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DEVELOPMENT OF CELLULAR MANUFACTURING SYSTEMS FOR OVERALL PRODUCTION EFFICIENCY

by

SRINIVAS LOKULA

Thesis Submitted to the Faculty of the Graduate School of the New Jersey Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Manufacturing Engineering

December 1991

APPROVAL SHEET

Title of Thesis

Development of Cellular Manufacturing Systems for

Overall Production Efficiency

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ABSTRACT

Title of Thesis: Development of Cellular Manufacturing Systems for Overall Production Efficiency.

SRINIVAS LOKULA
Master of Science in Manufacturing Engineering, 1991

Thesis Directed by: **Dr. Raj S. Sodhi**
Director, Manufacturing Engineering

For years the industrial job shop is facing an increase in complexity and decline in productivity due to increase in parts mix, volume of parts, plant size, machine production rates and part complexity. The development of Group Technology and Cellular Manufacturing seeks to eliminate or minimize complexity and to maximize productivity.

Cellular manufacturing is the physical division of job shop's manufacturing machinery into production cells. Each cell is designed to produce parts requiring similar machinery and machine operations. Cellular manufacturing is one of the best manufacturing techniques to support Just In Time manufacturing and Total Quality Management.

This thesis work involves grouping of parts requiring similar machinery and machine operations. The procedure of grouping the parts is presented using Production Flow Analysis method. The whole job shop is physically divided into production cells which fabricate tubing. The layout is designed to increase efficiency, and to reduce the set up time, the work in process, the material handling and the inventory.

TO

MY LOVING PARENTS

HANUMANULU & DHANA LAKSHMI

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SRINIVAS LOKULA

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Chapter 1

INTRODUCTION

1.1 Introduction to Cellular Manufacturing Systems

Cellular manufacturing has emerged as a new manufacturing system in recent years. It is the manufacturing process transferring raw material into sub-assemblies or finished parts with in a single organizational entity or a cell. The main aim of Cellular systems is to reduce set up times, lead times, making small lot production economical, reduce inventory level and to offer less costs and total quality advantages over the traditional manufacturing systems.

Cellular manufacturing is one of the best techniques used to implement Just In Time manufacturing, Total Quality Management. The effectiveness of cellular can be greatly increased using Computer Integrated Manufacturing (CIM) and it is the long range goal for all manufacturing companies.

Group Technology is the concept used and implemented for designing the cells. This is based on the sameness principles to help identify parts having the same manufacturing requirements. In group technology, a coding technique will be developed to code the parts to be manufactured and the codes in turn will be used to form part families. Other methods are also used based on process routing, whatever be the methods used, the selected designed cell should be able to operate with maximum efficiency. The benefits that are derived from Cellular Manufacturing are becoming more evident and proven as everybody is gaining greater knowledge and understanding of their behavior in the manufacturing environment. Even though there are lot of benefits and advantages, there are many small organizations that cannot move quickly towards Computer Integrated Manufacturing and Group Technology as the large firms, due to the requirement of the large capital investments. Yet, the many advantages tangible and intangible of cellular manufacturing can be realized by firms of all sizes, no matter what their capital budget may be.

1.2 History of Cellular or Work Cell Manufacturing

According to Huang and Houck [7] the concept of cellular manufacturing has been around since 1925. The European countries, Russia, and Japan have adopted the concept very well and the American companies have been less enthusiastic in the past. Recent interest in Cellular manufacturing among companies in the U.S can very well be inferred from the paper by Palframan [7]. Several companies are tending to cellular or preferring manufacturing cells over a flexible manufacturing system because of the cost and manageability.

A cell is defined as a group of dissimilar machines or processes located in close proximity and dedicated to the manufacture of a family of parts that are similar in their processing requirements. The most common reasons for establishing cells is to reduce work-in-process (WIP), setup time, through-put time, and materials handling and to improve output quality. Other motivating factors are to reduce the costs of indirect labor and inspection.

The concept of cellular manufacturing can be used in a wide variety of product lines like machinery and machine tools, agricultural equipment, construction equipment, hospital and medical equipment, defense products, engines parts and components, fabrication works, certain assembly operations, metal forming, metal cutting, welding, machining of primary parts etc. Cellular manufacturing can be developed in all areas of manufacturing combining with various operations. Cellular manufacturing is increasing the opportunity for achieving flexibility in product scheduling as well as creating more interesting and variable work for the management and employees.

1.3 PROBLEM STATEMENT

G & J Steel and Tubing, Inc is a tube fabricator and manufacturer of automobile, and aerospace parts. Large scale production of the company is fabricating tubing for the manufacturers of soda vending machines. These tubes are classified as:

1. Syrup Lines # 1
2. Syrup Lines # 2
3. Soda Tubes
4. Syrup Can inlet tubes, etc

The tubes have their original part numbers given by the manufacturer. At G & J Steel and Tubing, Inc these tubes are fabricated in separate lots and on different manually bending machines. This is leading to extra setup times, loss of time in production, extra labor, rework and scrap. The present system of the work reduces the efficiency and utilization of the production plant.

G & J Steel and Tubing, Inc fabricates these syrup lines, soda tubes which look similar in shape and fabrication. A total of 26 different types of tubes are fabricated. Lot sizes range from 500 to 600 every month. A very considerable time is consumed in set-up and rework.

This job is taken as an illustration to study the tubing operations, setup times, lead times, grouping the parts and making the layout for cell manufacturing.

1.4 OBJECTIVE OF THE PROJECT

1. The objective of the project is to reduce set-up time and material handling using Group Technology. The project includes grouping the parts into families and coding them.

2. To improve production efficiency of the plant.

3. To reduce inventory costs by purchasing all raw material in just in time.

4. To reduce rework and save thousands of dollars per month, concentrating mainly on incoming material, inprocess quality, statistical process control and customer management.

5. To propose the present layout into Cellular layout.

6. To train the employees in understanding Cellular and Group Technology.

Chapter 2

TRADITIONAL MANUFACTURING SYSTEMS

2.1 Process Layout Manufacturing Systems

The oldest and most common type of manufacturing system is the Process Layout Manufacturing System also called the Job shop is shown in the figure 2.1. Thirty to fifty percent of total manufacturing systems belong to this category. The Job shop is a transformation process in which units for different orders follow different paths or sequences through processes or machines. The layout is purely functional so that they can be adopted to the special requirements of different orders. The characteristics of the job shop are :

1. Flexible and general purpose machinery,
2. Highly skilled workers where one man is to one machine,
3. Much indirect labor and
4. A great deal of manual material handling like loading, unloading, setting up and adjusting. The price for the flexibility is paid in the form of long and variable in-process times, large work in process (WIP) inventories, lost orders and poor quality.

The job shop is the least productive manufacturing system. It results in products or services which are costly and whose costs tend to keep rising with inflation. In addition, some social and technological trends suggest that the number of and need for small lot production systems will increase in the future. These trends or needs include:

