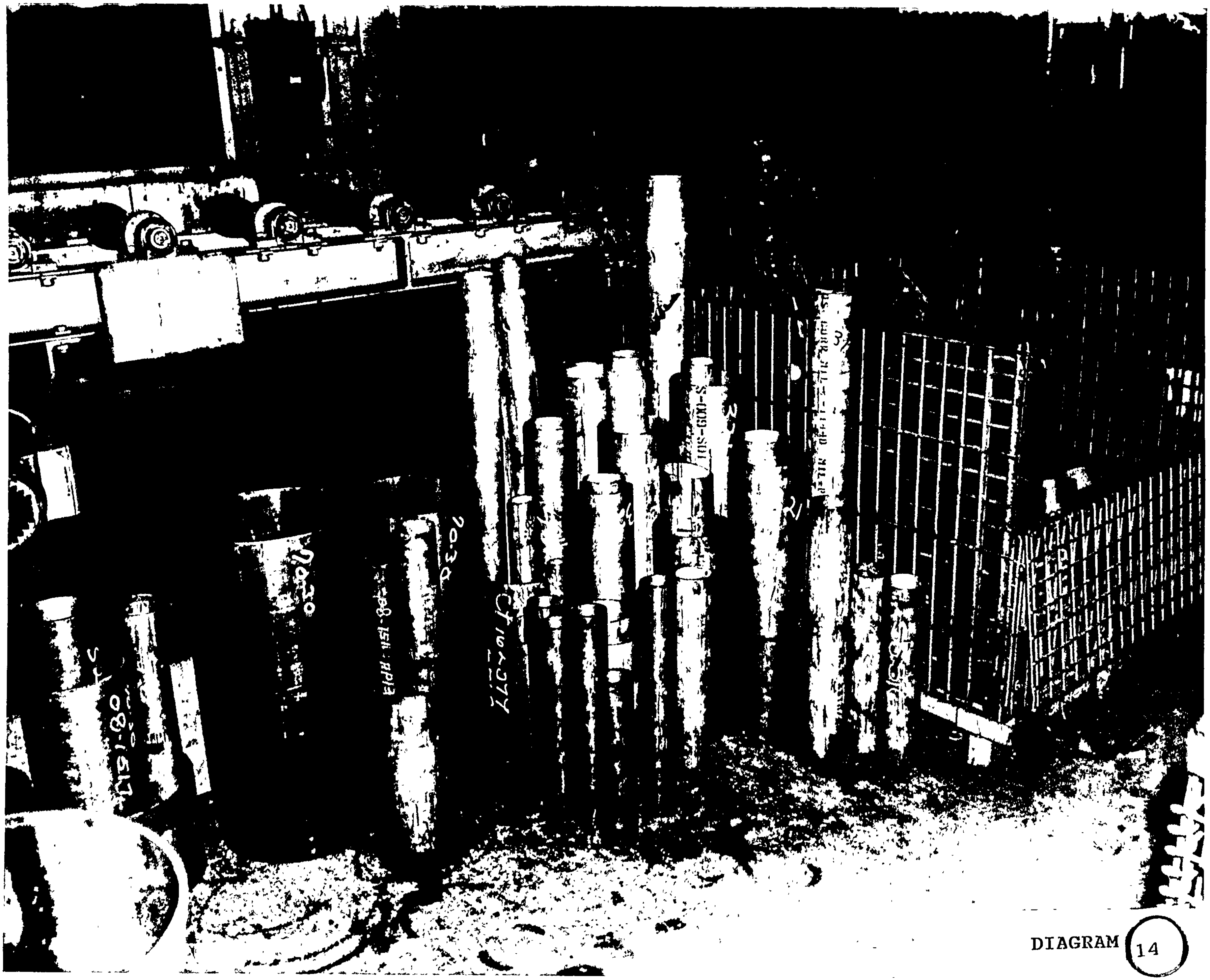
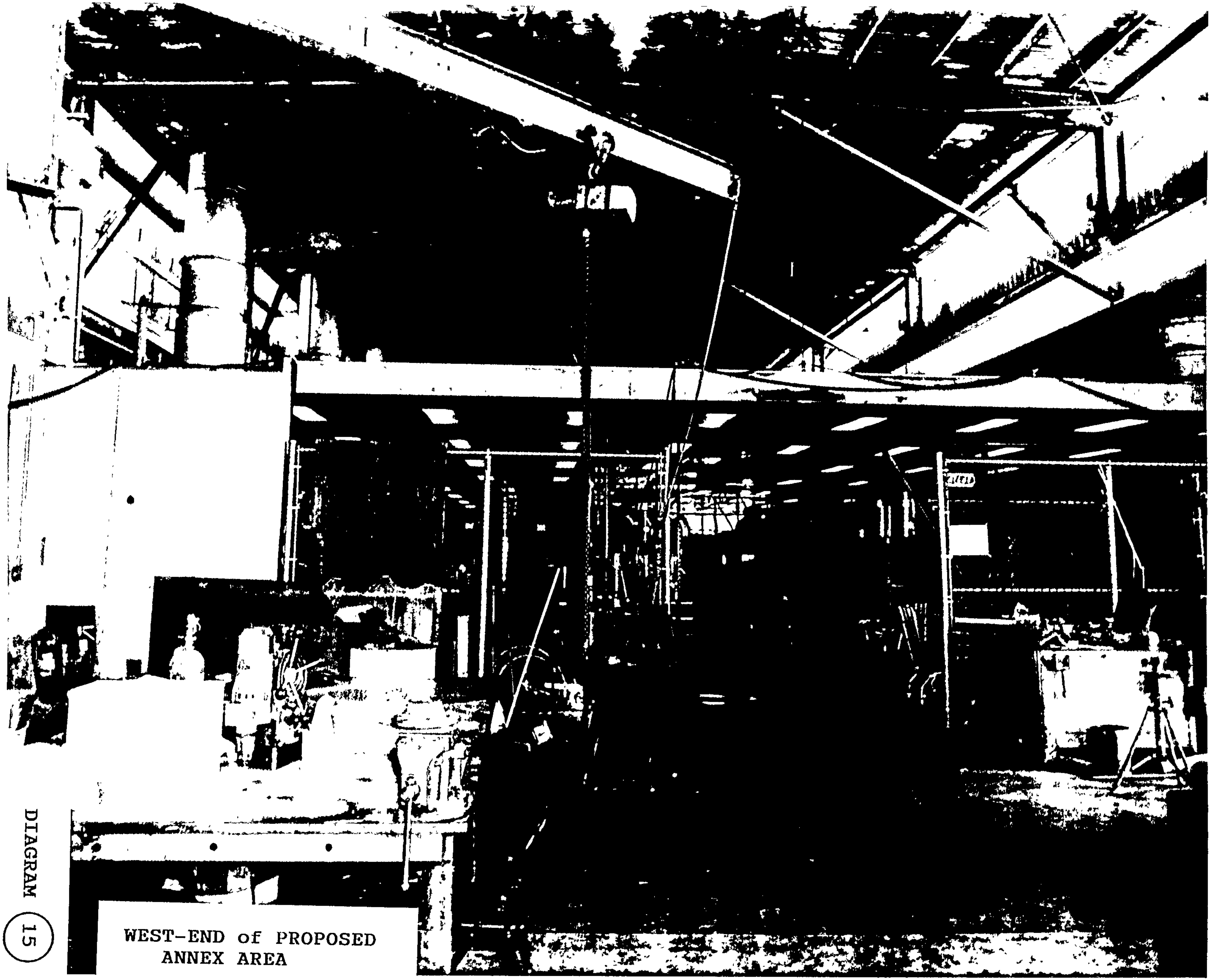
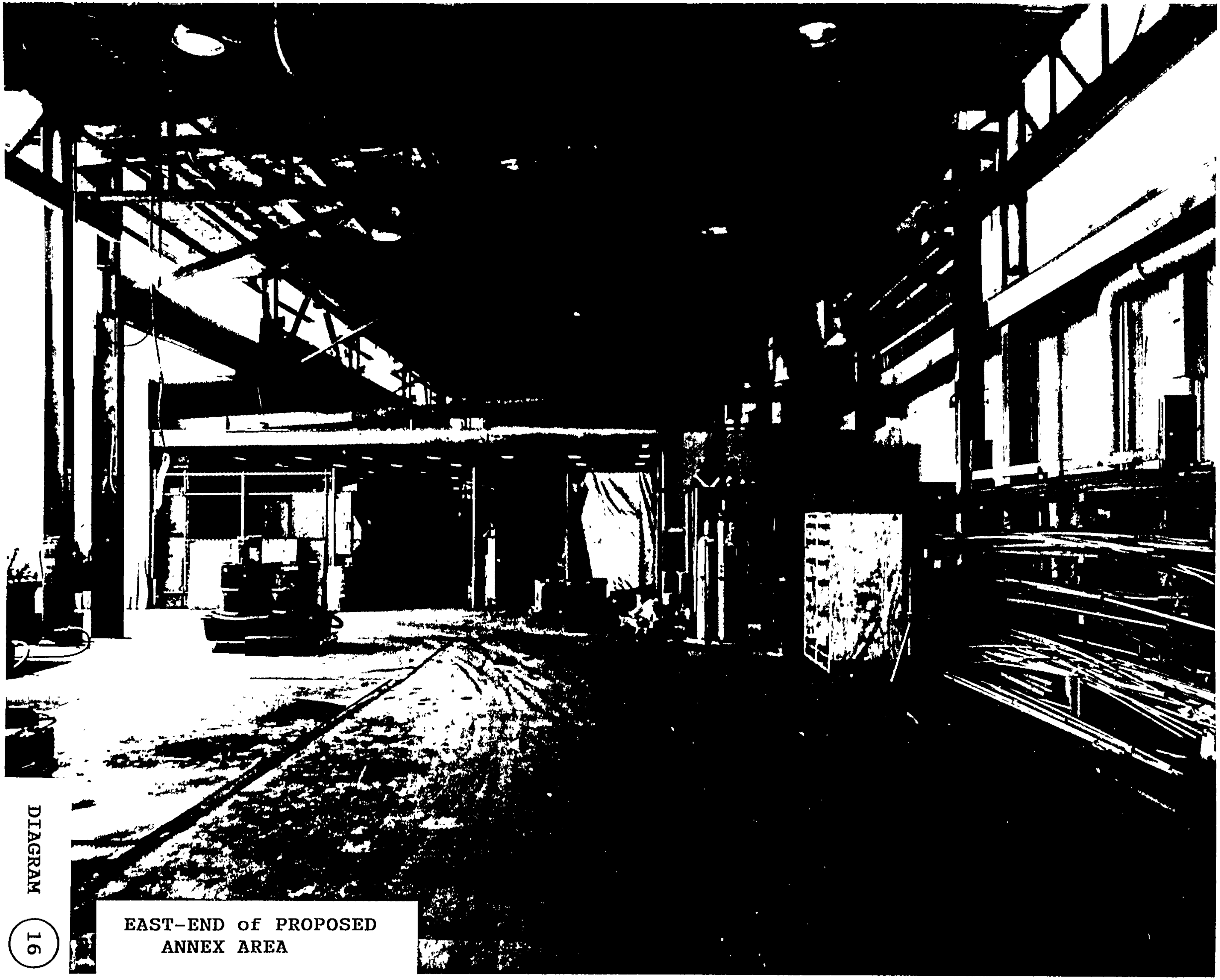


DIAGRAM 14



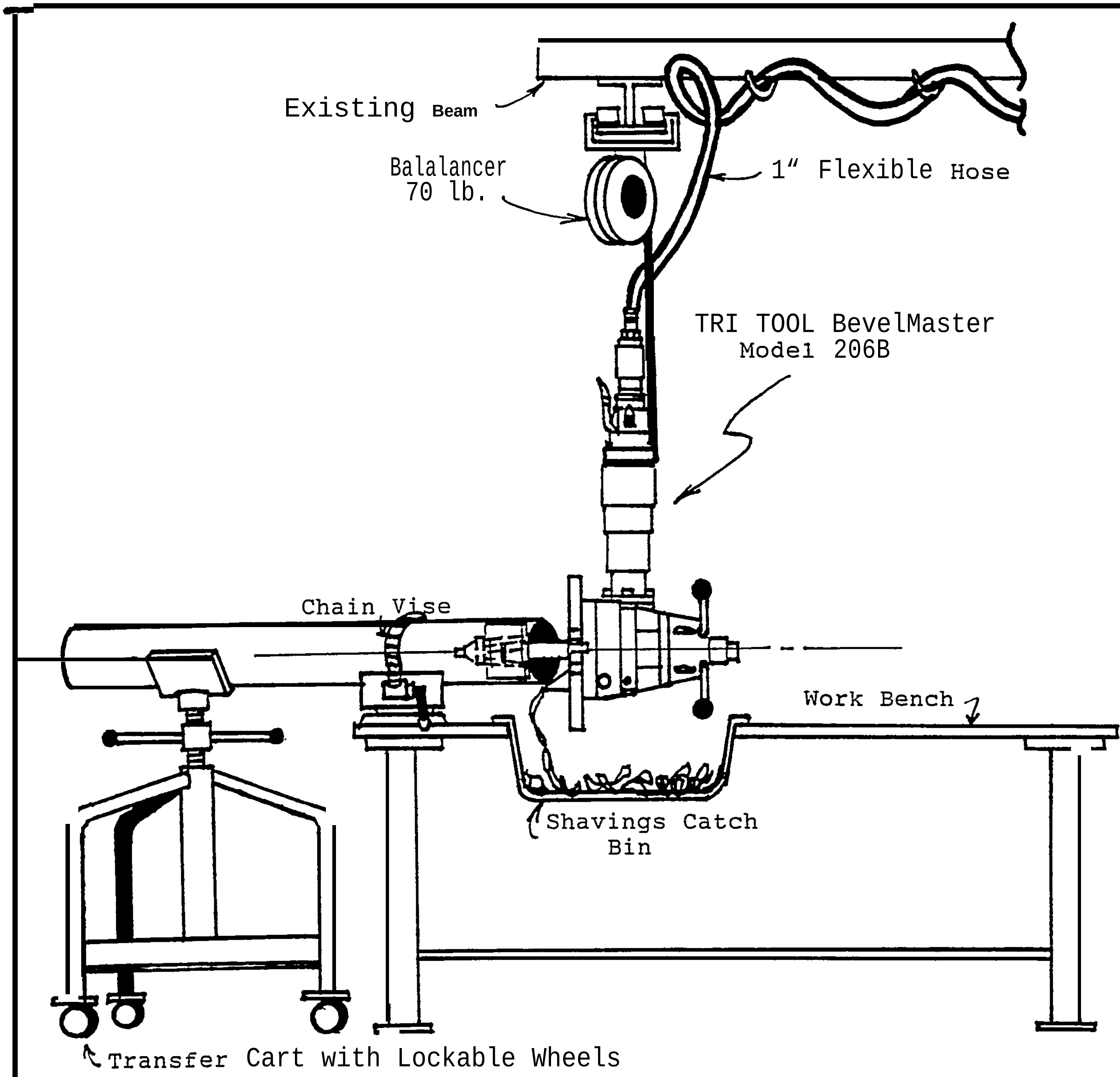
WEST-END of PROPOSED
ANNEX AREA

DIAGRAM (15)



EAST-END of PROPOSED ANNEX AREA

DIAGRAM 16



END PREP STATION
for
Proposed Pipe Shop Annex

DIAGRAM 17

CURRENT ABOVE GROUND WELDING LEADS

DIAGRAM 18

7.0. NASSCO FABRICATION METHOD IMPROVEMENTS (Current and Proposed)

7.1. GENERAL INFORMATION

In evaluating the current fabrication facility many areas were targeted for improvement. The fit up of pipe at NASSCO amounts to almost 42 percent of the total man hours required to fabricate each spool. This was one of the first areas targeted for improvement.