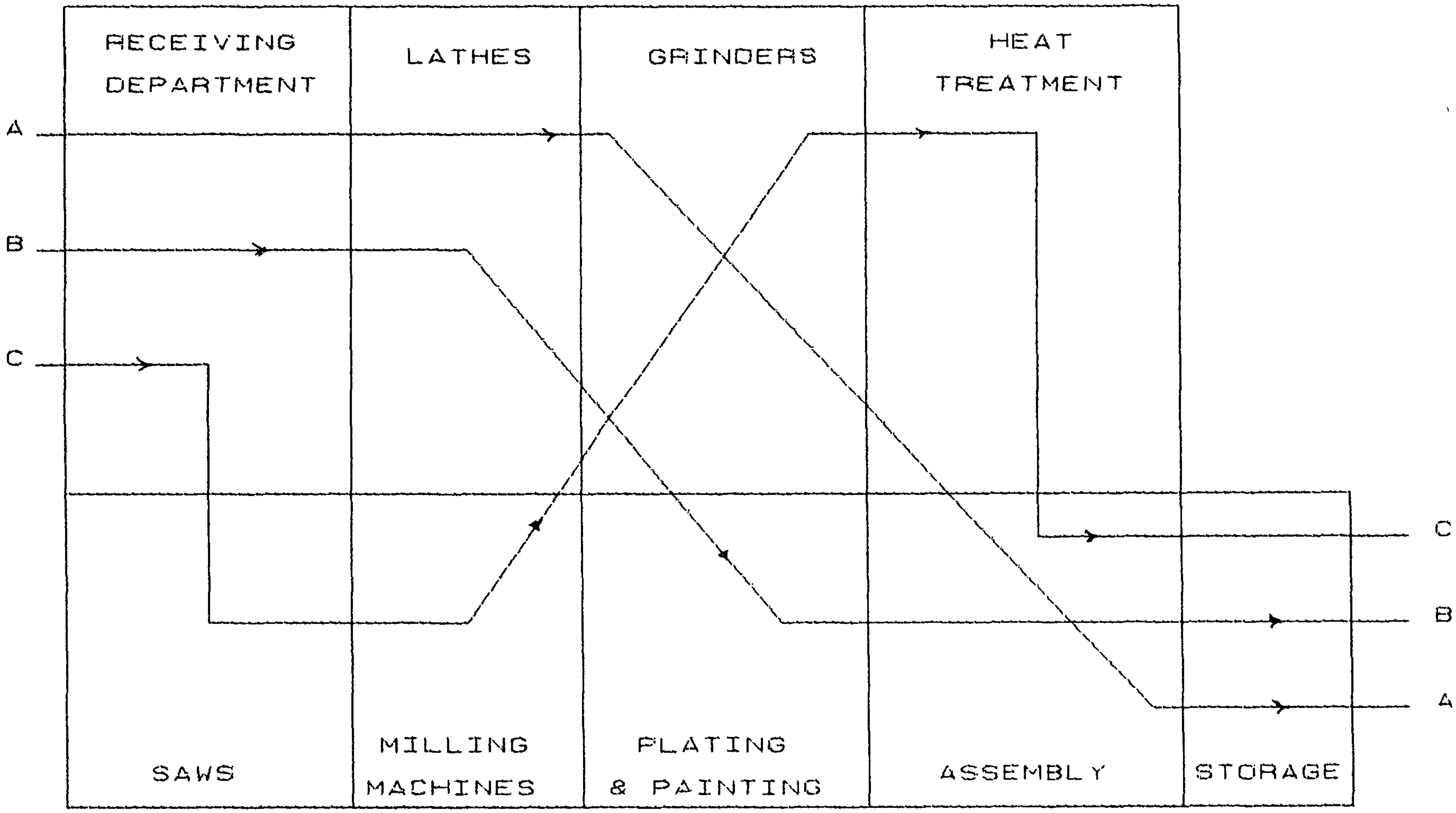

Fig 2.1 PROCESS LAYOUT MANUFACTURING SYSTEM
Ref:[2]

1. Proliferation of numbers and varieties of products. This results in smaller production lot sizes (as variety is increased) and decreased product life cycles. Set up cost, as a percentage of total cost, becomes greater, as do the problems of managing inventories and materials.

2. Greater need for closer tolerances and greater precision.
3. Increased cost of product and service liability as consumers demand accountability on the part of manufacturers, which requires greater emphasis on reliability and quality.
4. Increased variety in materials with more diverse properties, which requires great flexibility and diversity in the processes used to machine or form these new materials.
5. Increased cost of energy needed to transform materials and of capital and materials.
6. The need to markedly improve productivity and reduce the costs of goods and services to halt inflation and meet international competition from those who are using these systems.
7. The move away from a labor intensive manufacturing environment toward a service environment.
8. The need for shorter service times or lead times in production to reduce inventories and allow faster response to changes in demand.
9. Worker demands for improved quality of working life.

Overlaying these trends is the continued rapid growth of process technology, led by computer technology. No one can forecast the ultimate magnitude of this technological development, but it is clear that no segment of manufacturing and production will escape its impact.

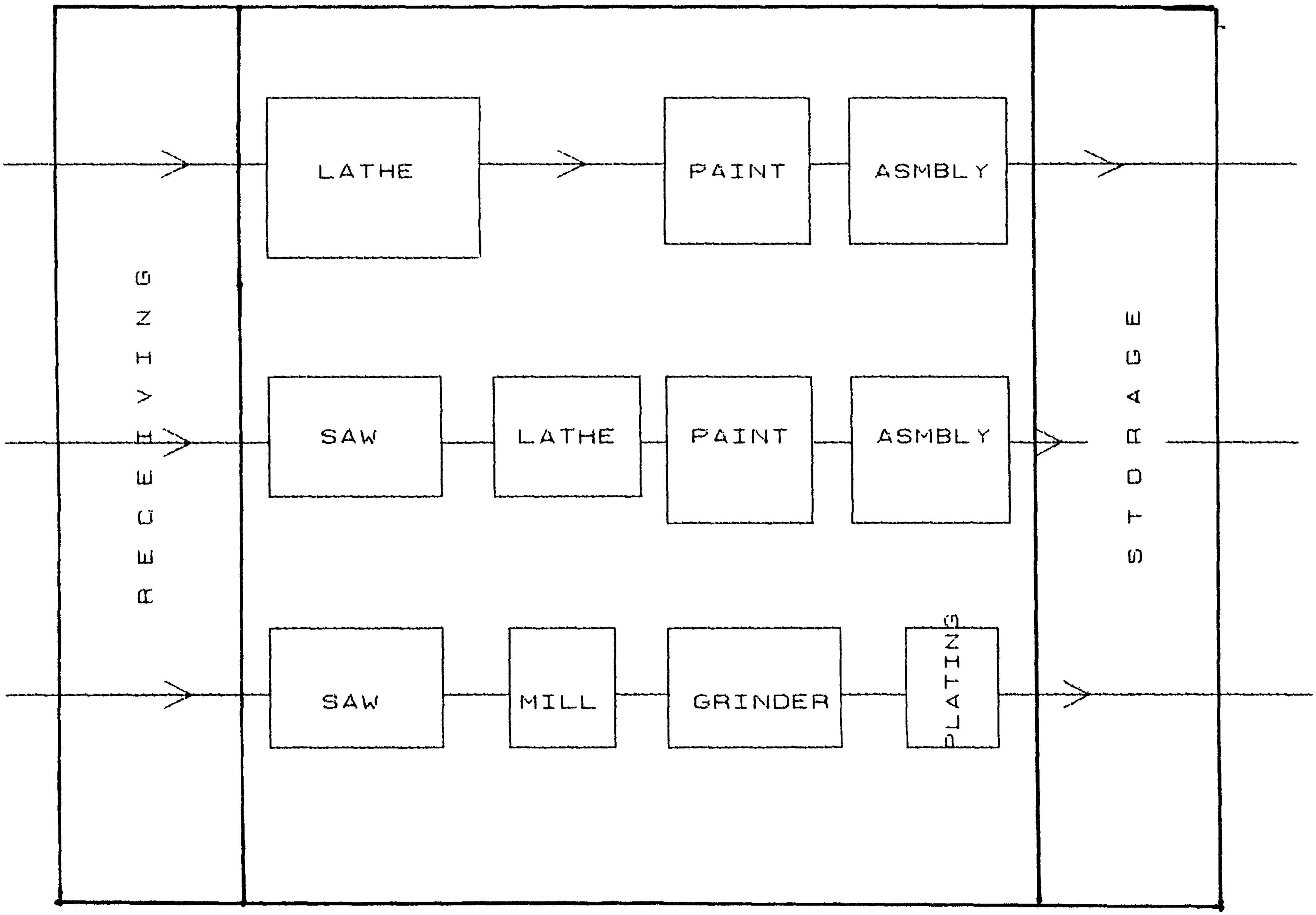

Fig 2.2 PRODUCT FLOW MANUFACTURING SYSTEM
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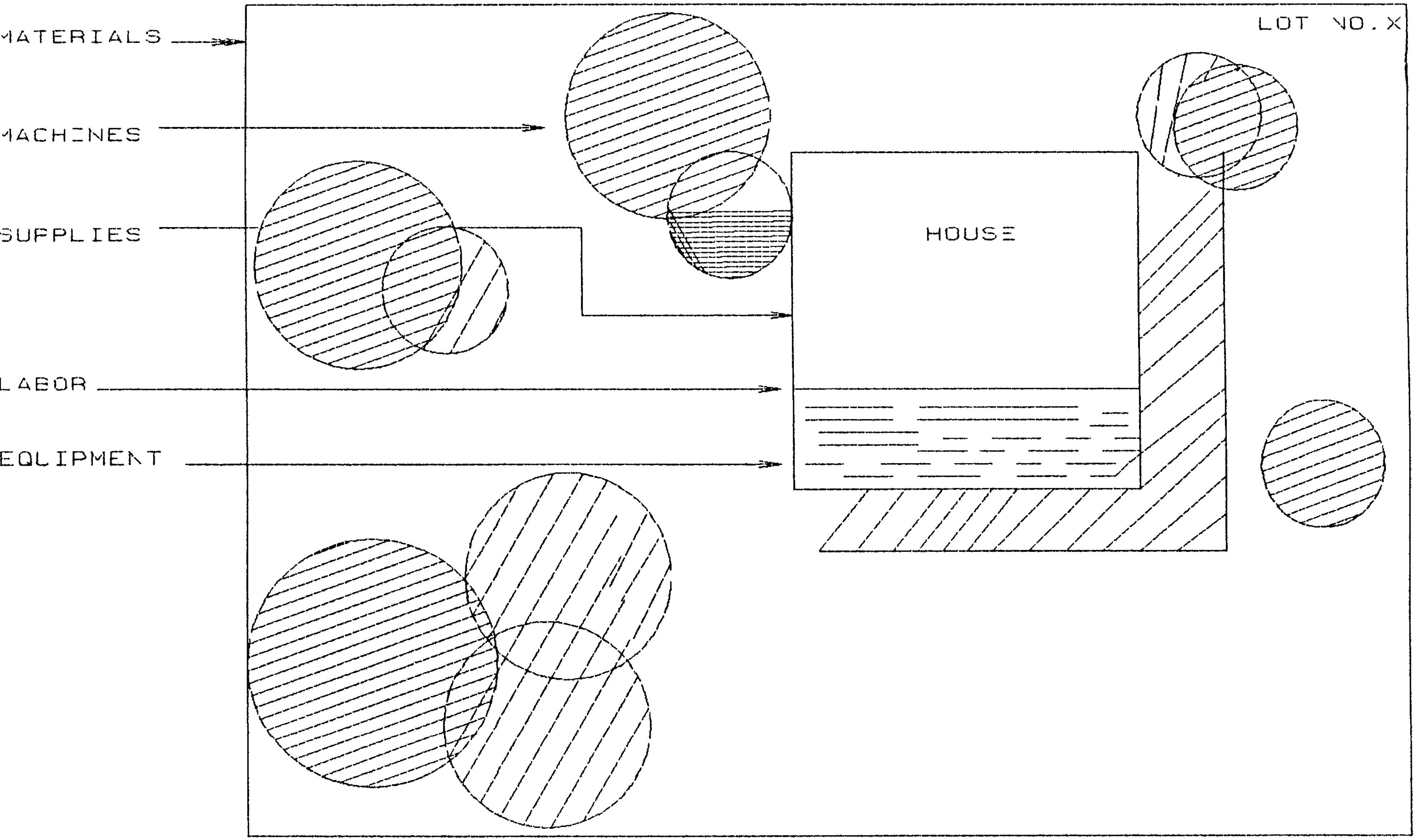

Fig 2.3 PROJECT LAYOUT MANUFACTURING SYSTEM
Ref:[2]

Computer Aided Design, Computer Aided Manufacturing, Computer Aided Process Planning, Computer Aided Testing and Inspection and Computer Aided Integrated Information Systems are rapidly being integrated into the factory of tomorrow.

2.2 Product Flow Manufacturing System

The product flow manufacturing system is a transformation process in which successive units of output undergo the same sequence of operations with more specialized equipment, usually involving a production line. In general the product flow manufacturing system is also called as Flow shop, figure 2.2.

The functions of product flow manufacturing system are of special purpose and single function type of machines. The set up time is long, workers being low skilled. The inventories in product flow manufacturing system are large to provide buffer storage. The production time is short and constant. The product flow manufacturing or flow shop layout are seen in the areas of auto assembly lines, and television manufacturing companies. In this system all units follow the sequence of operations and pass through all machines and backflow is absolutely not allowed.

2.3 Project Layout Manufacturing System

The third kind of system, the project layout manufacturing system also called project shop, figure 2.3, is directed toward creating a product or service which is either very large (immobile) or one-of-a-kind with a set of well defined tasks that typically must be accomplished in some specified sequence. The types of machines in project shop are general purpose and mobile.

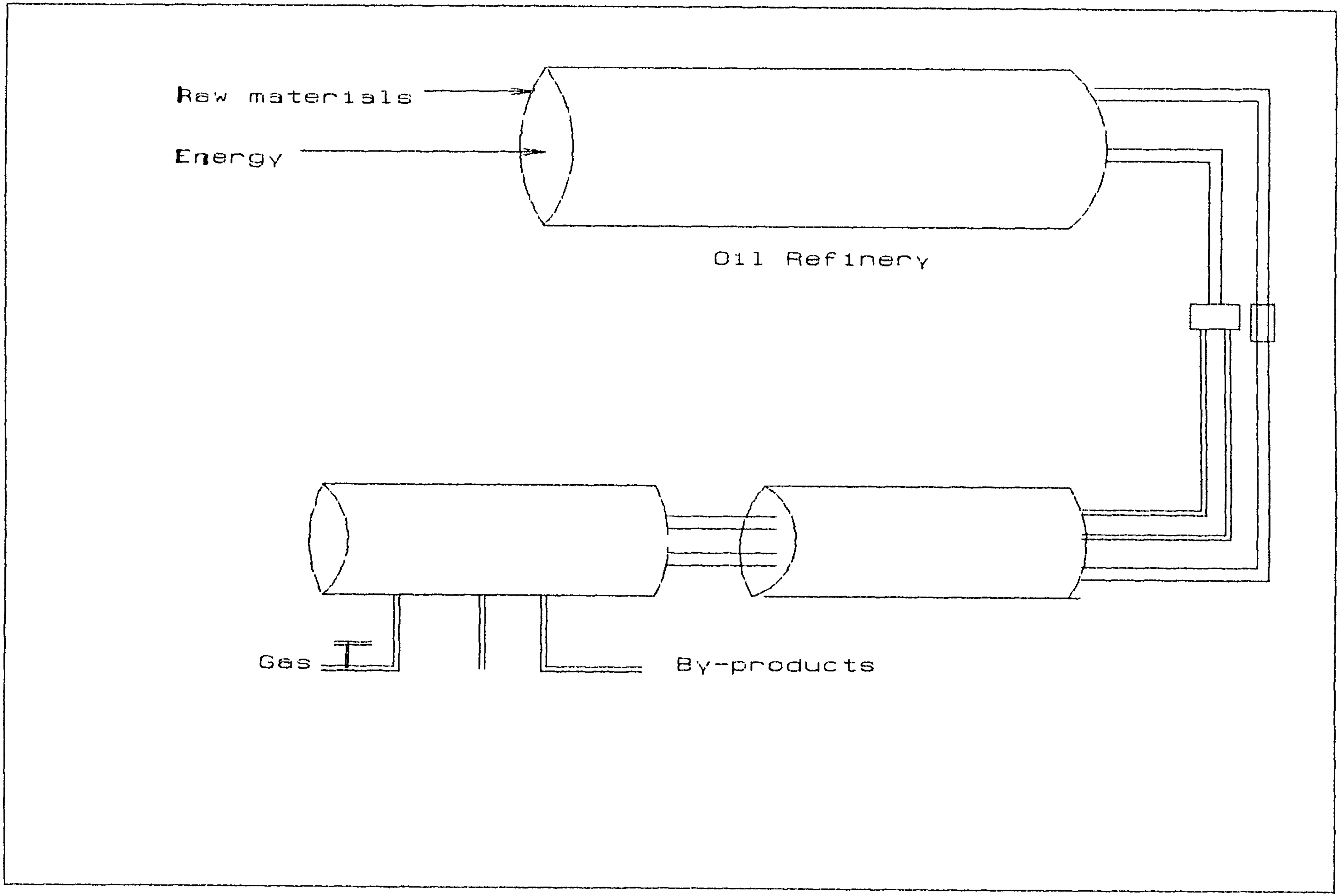

Fig 2.4 CONTINUOUS PROCESS FLOW SYSTEM
Ref:[2]

The people, materials and machines all come to the project site for assembly and processing. The project is generally backed up by a job shop and flow shop system to supply component parts and subassemblies to the project. Usually the set up times are variable and the lot sizes are very small. The inventories in the project shop are of a wide variety of raw materials. The best example where this system is followed is ship building.

2.4 Continuous - Process Flow System

The fourth type of traditional manufacturing system is the continuous process system illustrated in figure 2.4 in which products-generally gases, liquids or slurries flow through a series of directly connected processes or operations that link raw material (inputs) with finished products (outputs). The types of machines in this system are customized special purpose machines and the very design of processes is basically dependent upon the product. The system can be maintained with little skilled and unskilled manpower.

Chapter 3

FOUNDATION ELEMENTS FOR CELLULAR MANUFACTURING

All manufacturers in the world have become very receptive to new ideas that promise improved competitiveness. The latest technology and accent that was accepted by all is Just In Time (JIT) manufacturing and Group Technology as shown in the figure 3.1. JIT focuses on flow through the operation and cellular manufacturing is one of its core elements that leads to flow. Cellular manufacturing is an application of the Group Technology (GT).

Cellular Manufacturing may be defined as a production system consisting of several manufacturing equipment of different types to manufacture a family or group of parts requiring similar processing. A cell may be anywhere from two to fifteen machines. The cellular system groups processes, people and machines to treat a specific group of parts. The output typically is completed components, each of the classical manufacturing systems has a mechanism for handling information and material movement and storage, purchasing, planning, production control and so forth. Collectively, these activities represent the production system. The production system is designed around the manufacturing system to support it.

The emergence of the cellular manufacturing system and its highly automated form, the flexible manufacturing system (FMS) has resulted in a new type of production system which is capable of producing high quality products at low cost. The best example of this new production system appears to be the Toyota Motor Company's Just-in-time (JIT) production system.