7.2. SEMI-AUTOMATED END PREP STATION

End preparation / beveling process was an early target for improvement. End preparation of pipe is one of the most critical steps in achieving high quality butt welding results. An accurately machined weld joint directly contributes to the final quality of the weld itself.

7.2.1. FORMER SYSTEM

The former method of end preparation and beveling had the pipe being beveled by each Pipe Fitter at his own bench. The larger steel pipes (12 inch diameter) and above is cut and beveled simultaneously on a Plasma Pantograph. The Band-Saw and not the Pantograph is used to cut thin walled CuNi and 12 inch diameter pipes and below. This is due to the distortion of the plasma flame cut and the end finishing required to clean off the slag from the plasma torch. The pipe cut on the Band-Saw was then delivered unbeveled to either Tables 1, 2, 3 or in pipe baskets by a conveyor system. The fitter then brought the pipe to his bench and manually ground or cut a bevel on his pipe (See Diagram # 19). Approximately 30 percent of each fitter's time was spent each day manually beveling, facing, counter boring and end prepping pipe and fittings.

7.2.2. NEW SYSTEM

In the new system, the new semi-automatic Bevel End Prep Station will be located on the out-put end of the Band-Saw (See Diagram # 20). The Station allows the pipe to advance through it via the existing conveyor system (See Diagram # 21). The pipe then automatically stops at the station and is lifted by pneumatic jacks thus allowing freedom of the beveling machines' rotating blades. The bevel machines are two Tri-Tool portable lathes (See Diagram # 22). They are I.D. mount machines with incline feed knobs and pneumatic driven motors at a right angle to the lathe head.

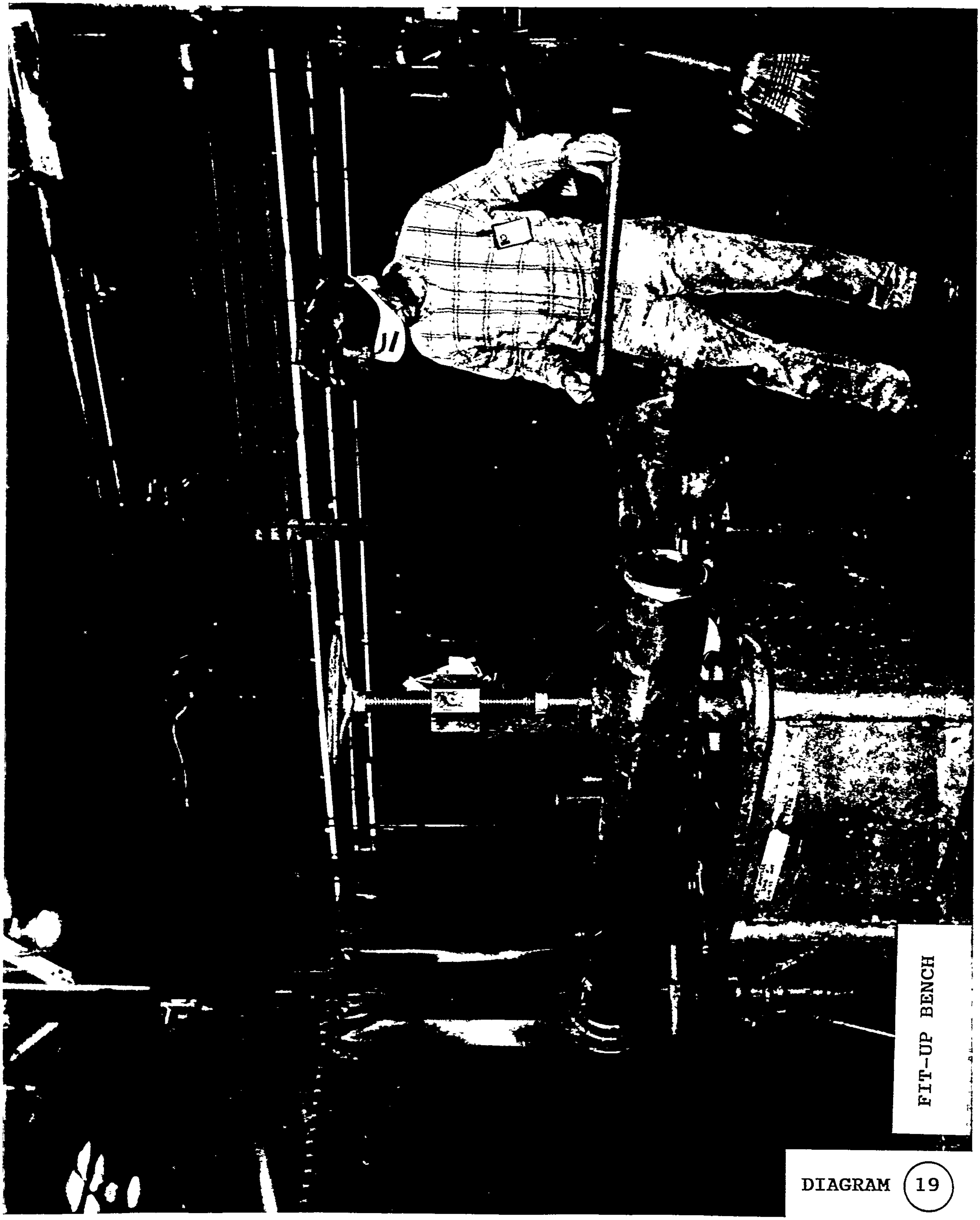


DIAGRAM 19

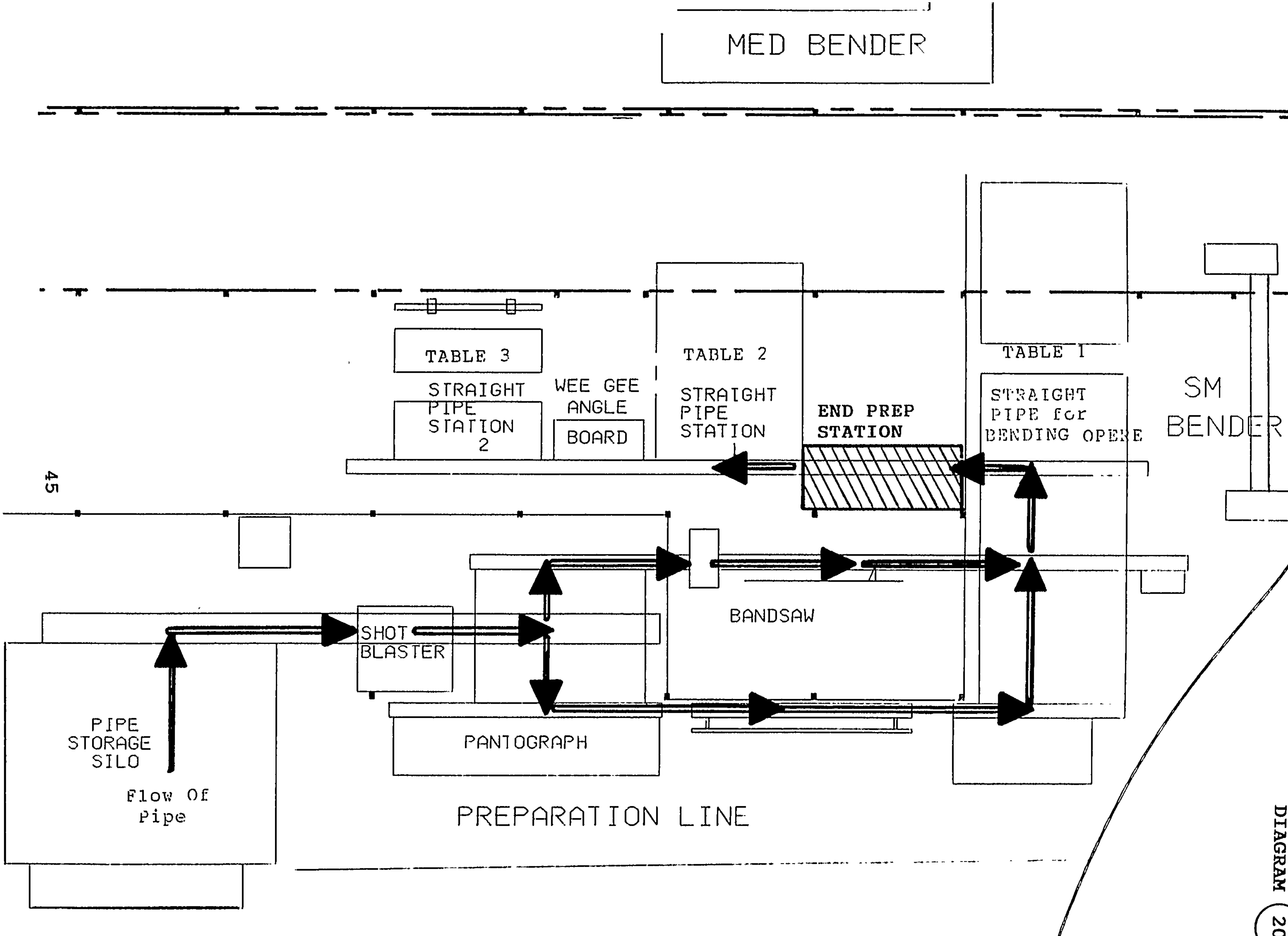
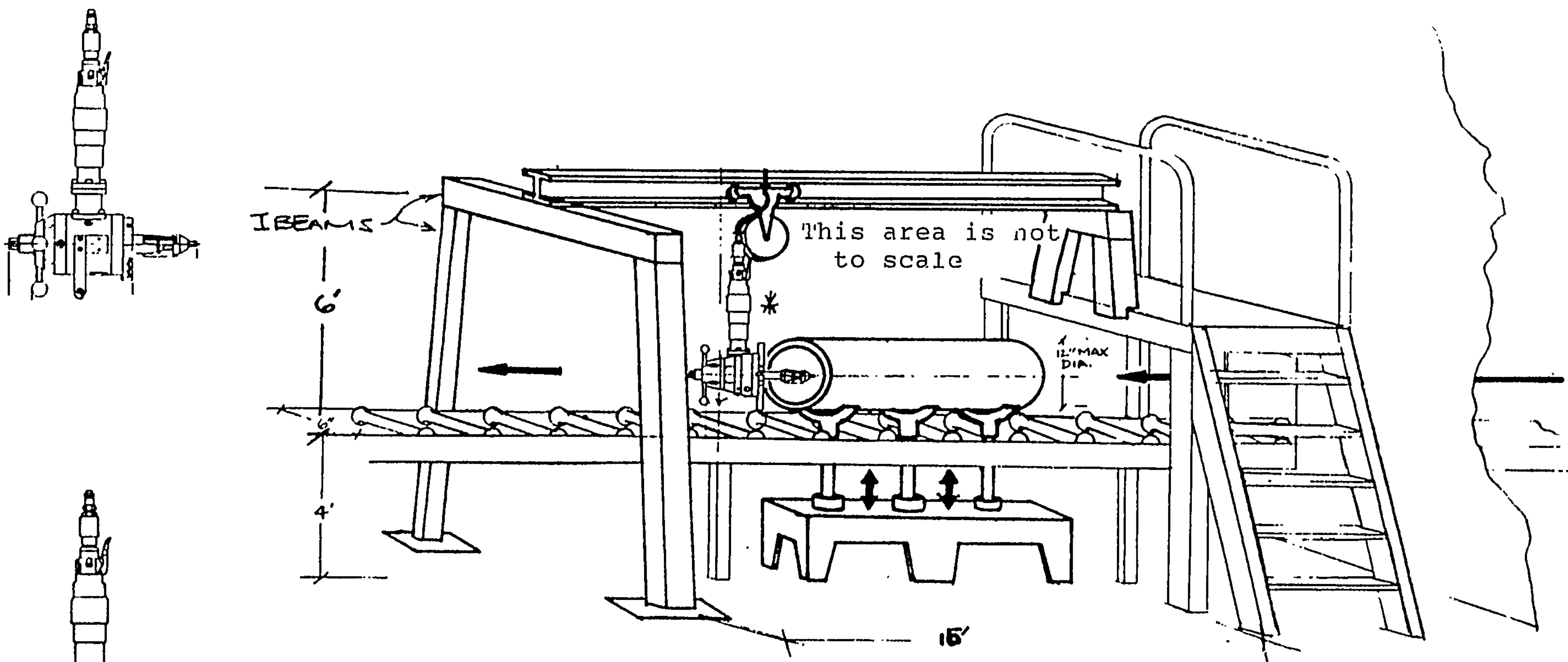

MED BENDER
TABLE 3
STRAIGHT PIPE STATION 2
WEE GEE ANGLE
BOARD
TABLE 2
STRAIGHT PIPE STATION
END PREP STATION
TABLE 1
STRAIGHT PIPE for BENDING OPERE
SM BENDER
45
SHOT BLASTER
BANDSAW
PIPE STORAGE SILO
Flow Of Pipe
PANTOGRAPH
PREPARATION LINE

DIAGRAM 20



SEMI-AUTOMATIC END PREP STATION

DIAGRAM 21

OVERVIEW of STATION and PLATFORM

DIAGRAM 22

The machines are pulled down from the overhead suspended cable balancers during operation. They are then affixed to the end of the raised pipe and ID mounted (See Diagram # 23). The tools allow for full simultaneous three function weld end preparations ie. (bevel, face and counter bore) or as separate functions.

The new system can end prep pipe pieces from 4 inches to 20 feet in length. Two independent chain-pipe vises are used to hold the smaller pipe pieces into place during the cutting process and also are used to hold fittings and flanges into place for beveling or counter boring (See Diagram # 24). The jacking system is made up of 5 pneumatic jacks operating in parallel (See Diagram # 25). The system can either operate as a one man operation or as schedule requires a two man operation. The same piece of pipe can be end prepped on both ends simultaneously or two separate pieces of pipe beveled simultaneously (See Diagram # 26). The cutting time has been reduced by over 80 percent when compared to the former process of the pipe fitters hand grinding. Fully operated by two (2) men, this system can end prep up to 1000 bevels a week.

Other fully automated European machines were evaluated and considered; however, it was determined that the same end prep results can be achieved at only 15 percent of the cost of the fully automated systems. The amount of floor space required was also only third as much as that required by the fully automated beveling machines.

The two machines are pneumatically driven. Each tool ranges in pipe capacity from 2 to 6 inches and 4 to 12 inches diameter. The overlap of the tools allows for simultaneous beveling of pipe at both ends. The combined system handles pipe from 2 to 12 inches in diameter with unlimited wall thickness capability. Multiple types of pipe material from stainless steel, carbon steel and copper nickel are now end prepped at the new station.

7.2.3. DESIGN FEATURES

Some of the design features include:

The tool accepts its own torque through the mandrel

The mandrel provides fast, accurate, self centering and self alignment

All tools needed for the operation are provided within the system

The tool is lightweight enough to handle through the overhead suspension by one operator

CuNi pipe is beveled at the same station. Both tools have expanding mandrels which eliminate the problem of ovalty and non-uniformity. (See Diagram # 27).