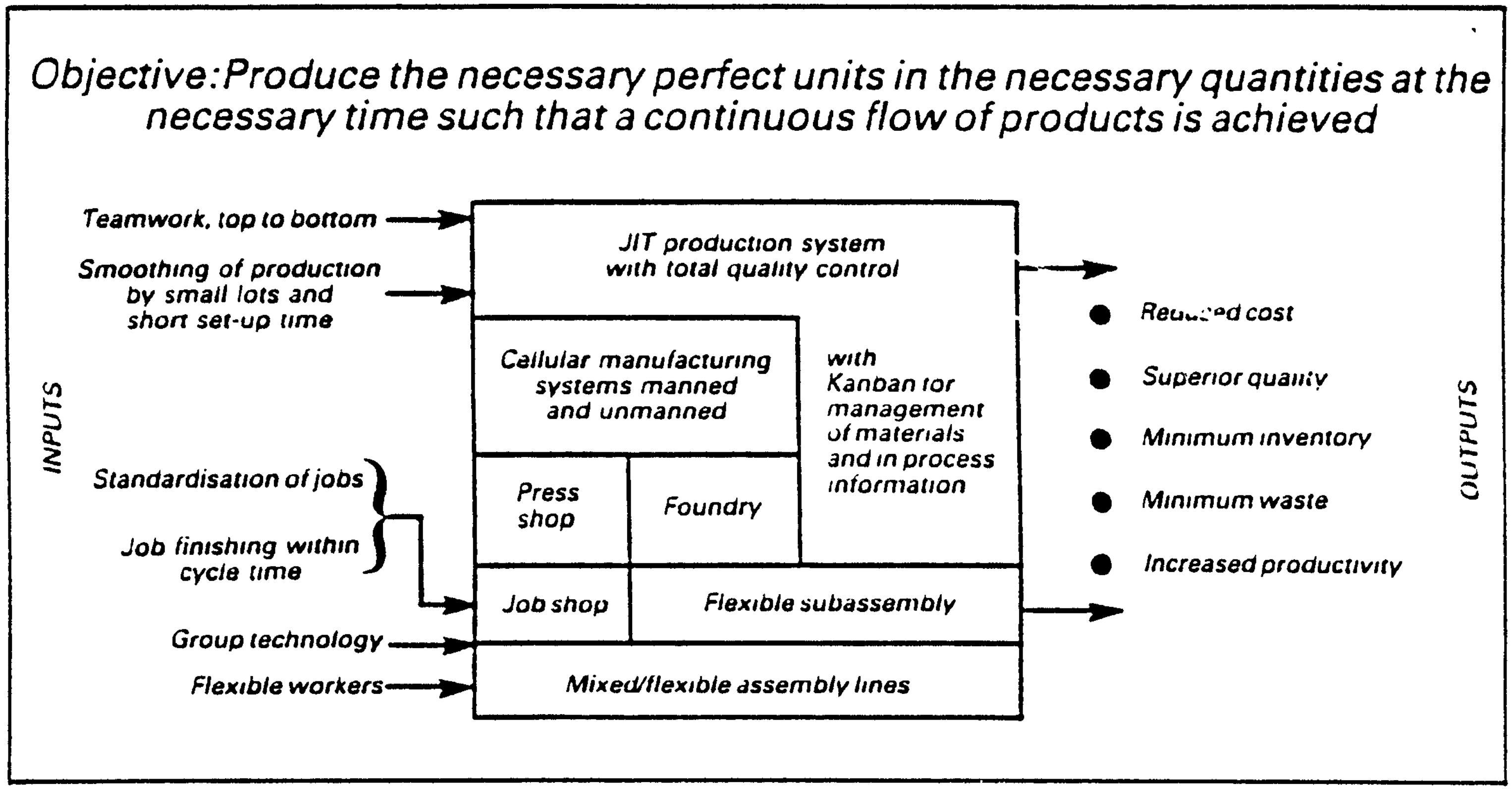

Fig 3.1 JUST IN TIME PRODUCTION SYSTEM
Ref:[27]

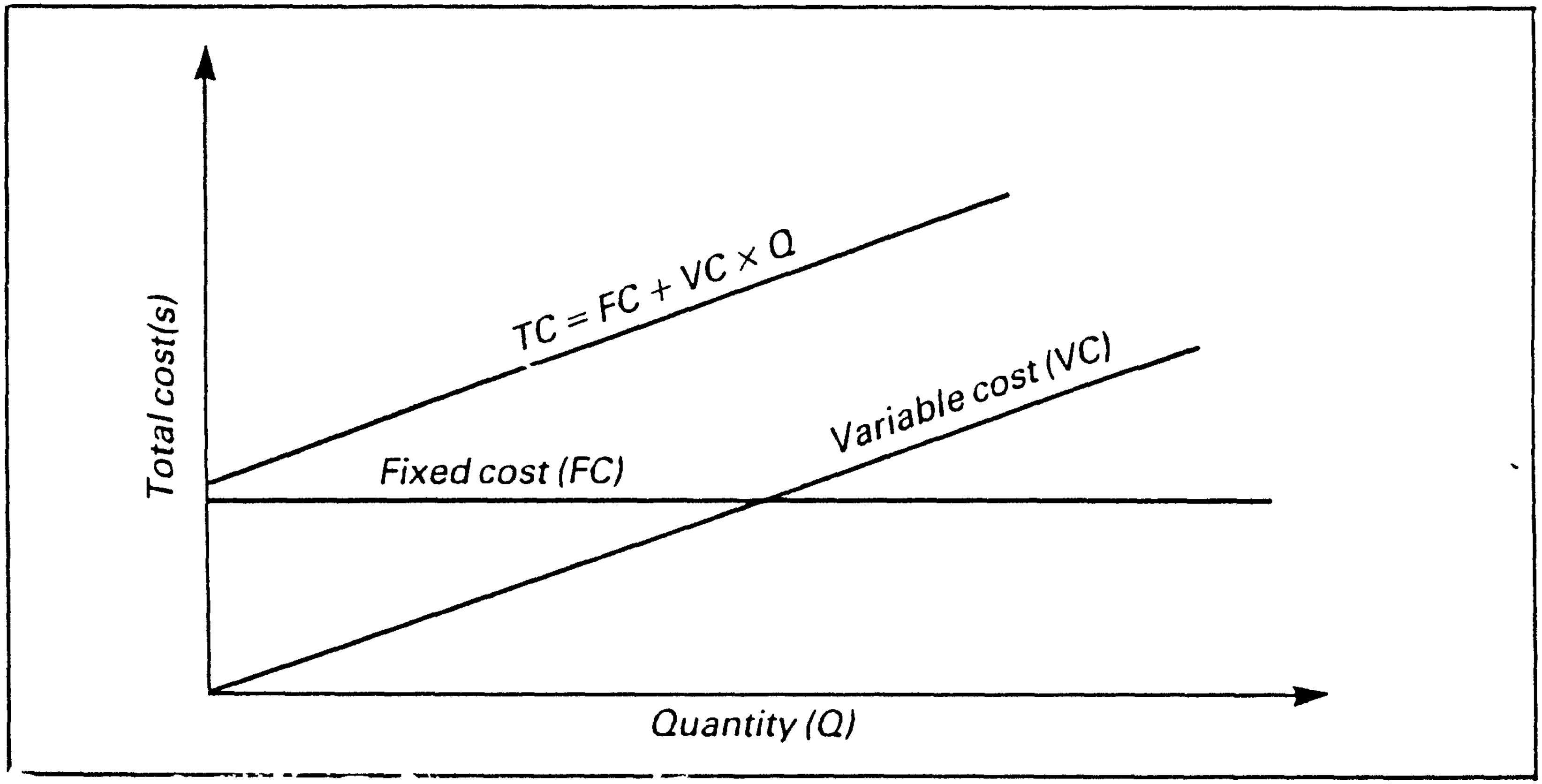

Fig 3.2 ECONOMICS OF LOT OR BATCH PRODUCTION
Ref:[27]