The entire beveling process has now been centralized from a multi-area, multi-man operation to a one-man, one-area operation. The operator sends pipe from the cutting station to the beveling station where it stops automatically. He then interrupts the automatic conveying system by switching the system over to manual. This is done at the main control station (See Diagram #28). The station is completely set-up with a tooling center (See Diagram #29). With the system in place, NASSCO pipe shop has the potential for fitting up to 30 percent more pipe than previously was possible. The potential for risk of eye injury from grinding at multiple benches has also been significantly reduced because the beveling is now centralized in one area, and the new cutting process has all but eliminated the former grinding process.

7.2.4. MEASURED SAVINGS

Through measured performance data and statistical process control (SPC), the overall man hours per spool for the fit up/fabrication and assembly stage were analyzed for both before and after implementing the semi automatic end prep station. The former method of grinding bevels on pipe has in almost all cases been eliminated. In comparing the data from the (52) weeks prior to the station and (20) weeks since its installation, a 36 percent reduction in man hours has been achieved in this stage. This represents an overall spool rate man hour reduction of 8.1 percent.

DIAGRAM 23

Tri Tool 206B End Prep Tool
(2 to 6 inches IPS)

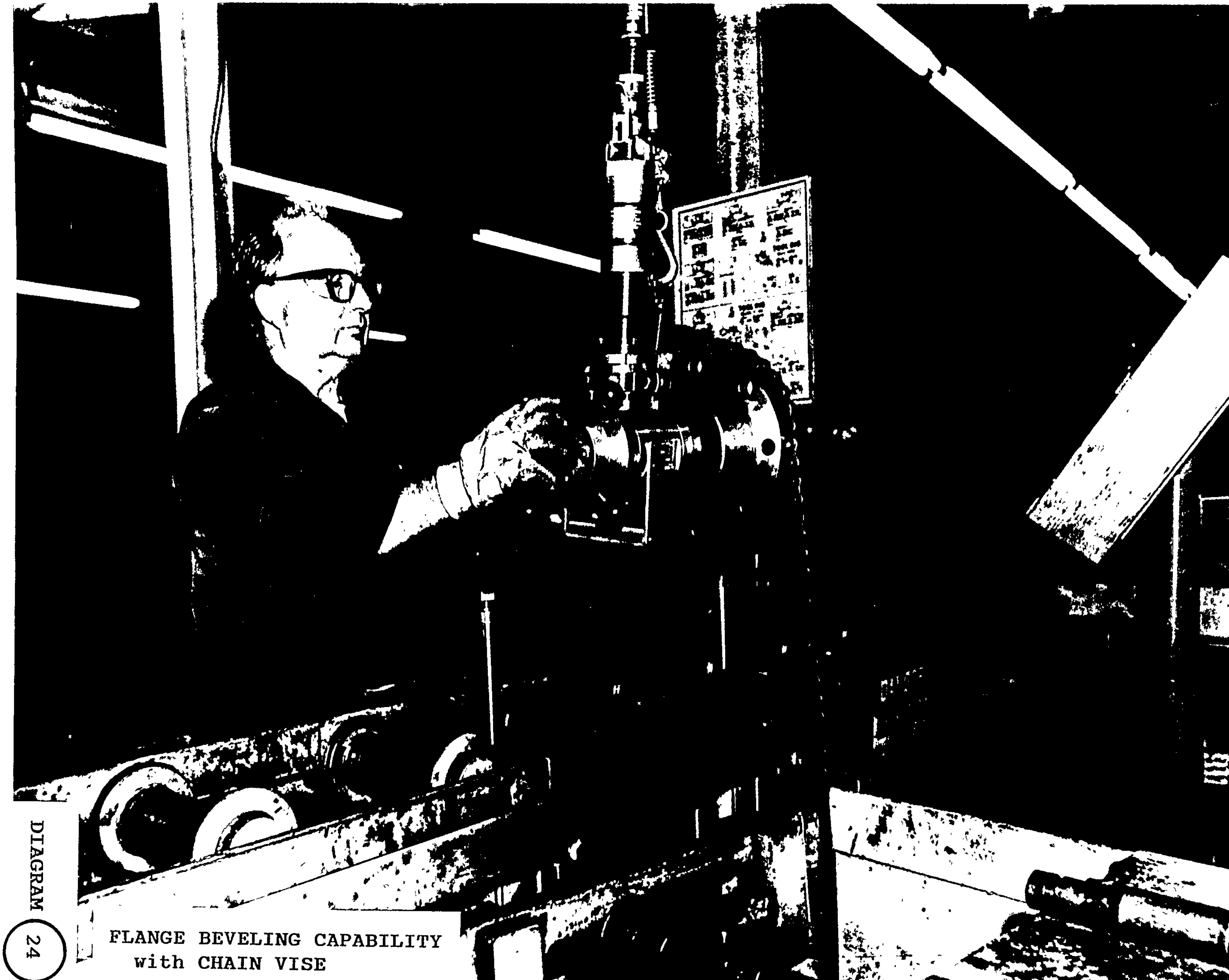
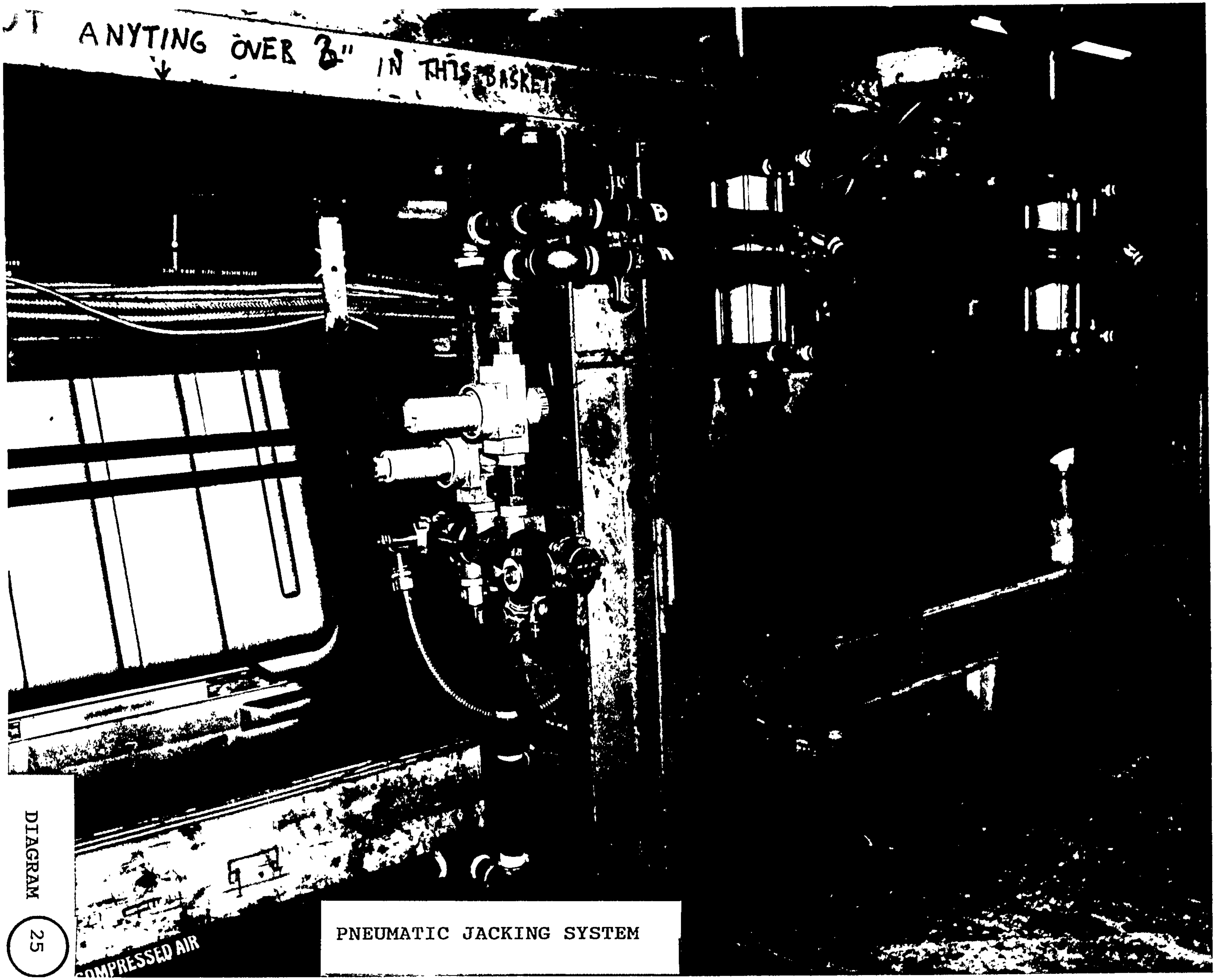


DIAGRAM 24

FLANGE BEVELING CAPABILITY
with CHAIN VISE

DIAGRAM 25



PNEUMATIC JACKING SYSTEM

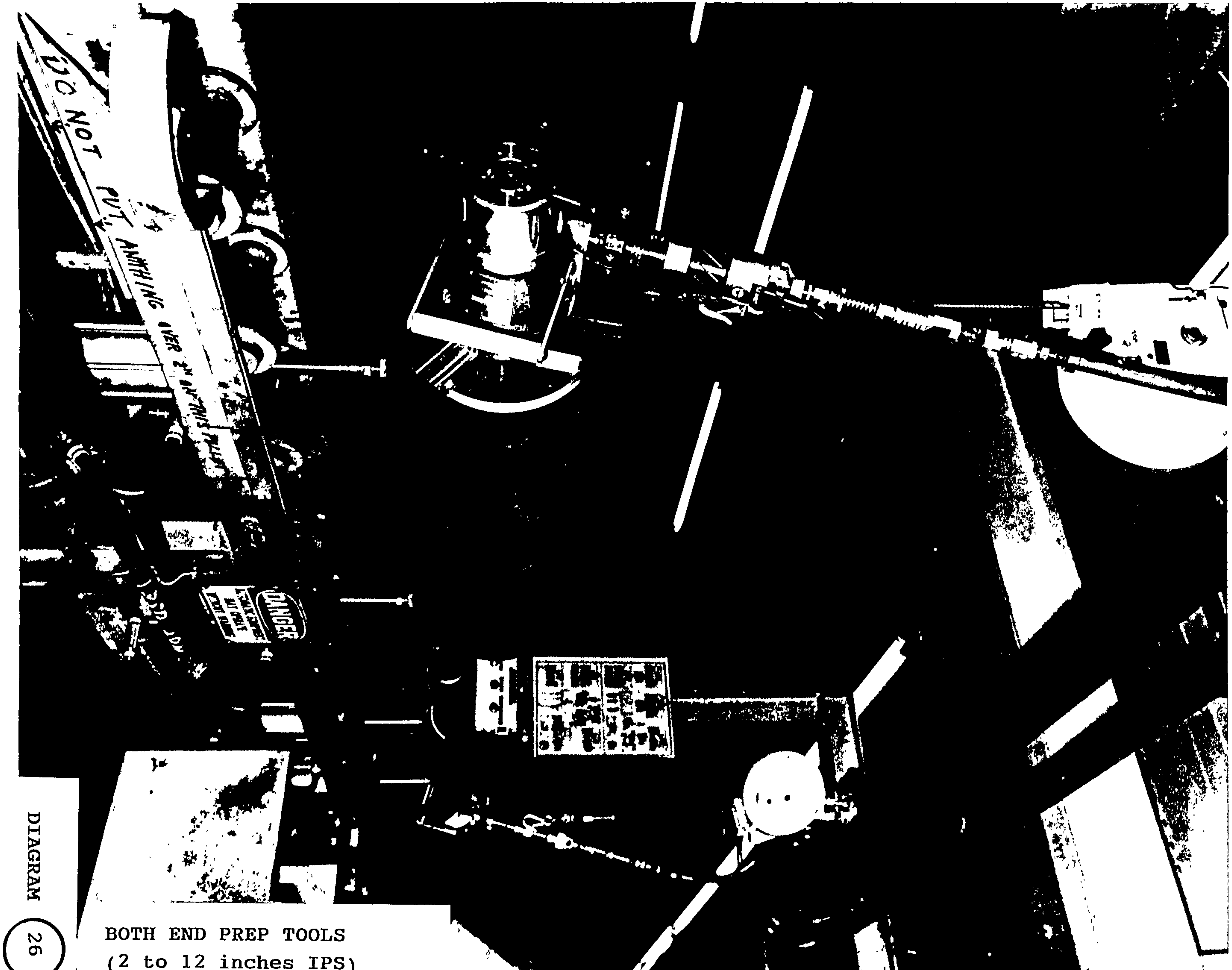


DIAGRAM 26

BOTH END PREP TOOLS
(2 to 12 inches IPS)