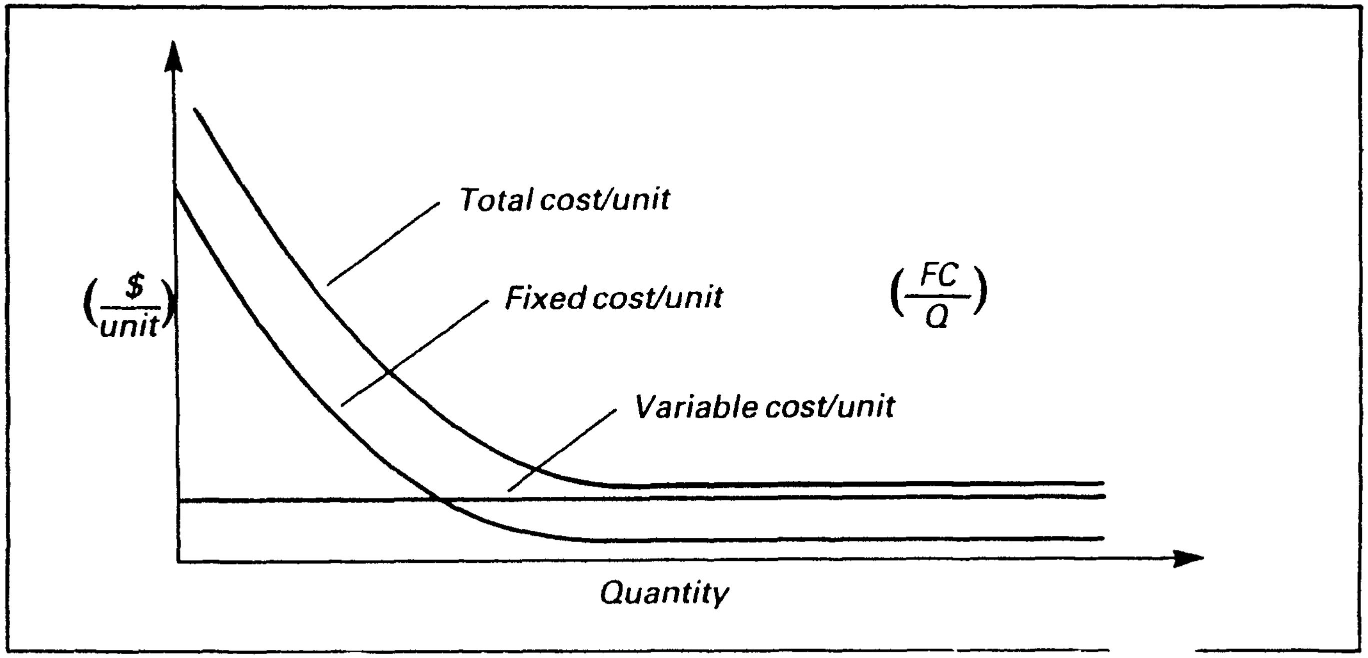

Fig 3.3 CLASSICAL REPRESENTATION OF PRODUCTION ECONOMICS FOR COST PER UNIT VERSUS QUANTITY
Ref:[2]

Group technology is a systems based rationale for solving the reorganization problems involved in setting up cellular manufacturing systems. It provides a computer oriented data base and tools which the manufacturing engineer can use to design the work cell. A Group Technology analysis develops the families of parts which can be manufactured by a flexible, cellular grouping of machines. The machines in the cells can be retooled so that one can rapidly change from one lot of components to another, eliminating setup time or reducing it to a matter of minutes. Eliminating setup time dramatically alters the economics of lot or batch production to permit the economical production of very small lots.

In equation form,

TC (Total Cost) = FC + VC X Q where,

FC = Fixed cost

VC = Variable cost

Q = Quantity. Setup is a fixed cost. It does not vary with the quantity made. Labor and material are variable costs. Fig. 3.2 is a graphical picture of this equation. The cost per unit is obtained by dividing the total cost (TC) equation by the quantity (Q) as shown in the figure 3.3

$$TC/Q = FC/Q + V$$

FC/Q represents, the fixed costs being spread out over many units to reduce the cost per unit sufficient enough to make production of the item economical. Eliminating or greatly reducing the fixed costs by eliminating the setup time and its related labor cost as illustrated in the figure 3.4. becomes economical to make things in small lots rather than making them in large lots.

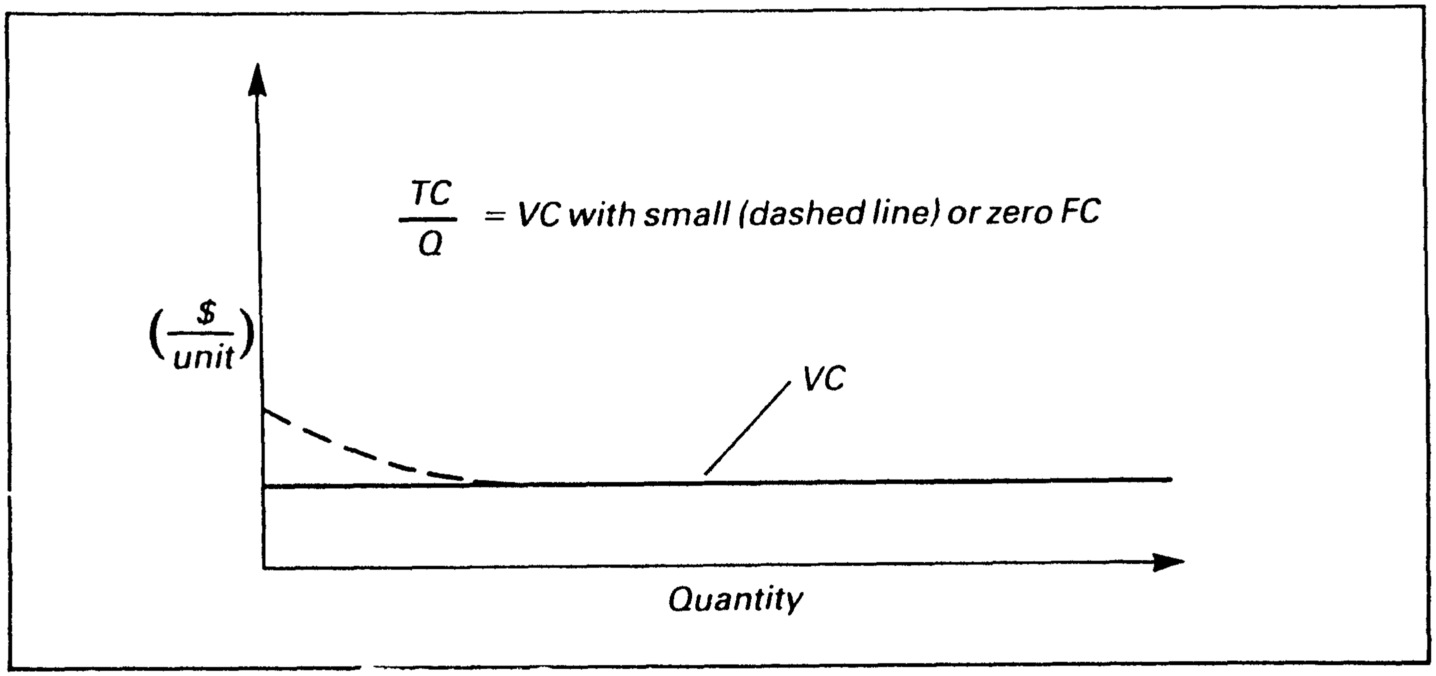

Fig 3.4 EFFECT ON UNIT COST OF REDUCED SET UP TIME
Ref:[2]

In cellular arrangements, one worker can hand a part directly to the next worker for another operation. If the part is defective, the process is halted to determine the cause. Quality feedback is immediate, and high quality products emerge. Small lot quantity, coupled with a 100% perfect product smooths the production flow.

After many years and much hard work, the discrete part system begins to look more and more like a *continuous flow process* in which products flow like water through the plant. But the *key* step to transforming a production system based on job shop/flow shop manufacturing systems is the transformation to a cellular manufacturing systems.

Cellular manufacturing has existed for many years, but it has not been properly defined or well understood, and it certainly hasn't been recognized as a particular type of manufacturing system. To define a manufacturing cell, it is a cluster or collection of machines designed and arranged to produce a specific group of component parts. Few rules, and virtually no theory, exists for designing cellular manufacturing systems. The first rule is that the design should be as flexible as possible so that it can readily expand to include other components or be modified to handle additional members of the family. The objective is to link the cells into a large manned or unmanned integrated manufacturing system. Cells can be categorized into two general groups: *manned and unmanned.*

<u>Manned Cells</u>: Manned cells contain machine tools which are conventional or programmable (NC or CNC machines) and production workers who have been trained and are skilled in the operation of more than one piece of equipment within the

the cell. The multifunctional worker is unusual in the typical job shop, but not in microelectronics job shops, where workers have been extensively cross trained with no difficulty. Manned cells are efficient because the number of workers can be adjusted and minimized to meet the desired output. Regarding the design of manned cells, Monden [19] notes that the U shape appears to offer the greatest flexibility because the range of jobs which the multifunctional worker can cover can easily be increased or decreased as needed. As the production requirements of the cell are reduced, the number of workers is reduced accordingly, and workers cannot simply expand the jobs to fill the increased time available.

The cells are tied to each other by a material handling system or are directly linked or combined into larger integrated lines. Layouts which result in waiting times for the worker, larger in-process inventories, isolation of the workers and situations in which worker waiting time is absorbed in producing unnecessary inventory are avoided. Linear manned layouts in which the worker walks from one machine to the next avoid most of these problems, but are not as flexible (in terms of rebalancing the number of workers in the cell in the event of demand changes) as the U-shaped cell.

In the manned cellular system, the worker is decoupled from the machines, so that the utility of the worker is no longer tied to the utility of the machine. (This means that there may be fewer workers in the cell than there are machines.) The objective is to improve the utilization of the people by making them multifunctional, capable of running all the machines in the cell.