DIAGRAM 27

COPPER-NICKEL MANDRELS

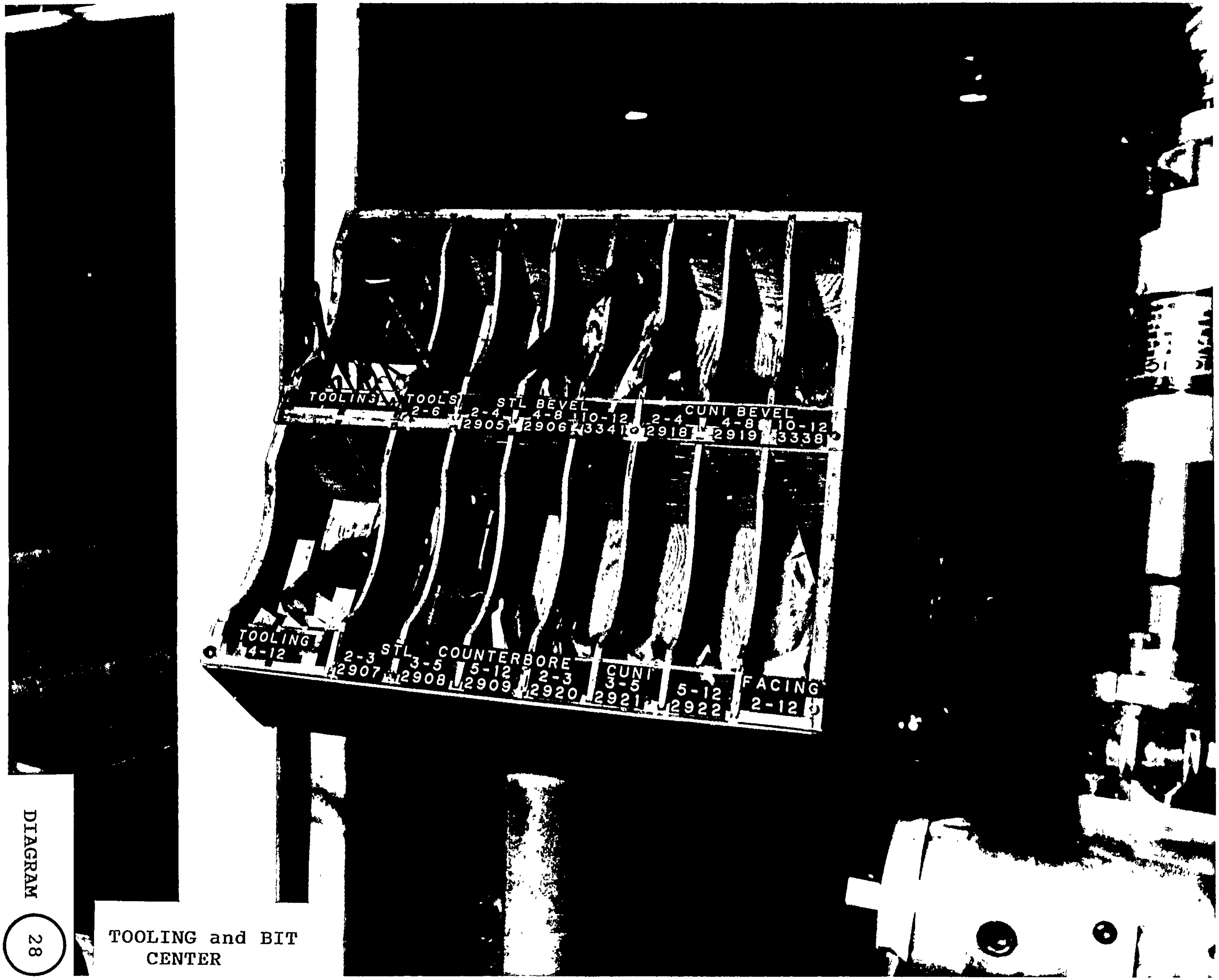


DIAGRAM 28

TOOLING and BIT CENTER

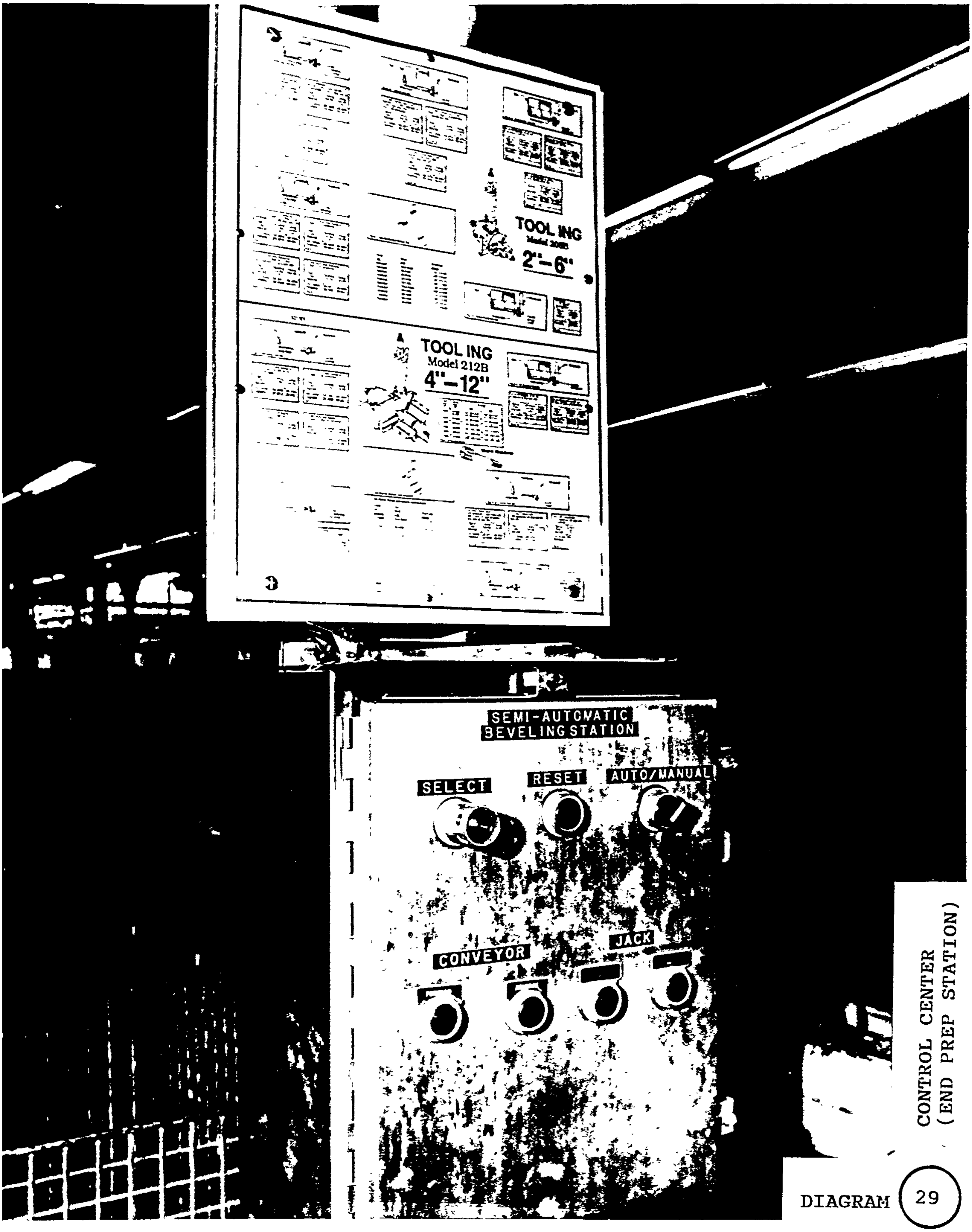


DIAGRAM 29

CONTROL CENTER
(END PREP STATION)

7.3. 2D BENDING

Bending is another area where significant gains in cost reduction and process time has been achieved. The 2-D process requires meeting certain Navy acceptance standards and criteria. These include allowable wall thinning, out-of-roundness percentages, minimal buckling, bulges, hmps, steps, and dents. It also requires the full support of engineering. The engineering design drawings are required to call for 2-D bends in place of fittings where ever is possible.

The recently acquired 2D CNC hydraulic bender in the main shop has already shown its cost effectiveness by reducing material cost (fittings), and weld metal volume (See Diagram # 30). Bending versus the conventional fabrication method eliminates the following (See Diagram # 31.A):

2 - Pipe End Cuts

2 - Cut Bevels

2 - Buttwelds

* Cost of Fittings

* Labor for Material Handling and Fabrication

The 2D bending machine has a pipe capacity from 2 to 8 inches in diameter, and is currently used to bend CuNi, copper, carbon steel, and stainless steel pipe of various wall thickness ranges. The performance features include some of the following:

7.3.1. PERFORMANCE FEATURES

- o The machine is rotary type with booster unit and pressure die assist
- o Maximum bend of up to 180 degrees
- o Pipe length over mandrel of 19 feet
- o Automatic mandrel extraction and lubrication
- o Hydraulic control valves
- o Hydraulically actuated dual pumps with additional pump for hydraulic fluid circulation.
- o Automatic pipe positioning unit

- Machine memory control and programs for saving pipe size, degree of bends, and other set-up configurations needed for repetitive bending

- Console control with digital read-out for degree of bend, distance between bends, program # indicator, program in use indicator, mandrel setting (distance from bend to tangent), bending and swing arm speed controls, mandrel extraction speed and direction controls, and automatic mandrel lubrication control.

The small bender to be installed in the new Pipe Shop Annex will bend pipe from 3/4 inches to 3 inches in dia.. It will have the same performance features as the current larger 2D bender in the main Pipe Shop. The smaller 2D bender will eliminate the current tedious tooling change-out required when bending small pipe on the larger bender.

Considering the large amount of savings which is realized in both costs and schedule, more pipes will be designed for bends in the coming days than for fittings.

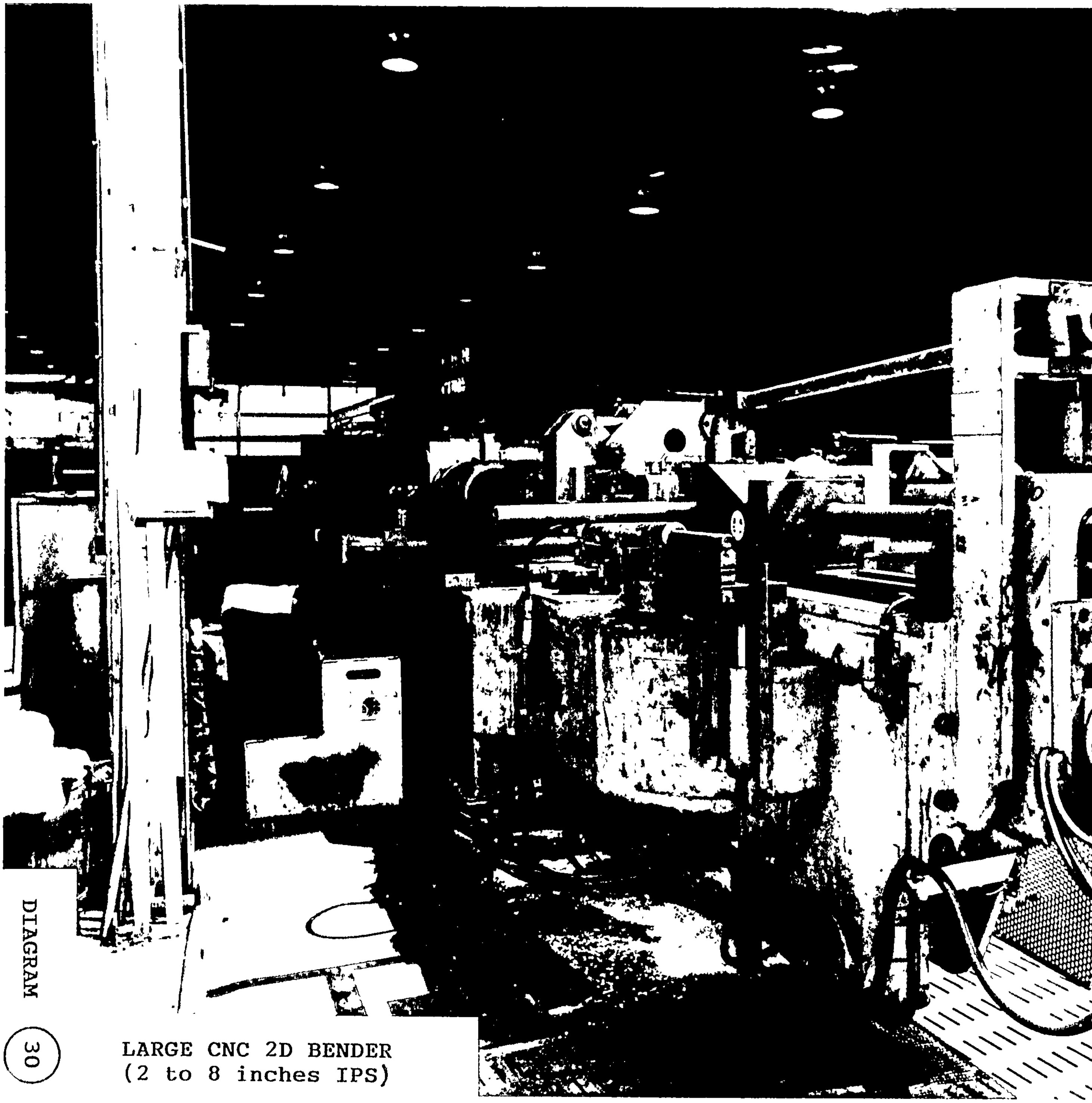
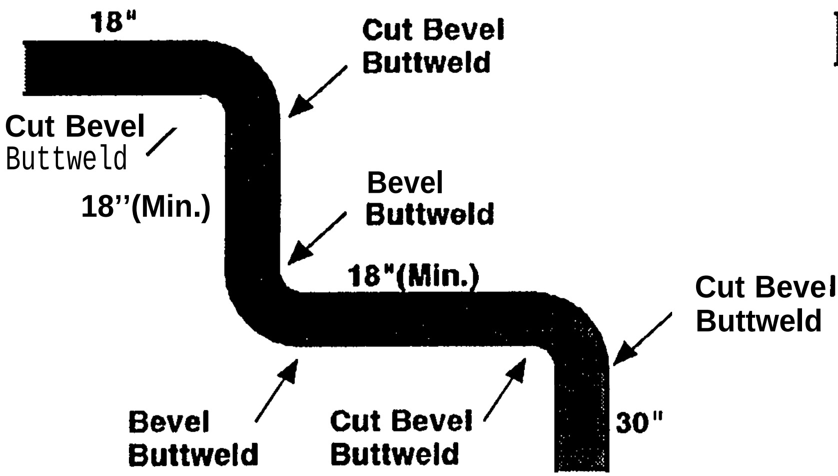


DIAGRAM (30)

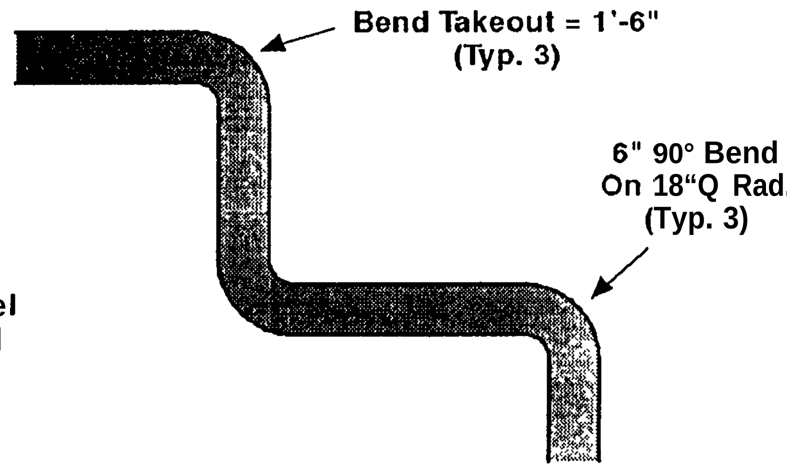
LARGE CNC 2D BENDER
(2 to 8 inches IPS)

CONVENTIONAL VS BENDING*

Conventional Fab



Bend Fab



* All Info Based On 6"Q Pipe

Conventional Fab	Bend Fab
Labor	**Labor**
4- P. E. Cuts	0- P.E. Cuts
6- Bevels	O - Bevels
6- Buttwelds	O - Buttwelds
Material	**Material**
3-90° ELL	0-90° ELL
7' - O" Pipe	11'- 6" Pipe

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DIAGRAM 31A

7.4. DIRECT COMPUTER DOWNLOADING CAPABILITY TO CNC BENDERS

7.4.1. FORMER METHOD

Utilizing the capabilities of the CNC bender was not an easv task. For approximately one year after the bender installation, NASSCO pipe shop personnel were still using the bender through manual input. The bender operator would hand calculate the following before each bend (See Diagram #31.B):

The length of the pipe from pipe end to start of bend "A"
The arc length “B”,
The length of the pipe between bends (travel) "C"
Straight or rolling offset "D", and
The total length of required pipe stock "E".

These calculations and hand measuring allowed for operator error and inaccuracy.

7.4.2. NEW METHOD

Currently the Pipe Shop has developed a new computer program which when imputed with the spool sheet specified dimensions (Set, Travel, Run, and Offset), allows a simulation of the bend and calculates the unknown bend information. This bend information is transferred down to the bender. This capability for downloading was provided by a computer interface called Electronic Data Module (EDM).