<u>Unmanned Cells</u>: Unmanned cells contain machine tools that are programmable (CNC machine tools or other automated equipment), and there are few if any

workers within the cell. Unmanned cells have a number of classes or arrangements. These are:

a. Fixed Automated or Transfer Lines: These cells are classically represented in which the quantities are very large (large lots) and the runs long. Such systems are generally arranged in lines, circles or the U shape. They usually have a conveyor which both locates the part and transports it from the machine station, and the line is balanced such that the part spends the same amount of time at each station. The volume of parts is very large and the variety very small. These cells are not very flexible.

b. Flexible Automated: These cells are represented by the FMS (flexible manufacturing systems) and the robotic cell. The FMS is generally arranged in a line or a rectangular design with a computer controlled conveyor to transport the parts to any machine in any order. The machines are programmable and therefore can change tools and machining programs to handle different parts. Parts can be introduced into the system in any order. Therefore, this system works on a family of component parts with medium to large lot sizes. These systems tend to be rather large and expensive, typically containing five to 12 machine tools; their cost parallels that of the transfer lines.

The robotic cell generally has few machines and is arranged so that a robot can load and unload the machines and change the tools in them, if necessary. In both the FMS and robotic designs, there should be liberal use of automation (automatic inspection) to ensure a high percentage of good parts. Robotic cells are typically circular in design to take advantage of the range of motion of the robot (assuming the robot has a spherical or circular spatial range), but are not limited to such arrangements. As rectangular and mobile robots become more common, other designs will emerge. In fact, as robots become more versatile, they will be able to communicate better with each other and will be able to hand parts to each other just as workers in manned cells hand parts to each other. In most robotic cells in place today, there is only one robot. If there are multiple robots, they are placed on the floor so that they cannot reach each other or are programmed so that they cannot enter the same space at the same time. When we have robots which are mobile within cells or can interact with each other, it appears likely that the FMS design will be employed only when parts are either too large (too heavy) for robots to pass from one to another or too small to be properly handled. The bottom line in these designs, however, is flexibility with small lot sizes.

3.1 Development of Cellular or Work Cell

Getting started in cellular manufacturing requires a long term commitment on the part of management, engineering and, most importantly, the shop floor. Some of the most successful efforts in implementing manufacturing cell required little or no investment in equipment. In the past, manufacturing engineers were always concerned with gaining the maximum utilization from a machine, particularly if the machine were new. This led to the effort of optimizing the machine load by obtaining as many parts that could be manufactured by the machine, regardless of how far away these parts had to travel or how far away their final point of use was.

The use of Group Technology (GT) will allow engineers to group parts into similar part families by geometric similarities or part/product likeness. Once the families are established, machine requirements are then determined. The main goal is to identify and dedicate existing machines to the specific groups of parts or product. When a group of machines has been determined, they are then located physically next to each other, preferably right next to where the parts or sub-assemblies will be finally used. The objective is to eliminate set-ups between the different component parts in the parts family or, at worst, to be able to use essentially the same fixturing for every part in the family with quick action modification, or 'one-touch set-up' between parts. In manned cells, this objective can be readily accomplished - as has been demonstrated by numerous Japanese and American manufacturers - with the result that one can economically manufacture in very small lots. Furthermore, the concept of single set-up which means that set-up is accomplished in less than ten minutes, can be extended to presswork and foundry areas which are still essentially in lot type shop production. In the press shop at Toyota, for example, workers routinely change dies in the presses in three to five minutes or less. The same job at many American or European companies may take four to five hours. This has the effect of markedly reducing inventory turns. However, the Japanese have found that the main benefits are superior quality, worker motivation and enhanced productivity. *Setups are thus greatly reduced or eliminated.*

Careful emphasis must be given to the core business strategy of the company to help identify what products and components should be manufactured inhouse and what out sourced.. While smaller firms may find it easier to focus on their core business, many larger companies will need to perform a computerized analysis of all part schedules and routings. Generally, such an analysis will reveal that 20% to 30% of the total routed part numbers make up 90% of the total machine loads. This means that roughly 75% of the routed part numbers contribute 10% or less of machine load.

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the cellular concepts and the implementation teams. Cellular manufacturing will impact the way in which all departments will function including purchasing, accounting, maintenance and materials management.

3.2 INTEGRATION OF THE DESIGN AND MANUFACTURING

The most common form of production in the United States is batch manufacturing which constitutes 50% or more of the total manufacturing activity. There is a growing need to make batch manufacturing more efficient and productive. Also, there is an increasing trend to achieve a higher level of integration of the design and manufacturing functions in a firm. One of the approaches that is directed at both of these objectives is **Group Technology (GT).**

Group Technology has its roots in Frederick Taylor's [10] attempts to identify and take advantage of means to improve productivity. As Taylor analyzed jobs he began to note that similarities did exist and was able to standardize and categorize these by attribute. The first documented description using the term 'Group Technology' is from Mitrofanov [10] a Russian whose purpose was to create a system that could minimize set-up time. Another driving force behind group technology is Opitz. His early text published [20] in Aachen, Germany, created a very basic nine digit code for rotational parts that can serve as an excellent springboard for today's Group Technology beginners. Later in the 1970's Han [18] at Penn State University and Allen [18] at Brigham Young University began in earnest to promote the concept of group technology via opportunities on the shop floor and in the organization of information in general, respectively. Since the early

1970's some commercial coding companies have evolved that provide group technology software and consulting. A few of these are:

1. The Vuoso-Praha System
2. DCLASS by Del Allen at Brigham Young University
3. CODE by MDSI.
4. Part Analog System by Lovelace.
5. Brisch by Hyde.
6. SAGT by ElGomayel.
7. CUTPLAN by Metcut, et all.
8. K K-3 System

Definition of Group Technology: Group Technology is a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in manufacturing and design. Similar parts are arranged into part families. For example, a plant producing 10,000 different part numbers may be able to group the vast majority of these parts into 50 or 60 distinct families. Each family would possess similar design and manufacturing characteristics. Hence, the processing of each member of a given family would be similar, and this results in manufacturing efficiencies. These efficiencies are achieved in the form of *reduced setup times, lower in-process inventories, better scheduling, improved tool control, and the use of standardized process plans.*

In product design, there are also advantages obtained by grouping parts into families. For example, a design engineer faced with the task of developing a new part design must either start from scratch or pull an existing drawing from the files and make the necessary changes to conform to the requirements of the new part.

The problem is that finding a similar design may be quite difficult and time consuming. For a large engineering department, there may be thousands of drawings in the files with no systematic way to locate the desired drawing. As a consequence, the designer may decide that it is easier to start from scratch in developing the new part. This decision is replicated many times over in the company, thus consuming valuable time creating duplicate or near-duplicate part designs. If an effective design-retrieval system were available, this waste could be avoided by permitting the Engineer to determine quickly if a similar part already exists. A simple change in an existing design would be much less time consuming than starting from scratch. This design-retrieval system is a manifestation of the group technology principle applied to the design function. To implement such a system, some form of parts classification and coding is required.

Parts classification and coding is concerned with identifying the similarities among parts and relating these similarities to a coding system. Part similarities are of two types: *design attributes* (such as geometric shape and size), and *manufacturing attributes* (the sequence of processing steps required to make the part). While the processing steps required to manufacture a part are usually closely correlated with the part's design attributes, this is not always the case. Accordingly, classification and coding systems are often devised to allow for differences between a part's design and its manufacture.

Whereas a parts classification and coding system is required in a design-retrieval system, it can also be used in computer-aided process planning (CAPP). Computer-aided process planning involves the automatic generation of a process plan (or route sheet) to manufacture the part. The process routing is developed by recognizing the specific attributes of the part in question and relating these attributes to the corresponding manufacturing operations.

3.2.a Formation of Part Families

Formation of part family is a collection of parts which are similar either because of geometric shape and size or because similar processing steps are required in their manufacture. The parts within a family are different, but their similarities are close enough to merit their identification as members of the part family. Figures 3.5 and 3.6 show two part families. The two parts shown in figure 3.5 are similar from a design viewpoint but quite different in terms of manufacturing. The parts shown in fig 3.6 might constitute a part family in manufacturing, but their geometry characteristics do not permit them to be grouped as a design part family. The part family concept is central to design-retrieval systems and most current computer-aided process planning schemes. Another important manufacturing advantage derived from grouping workparts into families can be explained with references to figure 3.7 and fig 3.8. Fig 3.7 shows a process type layout for batch production in a machine shop. The various machine tools are arranged by function. There is a lathe section, milling machine section, drill press section, and so on. During the machining of a given part, the workpiece must be moved between sections, with perhaps the same section being visited several times. This results in a significant amount of material handling, a large in-process inventory, usually more setups than necessary, long manufacturing lead times, and high cost. Fig 3.8 shows a production shop of supposedly equivalent capacity, but with the machines arranged into cells. Each cell is organized to specialize in the manufacture of a particular part family.

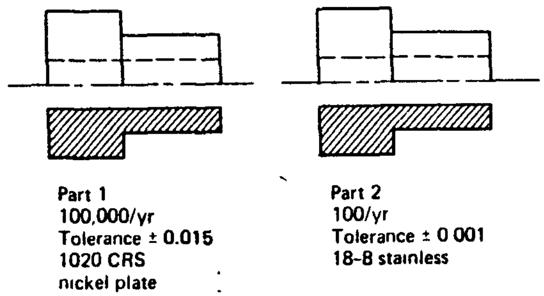


Fig 3.5 TWO PARTS OF IDENTICAL SHAPE AND SIZE BUT DIFF. MANUFACTURING REQUIREMENTS
Ref:[10]

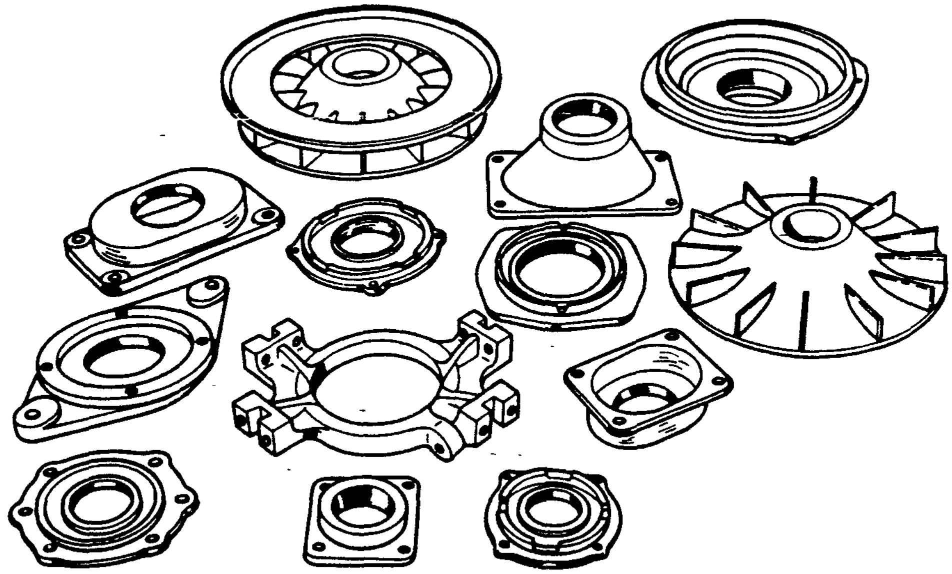


Fig 3.6 PARTS WITH SIMILAR MANUFACTURING BUT DIFFERENT ATTRIBUTES.
Ref:[10]

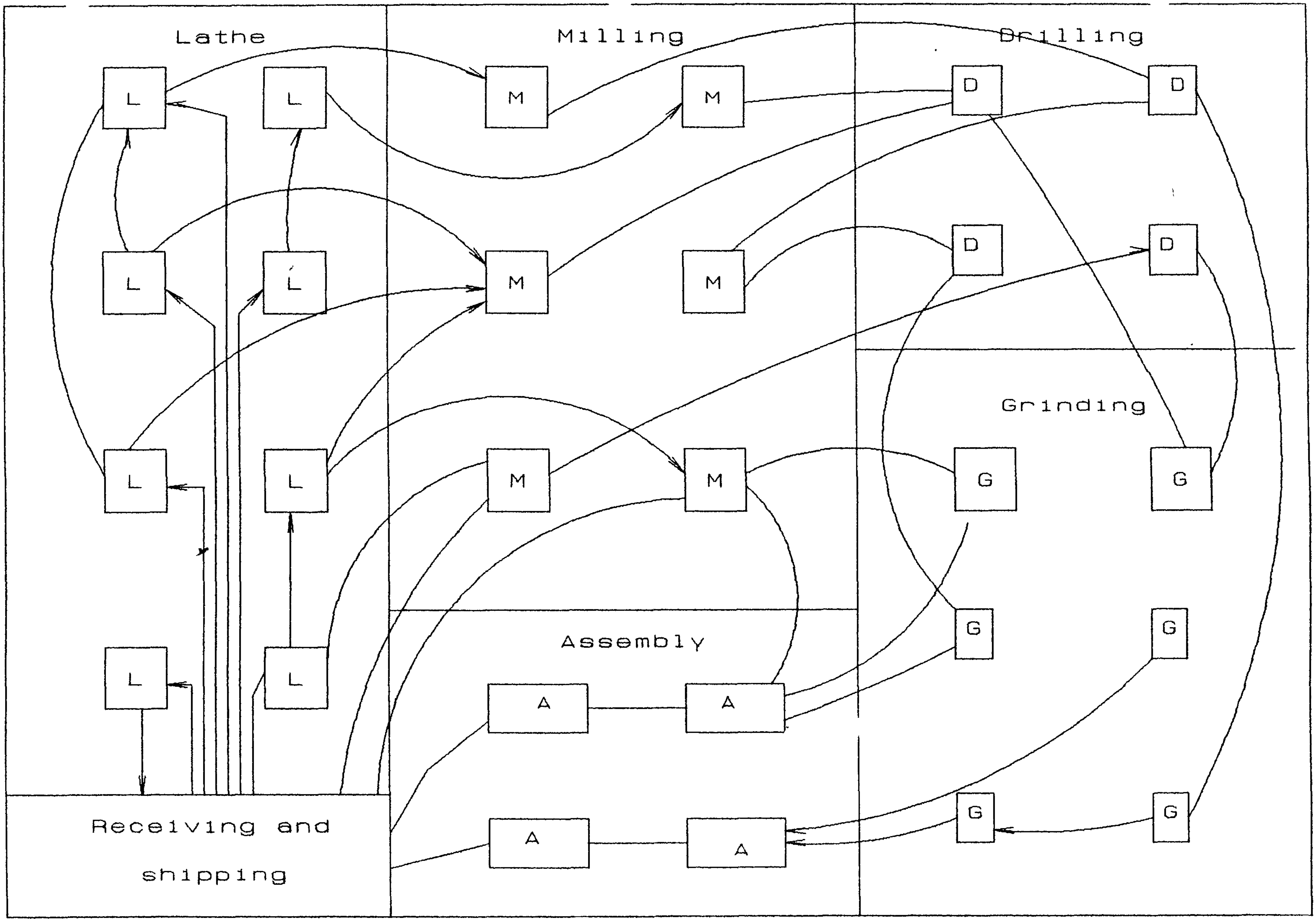


Fig 3.7 PROCESS TYPE LAYOUT

Ref:[7]