The EDM Program Box allows for the use of the full automation capability of the bender thus eliminating the requirement and potential for errors through manual input. The EDM allows for direct downloading of the data from the PC to the bender. Through data transfer, multiple spools can be loaded into the Bender with a week’s worth of bends and then Nested and Grouped according to the diameter and material type of the pipe to allow for multiple bends with the same tooling. This reduces the amount of Die and Tool Set-Up for the differing sizes while allowing multiple spools to be bent on the same length of pipe.

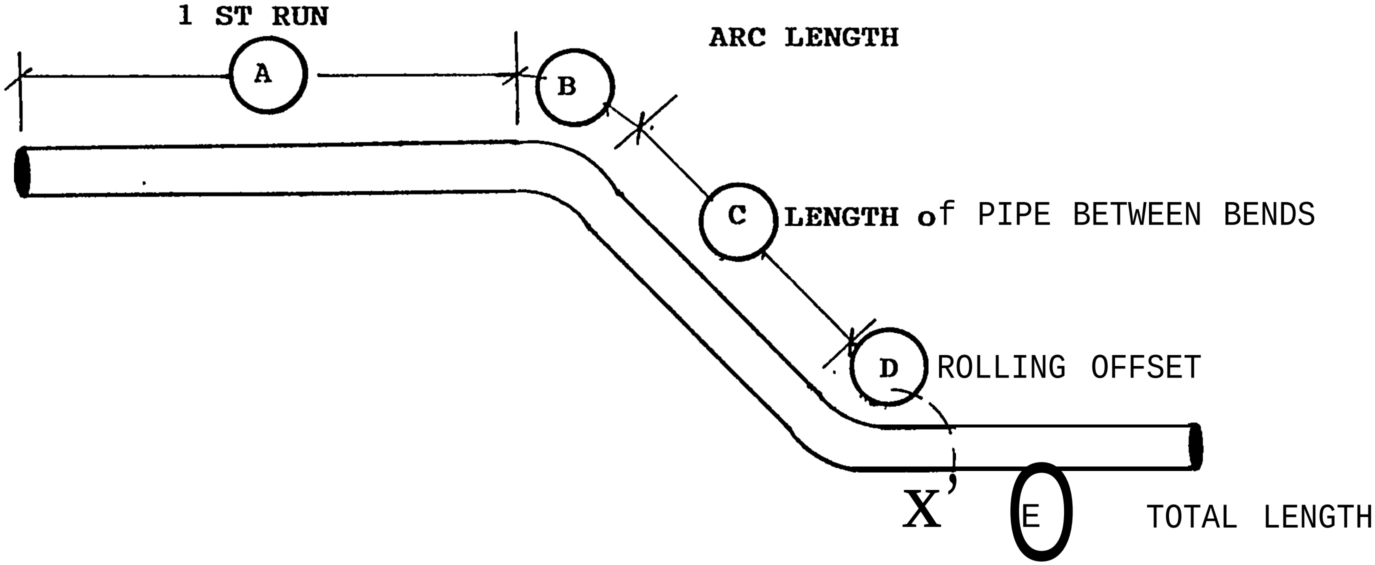
The modem direct connect cable from the PC to the console of the bender also allows for direct input, by-passing the EDM at the bender when off schedule spools need to be sent down to the bender. The cable allows for the transfer of one spool at a time and a working memory in the bender of up to 7 spools. This cable also requires a separate 12 Volt power supply. This data transfer system provides the pipe shop with the tools to be one step closer to directly downloading from Engineering to the 2-D Bending operation.

Following savings were realized as a result of implementing the down loading capability of the bender:

* An estimated (10) minutes per bend saved by eliminating the hand calculation of the unknown bend information.

* An estimated (10) minutes per bend saved by reducing set-up time through spool nesting and use of automated download module.

* Reduction in the amount of potential errors due to the manual input.



BEND PARAMETERS

DIAGRAM 31.B

7.5. HYDRO TEST AND FLUSHING STATION (See Diagram # 32. A & B)

7.5.1. HYDRO TEST

Hydro-test and flushing station is set-up in the pipe shop for testing of all the pipes for leaks. Since the implementation of the NASSCO designed testing station in the pipe shop, a significant man hour savings has resulted. By testing in the shop, leaks in joints can be more easily identified and repaired with a minimum down-time, and in an ideal work setting. Repair of joint leaks is much more cumbersome and time consuming on board the ship, requiring leads to be run down to the leak and scaffolding to be set up. The station has been in place for approximately (6) months and already 202 leaks have been identified and repaired in the shop taking approximately 50 hours. A conservative estimate triples the time to repair leaks on-board versus in the shop; therefore, 150 hours could have been expended, had the station not been in place. This works out to a net savings of 100 hours, not including all the time required for other services such as scaffolding to provide support. Additional test plugs and union hoses were acquired to allow testing of multiple spools at the same time. This is accomplished by connecting them in series (See Diagram 33 for system description).

7.5.2. SYSTEM DESCRIPTION

1) 1,000 gallon tank stands vertically.

2) Sump pump to transfer water from recovery tank to storage tank with manual and remote switch.

3) Plastic lined recovery tank 85 inch width by 312 inch length by 17 inch diameter.

4) System capacity 300 PSI.

5) Current pipe testing capacity from (1) to (8) inches in diameter schedules 40-80.

6) Test Stand Inputs: Test stand is able to work with the following pressures:

   Shop Line Air: 125 PSI
   Nitrogen Bottle: 0-2000 PSI
   Shop Water Line: 125 PSI max

7) Test Pressures Media and Pressure Ranges:

   Air: 0-125 PSI
   Nitrogen: 0-2000 PSI (Nitrogen Bottle)
   Water: 0-125

8) Test Gauges: 4 inch dial, 0.5 percent accuracy, panel mounting, with gauge savers and cut out valves are in the following ranges:

a) 0-60 psi
b) 0-160 psi
c) 0-300 psi
d) 0-600 psi
e) 0-1000 psi
f) 0-1500 psi
g) 0-2000 psi
h) 0-3000 psi

9) Test Stations: 8 each test stations, 3/4 inches main line with 3/4 inches SS ball valves. Panel mount per test station with quick disconnect ports. Each test station has a pressure gauge cut out valve to monitor test pressure. Each test station can be pressurized independercly or simultaneously, and maintained while other test stations are not being used. Each test station will have a dedicated gauge to test in one of the ranges listed in section 8, above.

10) Gauges Accuracy: The gauges maintain an accuracy of 0.5 percent more or less, even after being subjected to a 130 percent over-pressurization.

11) Valves: Check valves were used on the outlets of the three utility lines (air, nitrogen, water), to avoid back pressures into an outlets not being used in the test.

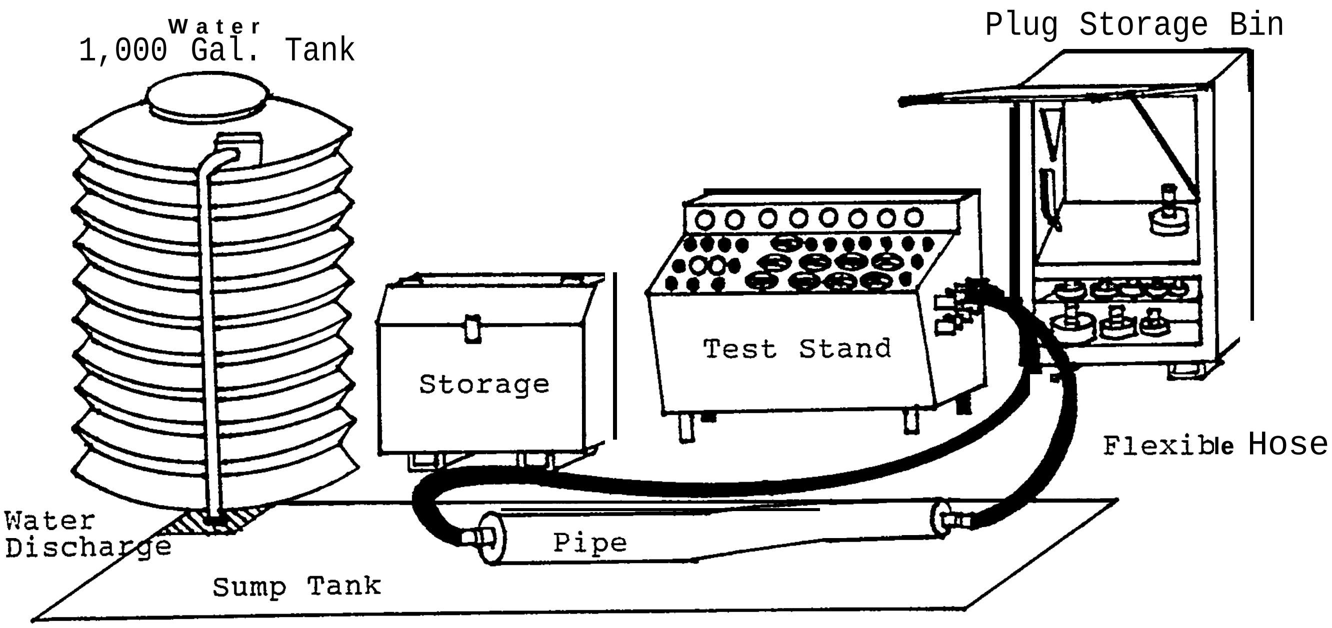
12) Schematic: Diagram #32.B shows conceptually how the system operates.

7.5.3. FLUSHING

The flushing of systems can also be accomplished at the station. The anchor windlass hydraulic piping system (440-343-7142) required that pipe tubing and fittings related to the anchor windlass hydraulic piping system be thoroughly cleaned and pickled prior to installation. They were required to be free from scale and foreign matter which could be detrimental to the operation of hydraulic equipment such as pumps, motors and valves. Other standards, ie. NAS 1638 and MIL-C-5501 specify cleanliness and stealing criteria respectively. These piping systems have been put together in series and flushed through filtering systems at high temperatures and pressures while maintaining specified flow rates. The flow rates are based on the pipes diameter. A portable flushing rig capable of meeting the flushing requirements was built in the shop. With this rig, more flushing and testing can be accomplished on systems in the shop before installed on-board where repair of leaks becomes more time consuming and costly.

HYDRO TEST & FLUSHING STATION

(A)



HYDRO-PNEUMATIC TEST STAND SCHEMATIC

(B)

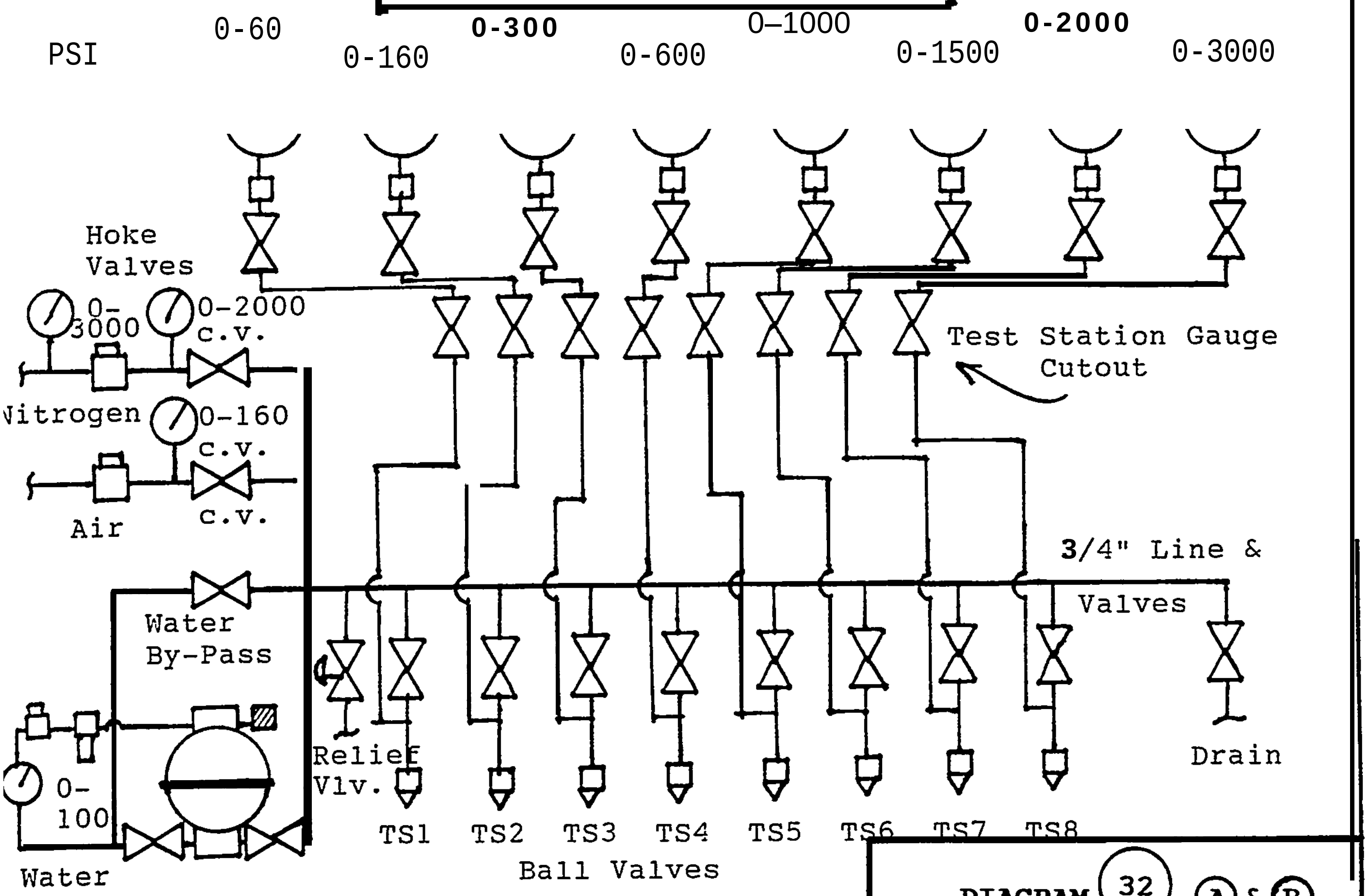
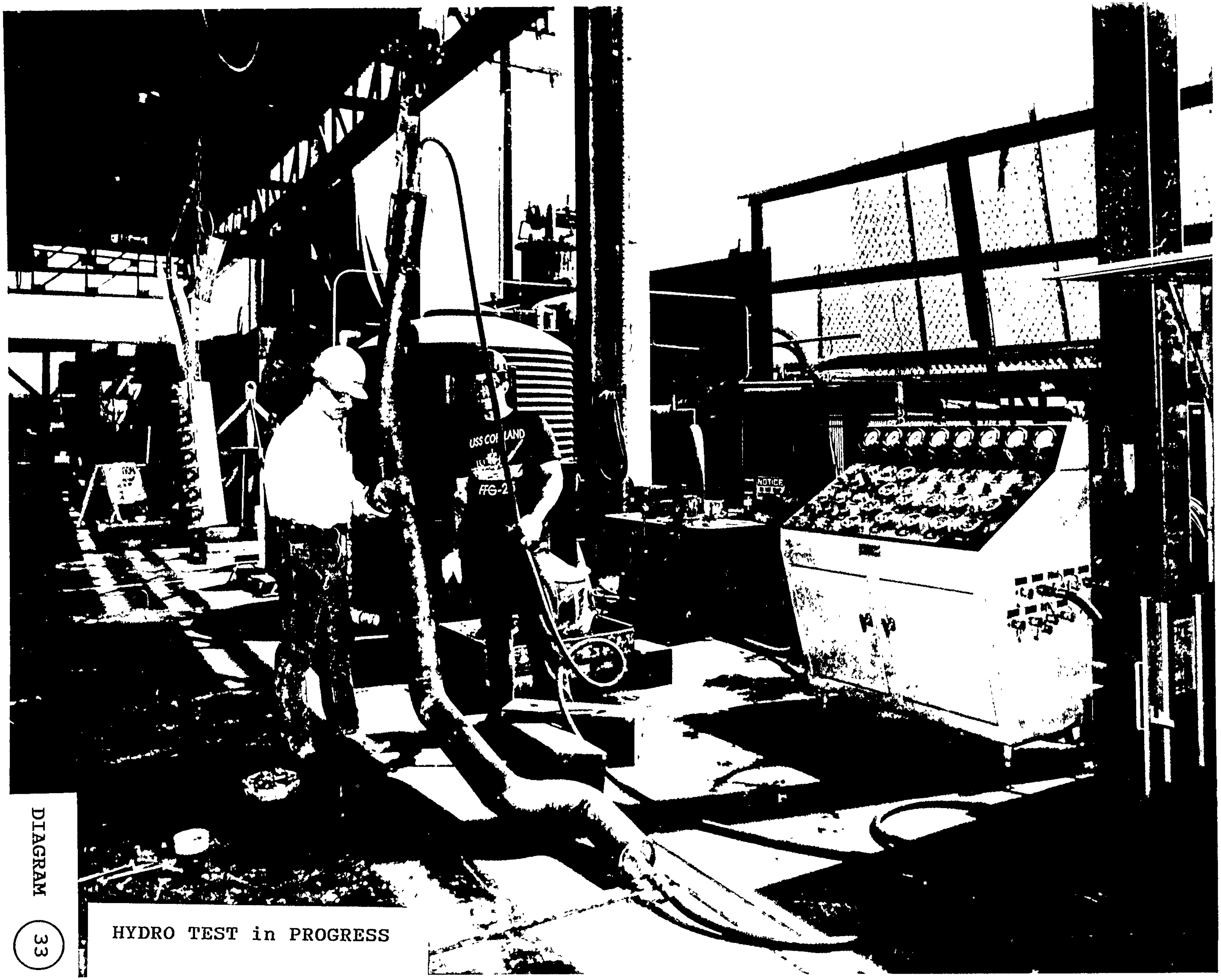


DIAGRAM (32) (A) & (B)

DIAGRAM 33



HYDRO TEST in PROGRESS

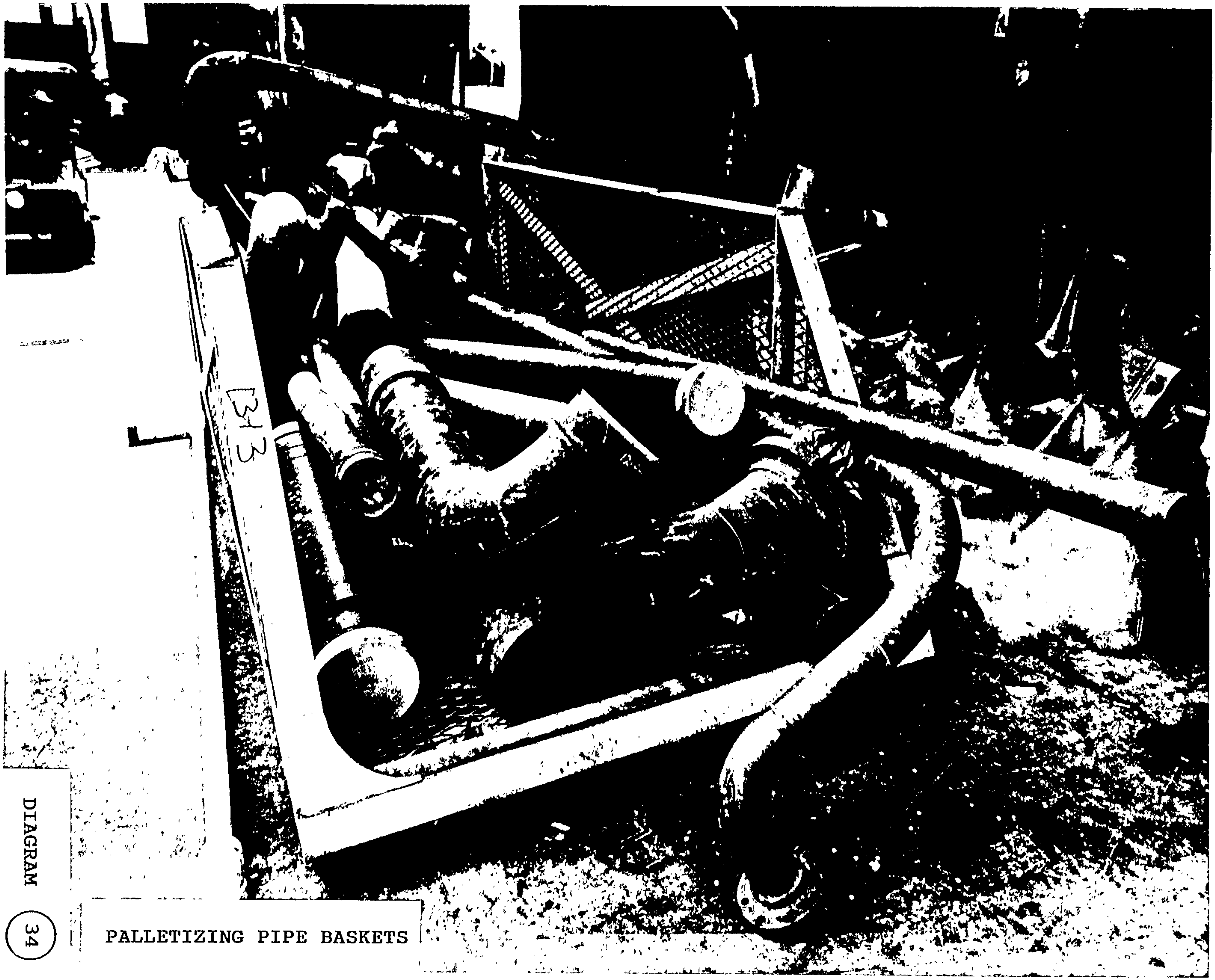


DIAGRAM 34 PALLETIZING PIPE BASKETS

7.6. PIPE EXTRUSION (See Diagram 35)

The cost of welding represents expending both money and time. An example was given in a December 1986 Fabricator Newsletter which gave a comparison of extrusion versus a nozzle weld. The article stated that "to nozzle weld a schedule 40 branch connection to a 10 inch run pipe requires roughly 5.9 man hours of time and can be reduced to approximately 3.9 man hours - through the process of - extrusion".

After study of this process NASSCO acquired a T-drill, T-150 model. The T-150 can pull outlets for 90 degree branch connections in copper, copper nickel, carbon steel, stainless steel and other alloys in sizes ranging from 1 1/2 to 6 inches in dia., IPS. This method was fully approved by the Navy and must meet all ANSI codes and Navy standards when used.

In comparing the two methods; items such as strength, corrosion properties, flow properties, economy and quality assurance needed to be considered. The strength of extrusions has shown itself to be better or equivalent to standard tees. Some of the previously used methods included tee-fittings, nozzles, and weld-o-lets. The biggest time saving factor of the extrusion is that it requires a butt weld and not a nozzle weld. Many industrial fabricators use a simple formula: (nozzle weld time = 1.5 x butt weld time) (Fabricator Article). The savings already experienced in the early use of the T-150 include the following:

ENGINEERING SAVINGS - Spooler account for extrusions vs. T - fittings

MATERIAL SAVINGS - Schedule 40 carbon steel
Schedule 20 stainless steel
Series 700 copper-nickel
Copper

SHOP SAVINGS Weld material

REDUCED FITTINGS - Utilizing standard fittings; Example: 8 inch x 8 inch x 8 inch and then weld a reducing fitting (ex. 8 inch by 4 inch) to provide the reduced connection size. T-DRILL would pull the applicable size, e.g., 4 inch directly out of the 8 inch pipe

FABRICATION SAVINGS - Eliminates purchase of fitting and associated costs
Eliminates two (2) butt welds and welders time
Eliminates two (2) X-rays (if required)
Eliminates cutting and preparation of pipe to install fitting
Minimizes potential for leaks or reworking due to two (2) less joints
Reduces inventory . . . elimination of tee fittings
Reduces lead time since fittings can be made in-house

REDUCER FITTING - Same savings as standard fitting plus . . .
Eliminate reducer fitting.
Eliminate one (1) more weld and its associated requirements.

7.6.2. SAVINGS

The following is the projected savings for branch outlets in 8 inch, 10 inch and 12 inch . . . per outlet.

7.6.2.1. BUTT WELD

Standard average industry times used in calculations

	CuNi	Carbon Steel
4 inch	1.40 hrs/weld	1.47 hrs/weld
6 inch	2.06 hrs/weld	1.95 hrs/weld
8 inch	2.90 hrs/weld	2.77 hrs/weld
10 inch	3.80 hrs/weld	3.54 hrs/weld
12 inch	4.85 hrs/weld	4.51 hrs/weld

Includes set-up, preparation weld time and clean-up.

7.6.2.2. T-DRILL EXTRUDED OUTLET FORMING TIMES*

	CuNi	Carbon Steel
4 inch	.19 hrs/branch	.32 hrs/branch
6 inch	.24 hrs/branch	.37 hrs/branch
8 inch	.22 hrs/branch	.35 hrs/branch
10 inch	.22 hrs/branch	.35 hrs/branch
12 inch	.23 hrs/branch	.36 hrs/branch

* Using plasma cutter
Includes set-up, pilot hole cutting, extrusion and facing.

7.6.2.3. FITTING COST

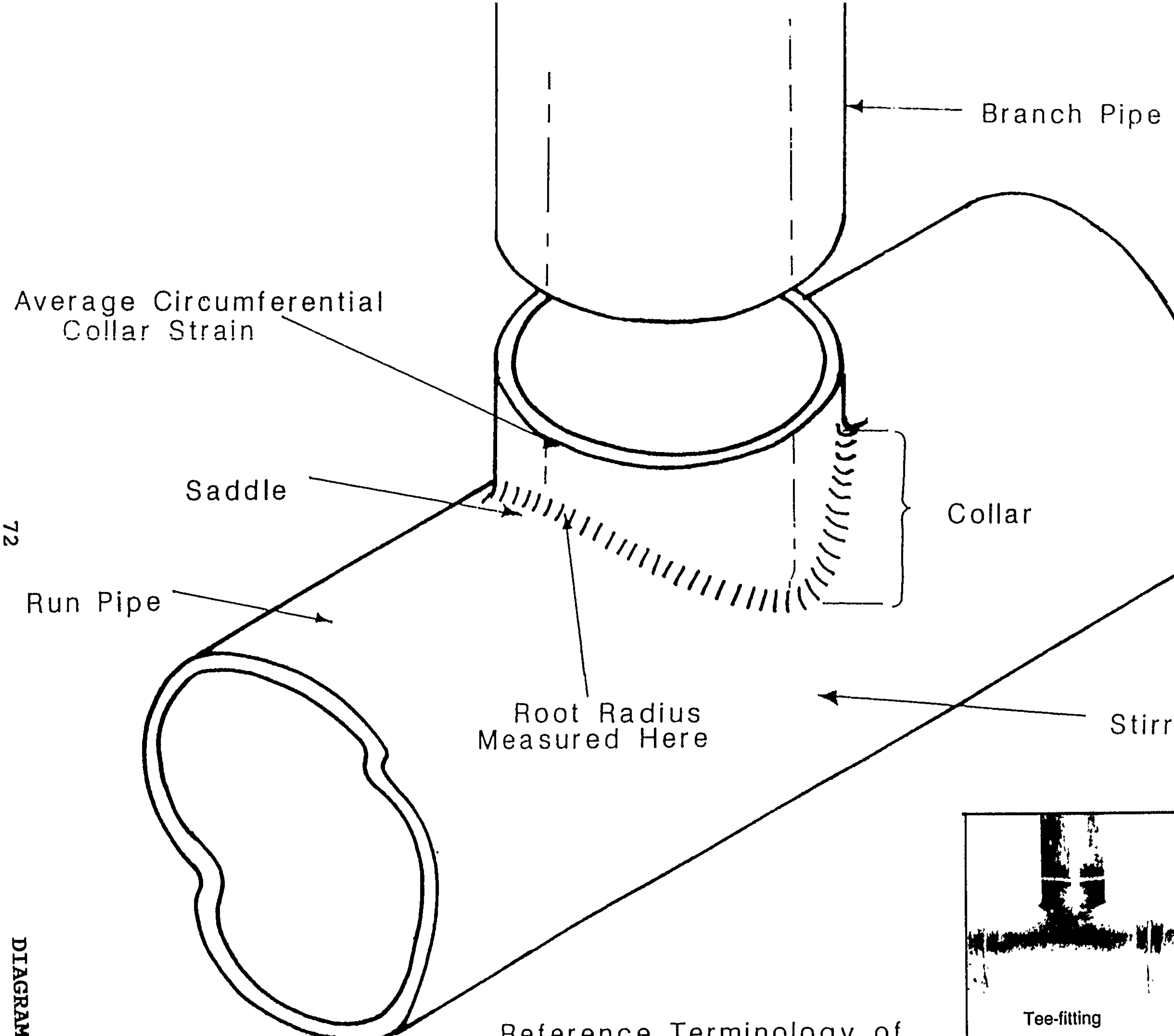
CuNi		Carbon Steel	
8 inch	$324	8 inch	$108
10 inch	$540	10 inch	$143
12 inch	$620	12 inch	$210

EXAMPLE 1: 8 INCH OUTLET IN 8 INCH PIPE

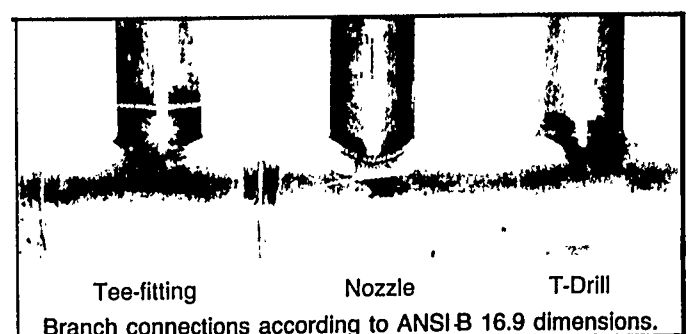
a. Schedule 40 Carbon Steel Fitting Cost	$108
Butt Welds 2.77 x 2 x $44.26*	$245
Total Installed Costs	$353
Less T-DRILL .35 x $40.58*	- $14
SAVINGS/FITTING	$339

* ESTIMATED AVERAGE SHOP WELD AND SHOP PIPE COSTS PER HOUR.

Significant savings have already been experienced and are expected with continued and increased use of the T-150 extrusion equipment.



Reference Terminology of
EXTRUSIONS



Branch connections according to ANSI B 16.9 dimensions.

DIAGRAM 35

7.7. WELDING PROCESSES

NASSCO employs similar weld processes as the other yards surveyed. These include: shielded metal arc welding, ARC welding, gas metal ARC and flux cored ARC welding which include: TIG and MIG welding. A large range of available weld types and processes exist and are dependent on the material type and system. Areas identified for improvement in the welding process include:

- o Upgrading current weld systems
- o Automate welding systems when possible
  Standardization of methods and processes
- o Reduce re-work

Improvements in these areas will lead to higher quality with better procedures and increased productivity

7.7.1. UPGRADING CURRENT WELD SYSTEMS

7.7.1.1. WELD MACHINES

An upgraded Powcon welding machine was acquired to be used primarily for Class 1 (X-rayed) pipe spools (See Diagram #36). For Class 1 spools TIG welding is used to provide the highest quality consistent welds, reducing the potential for inferior welds and rework.

This machine was used here at NASSCO on a trial basis. During the first week of its use, all the 28 spook Which were welded with the machine and X-rayed for leaks were FREE of leaks!

Previously, any spool with multiple leaks required approximately five hours of re-work and re-Xray. The new machine allows for the higher quality welds because the newer model comes with a built-in voltage filter which maintains a constant voltage of ± 1 VOLT at the end of the lead (Max up to 200 feet). This constant voltage helps to reduce the porosity and subsequent leaks found in weld joints where the voltage fluctuation tolerance is higher as is with the current Pipe Shop Machines. Another benefit to this machine is the built-in power converter which is more efficient to operate.

NASSCO pipe shop plans to purchase more of the same welding units for use in both the main shop and new annex.

7.7.1.2. POSITIONERS (See Diagram#37)

Positioners/Roll out tables are also used in NASSCO pipe shop to improve the quality of work as well as the speed. A positioner is an equipment that re-positions the weld piece and allows it to rest in a horizontal position. This increases the quality of work and reduces rework.

Welding a piece that rests in the flat position keeps the welded metal in the joint. The welder can better control the ARC weld in the flat position than in any other position. If a weld piece needs to be re-positioned without the positioner, the weld time increases due to the manual effort by the welder or the waiting period that may be required for a crane to move the piece. NASSCO pipe shop has determined that the positioners/roll out tables are fast and produce higher quality welds with much less defects. It has also been observed that a joint can be filled with fewer passes because of the high disposition rates in the flat position.

7.7.2. AUTOMATED WELDING SYSTEMS

Automation or semi-automation has been achieved in many pipe fabrication and transferring systems within the shop. Equipment with automated welding capabilities and turning tables for flange welding were integrated into the pipe shop systems in the past. At that time, it proved to be incompatible with the over-all capability of the shop to handle the large variety of pipe piece configurations. Repeatable pipe pieces or straight pipe fabrication is ideally suited for fully automated systems.

Further integration of manual and automatic processes is still being considered for many welding applications (i.e. flange welding for slip on flanges and weld neck flanges). The major factor for consideration still remains to be the initial cost and set-up time of the fully-automated systems versus the actual welding time saved. At the current levels of operation, and with the capital expenditure that may be required, it appears that the more simplified semi-automated systems is the best option for the shop. Most of the larger shops visited have at least to this time appeared to have come to these same conclusions. The European and Asian markets have better integrated the full-automation practice by applying a Group Technology and Pipe Piece Family Manufacturing approach.

7.7.4. REDUCING SHOP CAUSED REWORK

Rework includes any unnecessary work. Almost all rework is a direct cost and affects profits. These hours can be controlled by applying the best methods and standards to the work. This is in process and has been accomplished through further training and making each person responsible for his own quality performance. The new hydro test station has allowed accountability and traceability back to each fitter and welder. Another cause was traced back to the lack of qualified welders for silver brazing. Classes were added providing additional training in silver brazing. The people were rotated into the class and monitored throughout the day on the shop floor. Once the class was completed, a second rotation began. A much better quality of work was observed for the welders who completed the training session.

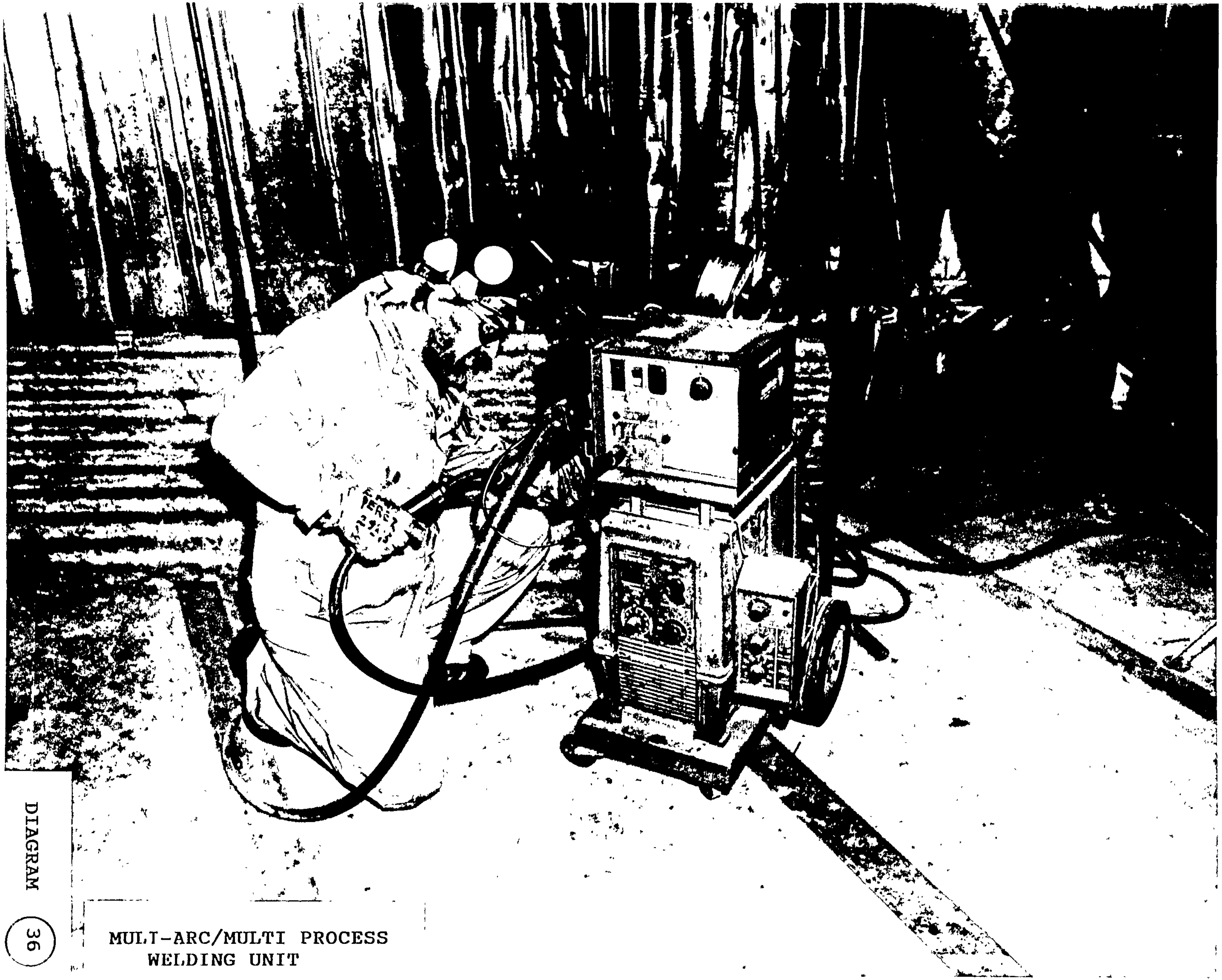


DIAGRAM 36

MULT-ARC/MULTI PROCESS
WELDING UNIT

DIAGRAM 37

ROLLOUT/ POSITIONER
in PROGRESS

The BEVELMASTERS™

End Preparation Systems

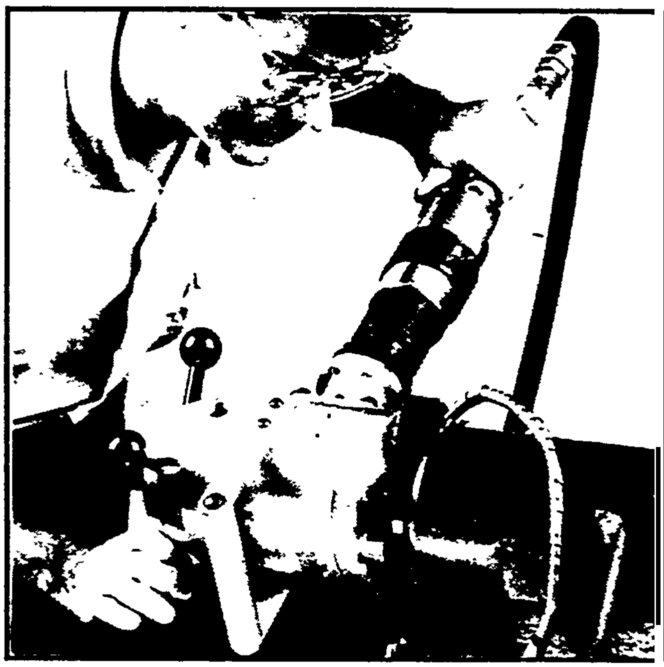
- Fast Boiler Tube Weld Preps
- Mount In Elbows Or Thin Wall
- In-Place Flange Facing

TRI TOOL INC.

DIAGRAM (38) gn Patents Pending

TRI TOOL INC.

3806 SECURITY PARK DRIVE. RANCHO CORDOVA. CA 95742-6990
800-345-5015 916-351-0144
Fax 916-351-0372



MODEL 206B BEVELMASTER™ PIPE BEVELING LATHE

Weld End Preparations on 2“ to 6“ pipe are fast, simple and “on time” with this rugged, tough, bullet proof tool. At an operating weight of only 44 pounds the tool is easily handled by one operator. The tool allows full simultaneous three function weld end preparations (bevel, face and counterbore).

The BEVELMASTER™ features:

- “Adjustable” torque keys
- Tapered roller bearings
- 3 HP pneumatic motor to deliver the cutting torque at the right speed
- Unique wide stance slide ramp mandrel for maximum stability.

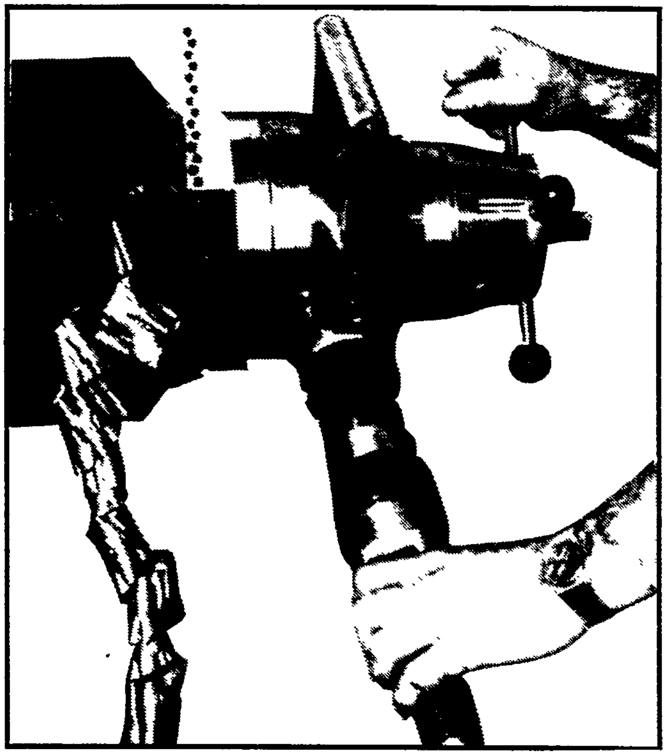
Optional accessories include:

- Flange Facing Module for 1.75” to 14” cutting diameters
- Elbow Mandrels for 1.63" to 6.5" inside diameters (Mandrels allow mounting in elbows, tees, valves, and other short perch applications)

DIAGRAM 39

TRI TOOL INC.

3806 SECURITY PARK DRIVE, RANCHO CORDOVA. CA 95742-8990
800-345-5015 916-351-0144
Fax 916-351-0372



MODEL 212B BEVELMASTER™

RUGGED, FAST, LIGHT, 4" TO 12" WELD END PREPARATION LATHE

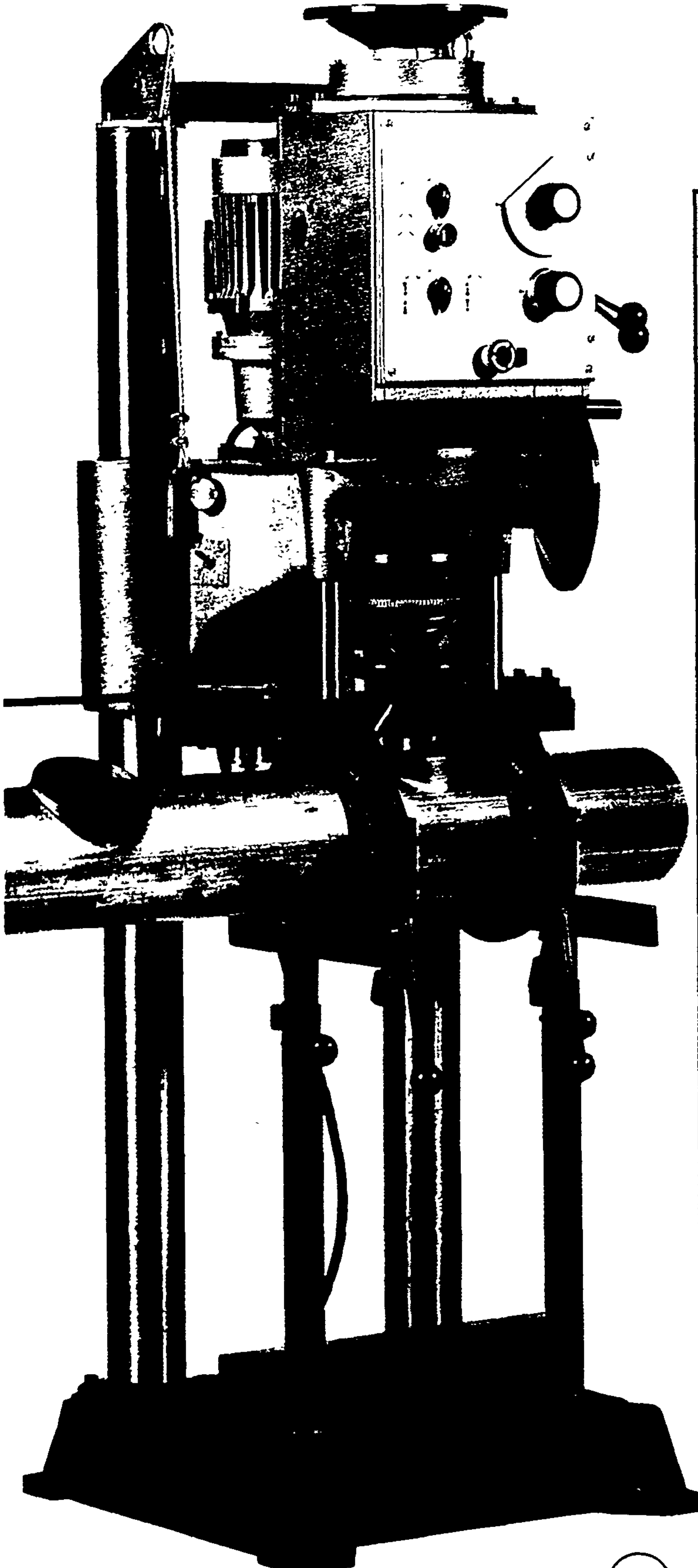
The Model 212B BEVELMASTER™ ID mounting Pipe Lathe end preps 4" to 12" pipe (all Schedules except 4" XX) in carbon steel, stainless steel and exotic alloys. Tool bits are available for 371/2", compound bevels and "J" preps to meet your specified prep design.

THE 212B FEATURES:

- Compact design with handle for easy operation by one man
- Fast efficient, precision production end preps
- Perfect fit ups – eliminate cold spring and X-ray problems
- Cold cutting – No **heat affected zone (HAZ) –** Minimum IGSCC
- Bevel – Face – Counterbore in one operation
- Electric and pneumatic power options
- Optional elbow mandrels for mounting in elbows, tees & valves
- Optional full support mandrels for thin wall tube and pipe
- Optional Flange Facer Module (Special order only)

DIAGRAM 40

T-DRILL T-150



COLLARING RANGE AND WALL THICKNESS CAPABILITY — T-150 COLLARING HEADS								
Outlet O D D_B	Runpipe O D D_O	Collaring Head No.	A Mild steel		B Austenitic stainless steel		C Copper and copper alloys	
			t_{max}	h	t_{max}	h	t_{max}	h
42 4	42 4	[illegible]	2 [illegible]	2 5	2 3	2 5	2 3	2 5
	48 3	1	2 3	3	2 5	3	2 6	3
	60 3	1	2 5	3	2 7	3 5	2 7	3 5
	76 [illegible]	1	2 6	4	2 7	4	[illegible]	4
	88 9	1	2 9	4 5	3 0	4 5	3 0	4 5
48 3	48 3	1	2 6	3	2 7	4	2 6	3 5
	60 3	1	2 9	3 5	3 2	3 5	3 0	3 5
	76 [illegible]	[illegible]	2 9	4	3 6	4	3 2	4
	88 9	[illegible]	3 2	4 5	3 6	5	3 5	5
	219 1	1 or 2	3 2	4 5	3 6	5	3 5	5
60 3	60 3	2	2.9	3 5	3 2	3 5	3 2	3 5
	76 1	2	3 2	4	3 6	4	3 6	4
	88 9	2	3 6	5	4	5	4	5
	114 3	2	4	6	4 5	6	4 5	6
	139 7	2	4 5	6	4 5	6	4 5	6
76 1	76 1	2a	3 6	4 5	4	4 5	4	4 5
	88.9	2a	3 6	5	4 5	5	4 5	5
	114 3	2a	4 5	6	5	6	5	6
	139 7	2a	5	6	5	7	5	[illegible]
88 9	88 9	2a	4	5	3 6	5	4 5	5
	114 3	3	5	6	5	6	5	6
	139 7	3	5 6	7	5 6	7	5 5	[illegible]
114 3	114 3	4	4 5	6	3 8	6	4 5	6
	139 7	4	5 6	7	4 5	7	5 5	[illegible]
	168 3	4	6 3	7	5	7	6	[illegible]
	219 1	4	6 3	8	5 6	8	6	9
139 7	139 7	5	4 2	7	3 5	7	4	7
	168 3	5	5	7	4	7	5	7
	219 1	5	5 6	8 5	4 5	8 5	5 5	8 5
	273	5	5 6	10	5	10	5 5	10
168 3	168 3	5	3 8	6	3 2	6	4	6
	219 1	5	4 8	8 5	4	8 5	5	8 5
	273	5	5 6	10	4 5	10	5	10

ACTUAL PROPERTIES OF MATERIALS

A Mild steel
- elongation to fracture about 30% or better (22% to 25% in material codes)
- yield strength about 300 N/mm² (43500 psi) or lower (200 to 250 N/mm², 29000 to 36000 psi in material codes)

B Austenitic stainless steel
- elongation to fracture about 45% or better (in material codes 35% to 40%)
- yield strength about 250 N/mm² (36000 psi) or lower (about 200 N/mm² 29000 psi in material codes)

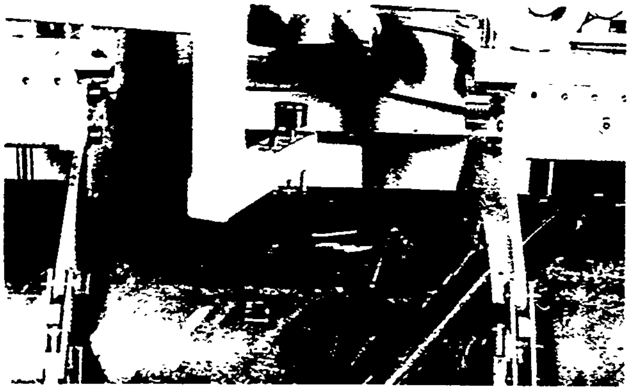
C Copper and copper alloys
- elongation to fracture about 35% or better (in material codes 27% to 30%)
- yield strength about 250 to 300 N/mm² (36000 to 43000 psi) or lower (in material codes 250 N/mm² 35000 psi)

DIAGRAM (41)

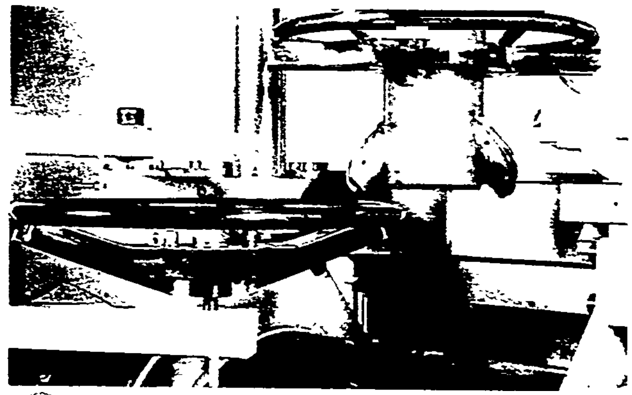
PRECISION BUTT WELD COLLARS IN ONE SETUP

T-DRILL: STEPS OF OPERATION

In the **illustrations there is shown model 7-500 — the principle is *similar* to the T-150,**



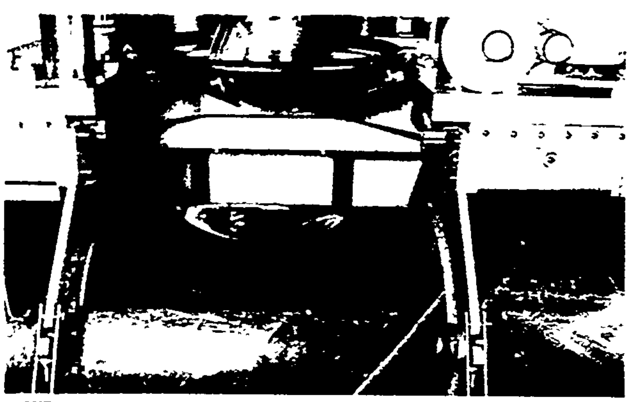
A piple section is secured by means of quick-acting ring clamps and is positioned to a mark.



Elliptical pilot hole cutter is fitted.

Pilot hole dimensions and cutting speed are **controlled by dial settings.**

4 **As the cutting angle is conical, a range of sizes can be cut with each tool.**



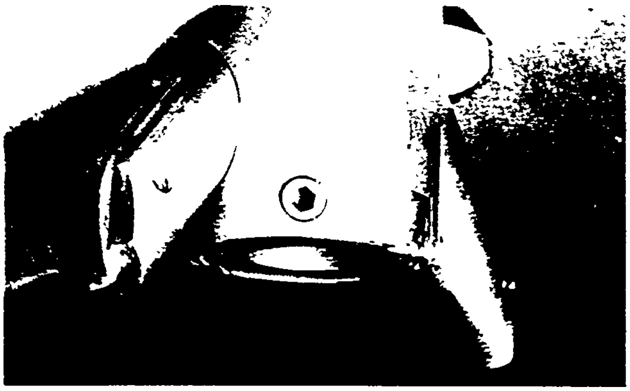
5 **Pilot hole after machine cutting.**

6 **The operator performs a minor deburring operation on the edge of the hole.**

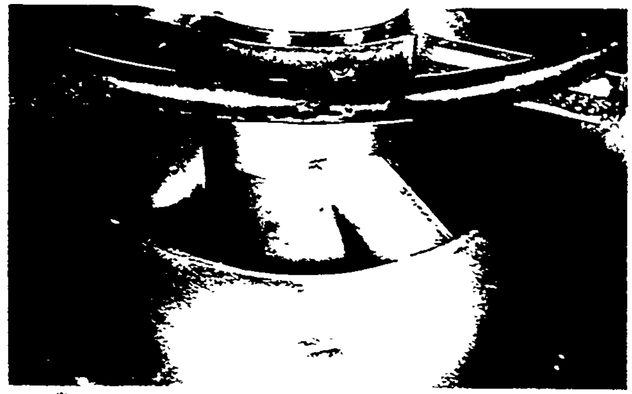
DIAGRAM 42

Deburred **pilot hole.**

Collaring head is a tool which forms the collar

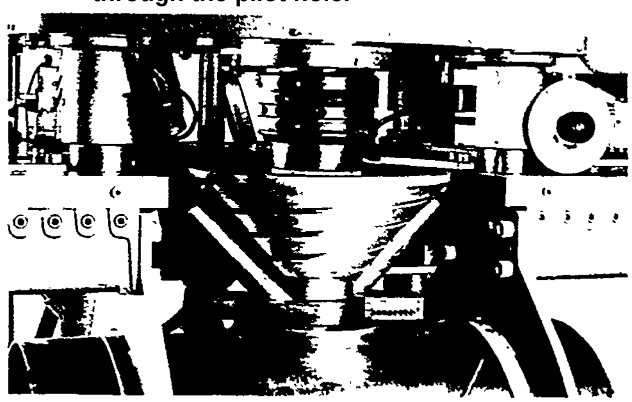


Collaring head mserted into pipe through a pilot hole. Forming pins are extended to a preset dlmension.



10 The machine forms the collar by rotating the collaring head slmultaneously outwards through the pilot hole.

11 *During the collaring lubrication compound is applied onto the forming pins.*



12 With no change of tooling the machine mills the collar rim to the required final height.

13 *Chamfer device can be used to bevel the collar rim to the required weld preparation angle.*

14 **The collar is ready for butt welding.**

DIAGRAM 43

RACK UP MULTIPROCESS FLEXIBILITY

PowCon

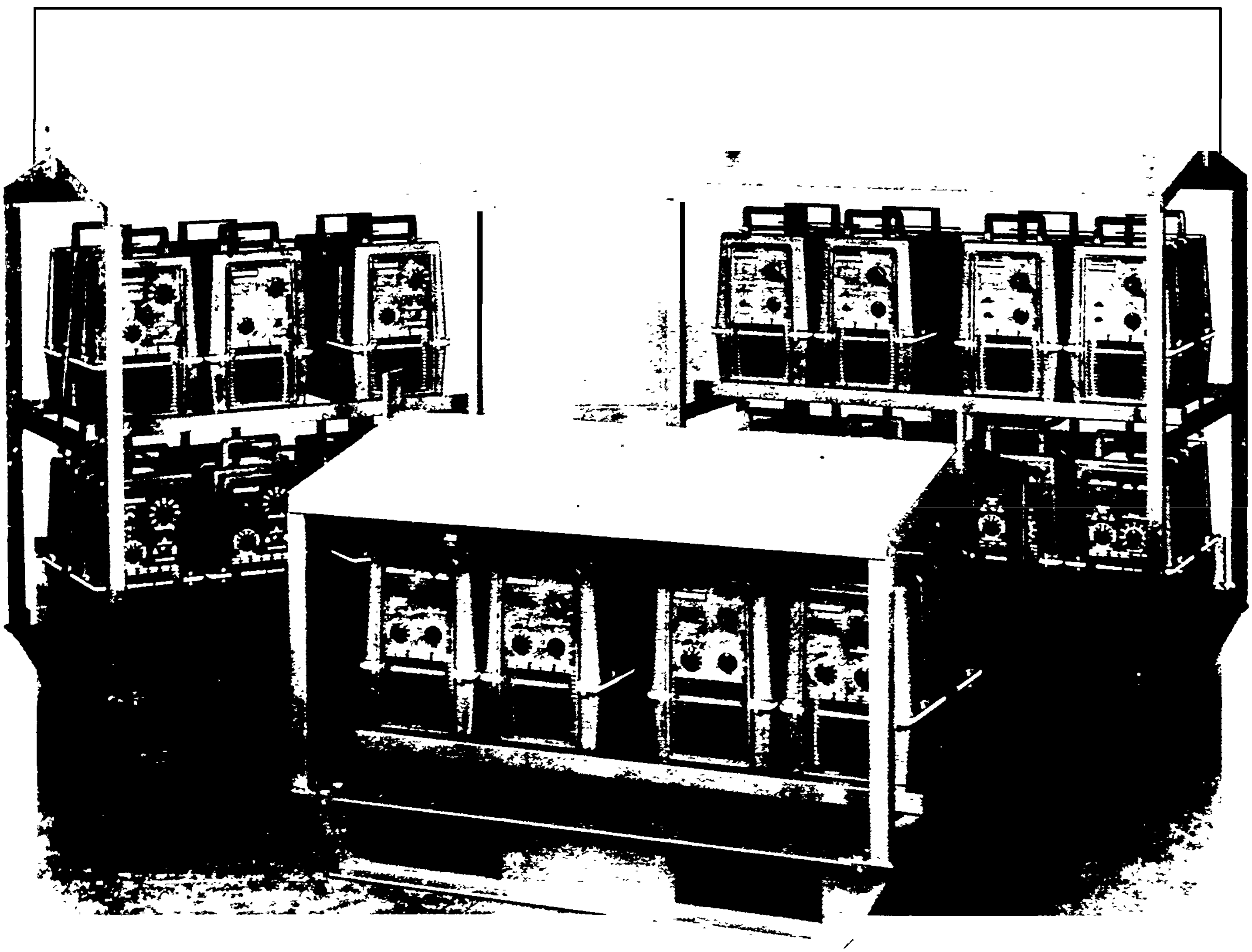
LIFT-PAKS & ECONO-PAKS

PowCon offers you a new modular approach to multl-arc multlprocess welding systems. Now you can combine several high performance. energy efficient PowCons in a compact "Lift-Pak or "Econo-Pak system to handle virtually any job. Best of all, when your "Paks" are not in use, you can use the individual PowCons on other jobs.

These compact, durable PowCon Pak systems are built to meet the tough demands of the construction industry, with energy saving invetier power sources converting input power much more efficiently than conventional equipment or grid systems. And these heavy duty, NEMA Class One rated power sources are still the only inverters with both UL and CSA approvals and backed by a 3-year warranty.

Available in both two or four unit Lift-Paks and four, six or eight unit Econo-Paks, you can choose the best combination of PowCon 300 amp three-phase welding and StarCut plasma cutting power sources for your Pak. Lightweight and portable. you'll find each Pak is easy to move to and around any job site. Even a fully loaded 8-Pak can be transported in a small pick-up truck.

So pick the Pak that meets your needs and rack up the best construction welding and cutting system available today.



The Smart Machine
PowCon

DIAGRAM 44

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