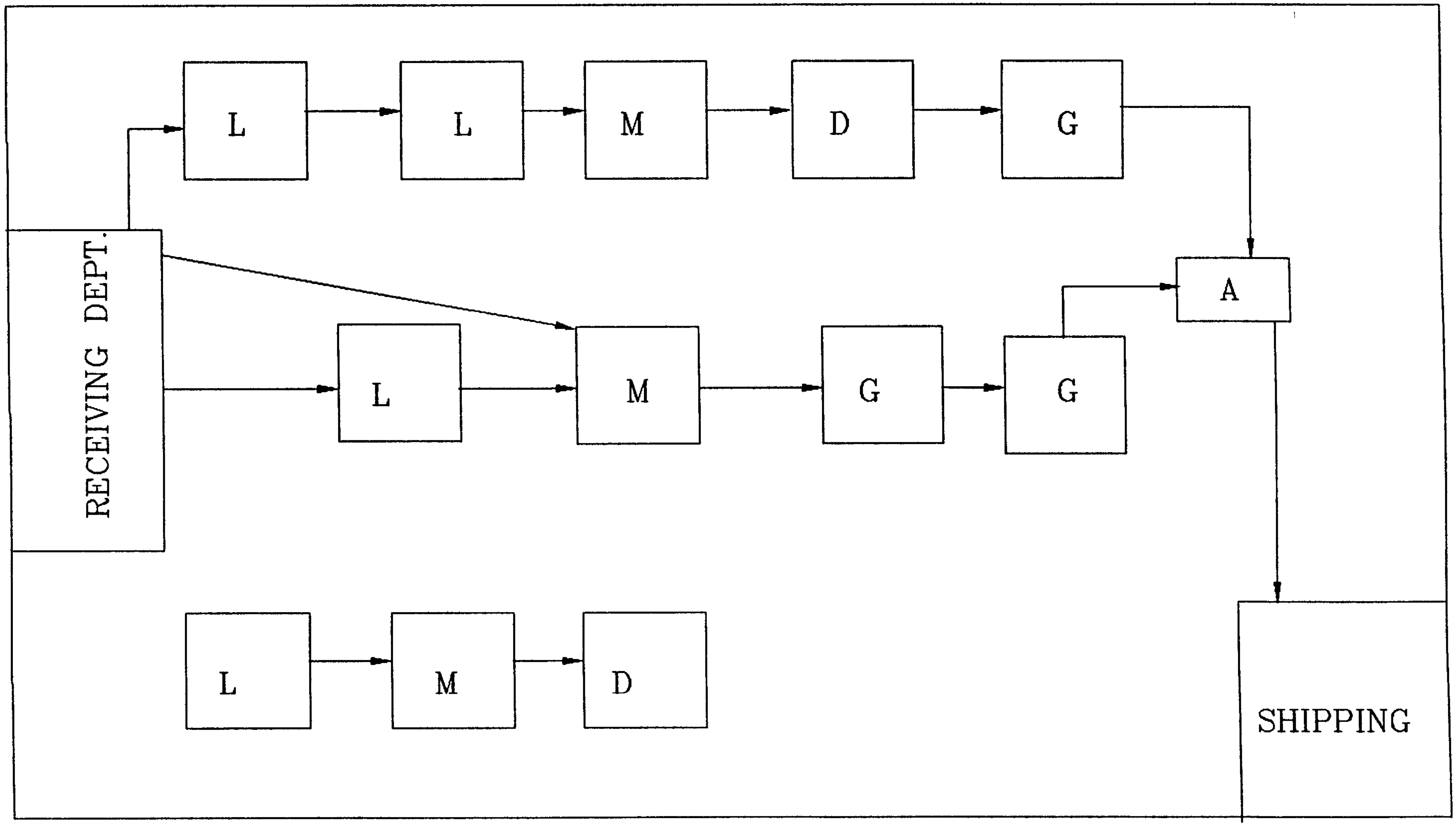


Fig 3.8 GROUP TECHNOLOGY LAYOUT
Ref:[10]

Advantages are gained in the form of reduced workpiece handling, lower setup times, less in-process inventory, less floor space, and shorter lead times. Some of the manufacturing cells can be designed to form production flow lines, with conveyors used to transport workparts between machines in the cell.

The biggest single obstacle in changing over to group technology from a traditional production shop is the problem of grouping parts into families. There are three general methods for solving this problem. All three methods are time consuming and involve the analysis of much data by properly trained personnel. The three methods are:

1. Visual inspection
2. Production flow analysis (PFA)
3. Parts classification and coding system

The visual inspection method is the least sophisticated and least expensive method. It involves the classification of parts into families by looking at either the physical parts or photographs and arranging them into similar groupings. This method is generally considered to be the least accurate of the three.

The second method, production flow analysis is method of identifying part families and associated machine tool groupings by analyzing the route sheets for parts produced in a given shop. It groups together the parts that have similar operation sequences and machine routings. The disadvantage of PFA is that it accepts the validity of existing route sheets, with no consideration given to whether these process plans are logical or consistent.

The third method, parts classification and coding, is the most time consuming and complicated of the three methods. It is the most frequently applied method and is generally recognized to be the most powerful of the three.

3.2.b Classification and Coding of Parts

This method of grouping parts into families involves an examination of the individual design and/or manufacturing attributes of each part. The attributes of the part are uniquely identified by means of a code number. This classification and coding may be carried out on the entire list of active parts of the firm, or a sampling process may be used to establish the part families. For example, parts produced in the shop during a certain given time period could be examined to identify part family categories. The trouble with any sampling procedure is the risk that the sample may be unrepresentative of the entire population. However, this risk may be worth taking, when compared to the relatively enormous task of coding all the company's parts.

Many parts classification and coding systems have been developed throughout the world, but none of them has been universally adopted. One of the reasons for this is that a classification and coding system should be custom-engineered for a given company or industry. One system may be best for one company while a different system is more suited to another company. The three parts classification and coding systems which are widely recognized in Group Technology are:

1. Opitz system
2. MICLASS system
3. CODE system

Design Systems Versus Manufacturing Systems

Parts classification and coding systems divide themselves into one of three general categories:

1. Systems based on part design attributes
2. Systems based on part manufacturing attributes
3. Systems based on both design and manufacturing attributes

Systems in the first category are useful for design retrieval and to promote design standardization. Systems in the second category are used for computer-aided process planning, tool design, and other production-related functions. The third category represents an attempt to combine the functions and advantages of the other two systems into a single classification scheme. The types of design and manufacturing parts attributes typically included in classification schemes are as follows:

Table: Design and Manufacturing Part Attributes Typically Included in a Group Technology Classification System

Part design attributes	
Basic external shape	Major dimensions
Basic internal shape	Minor dimensions
Length/diameter ratio	Tolerances
Material type	Surface finish
Part function	

Part manufacturing attributes

Major process	Operation sequences
Minor operation	Production time
Major dimensions	Batch size
Length/diameter ratio	Annual production
Surface finish	Fixtures needed
Machine tool	Cutting tools

Structure of Coding System

A part coding scheme consists of a sequence of symbols that identify the part's design and/or manufacturing attributes. The symbols in the code can be all numeric, all alphabetic, or a combination of both types. However, most of the common classification and coding systems use number digits only. There are three basic code structures used in group technology applications:

1. Hierarchical structure
2. Chain-type structure
3. Hybrid structure, a combination of hierarchical and chain-type structures

With the hierarchical structure, the interpretation of each succeeding symbol depends on the value of the preceding symbols. Other names commonly used for this structure are monocode and tree structure. The hierarchical code provides a relatively compact structure
which conveys much information about the part in a limited number of digits.

In the chain-type structure, the interpretation of each symbol in the sequence is fixed and does not depend on the value of preceding digits. Another name commonly given to this structure is polycode. The problem associated with polycodes is that they tend to be relatively long. On the other hand, the use of a polycode allows for convenient identification of specific part attributes. This can be helpful in recognizing parts with similar processing requirements.

The difference between the hierarchical structure and the chain-type structure can be found out considering a two-digit code, such as 16 or 26. Suppose that the first digit stands for the general part shape. The symbol 1 means flat rectangular and 2 means round workpart geometry. In a hierarchical code structure, the interpretation of the second digit would depend on the value of the first digit. If preceded by 1, the 6 might indicate some length/diameter ratio, and if preceded by 2, the 6 might be interpreted to specify some overall length. In the chain-type code structure, the symbol 6 would be interpreted the same way regardless of the value of the first digit. For example, it might indicate overall part length, or whether the part is rotational or rectangular.

Most of the commercial parts coding systems used in industry are a combination of the two pure structures. The hybrid structure is an attempt to achieve the best features of monocodes and polycodes. Hybrid codes are typically constructed as a series of short polycodes. Within each of these shorter chains, the digits are independent, but one or more symbols in the complete code number are used to classify the part population into groups, as in the hierarchical structure. This hybrid coding seems to best serve the needs of both design and production.

3.2.c Factors for Parts Coding and Classification

According to Inyong Ham [11] the following factors must be considered when implementing a parts coding and classification system:

1. Objective: The prospective user should first define the objective for the system. Whether it is being used for design retrieval or part-family manufacturing or both.
2. Scope and application: The company must define the department, department specific requirements in which the system is to be implemented. It should know of what kind of information to be coded on the product, and how wide a range of products must be coded. The company should also define the parts, shapes, processes, tooling and so forth.
3. Costs and time: The company must consider the costs of installation, maintenance of system and the time required for installation and training the staff to operate and maintain it. It should also consider the time range before the benefits of the system are realized.
4. Adaptability to other systems: The company must consider whether the classification and coding system be readily adapted to the existing company computer systems, integrated with other company procedures such as process planning, NC programming, production schedules and other data base.
5. Management problems: The company should inform the management personnel, union and various departments and it should know whether all these people cooperate and supports the system. The three parts classification and coding systems widely recognized are Opitz, MICLASS, CODE.

OPITZ CLASSIFICATION SYSTEM

This parts classification and coding system was developed by H. Opitz [20] in West Germany. This represents one of the pioneering efforts in the group technology area and is perhaps the best known of the classification and coding systems. The Opitz coding system consists of a geometric code and a supplementary code. Geometric code or basic code consists of nine digits, which can be extended by adding four more digits.

The Opitz coding system uses the following digit sequence:

12345 6789 ABCD

The first nine digits are intended to convey both design and manufacturing data. Ex: Rotational, Flat, Long and Cubic. The first five digits 12345 are called the 'Form Code' and basically describe the primary attributes of the part. The next digits 6789 represents supplementary code indicating some of the attributes that may be used in manufacturing. The first insupplementary code digits represents the major dimension (either diameter or edge length). The appropriate component size can be determined by using the dimension ratio specified in the geometry. The dimension range is specified from 0.8 to 80.0 in. Dimensions of less 0.8 in and greater than 80.0 in are represented by a 0 or 9 code respectively. The Opitz coding is concise and easy to use. The extra four digits, ABCD, are referred to as the "secondary code" and are intended to identify the production operation type and sequence. The secondary code can be designed by the firm to serve its own particular needs. Fig 3.9, Fig 3.10 shows the definitions of code values 0,1,2 and coding of first digits respectively.

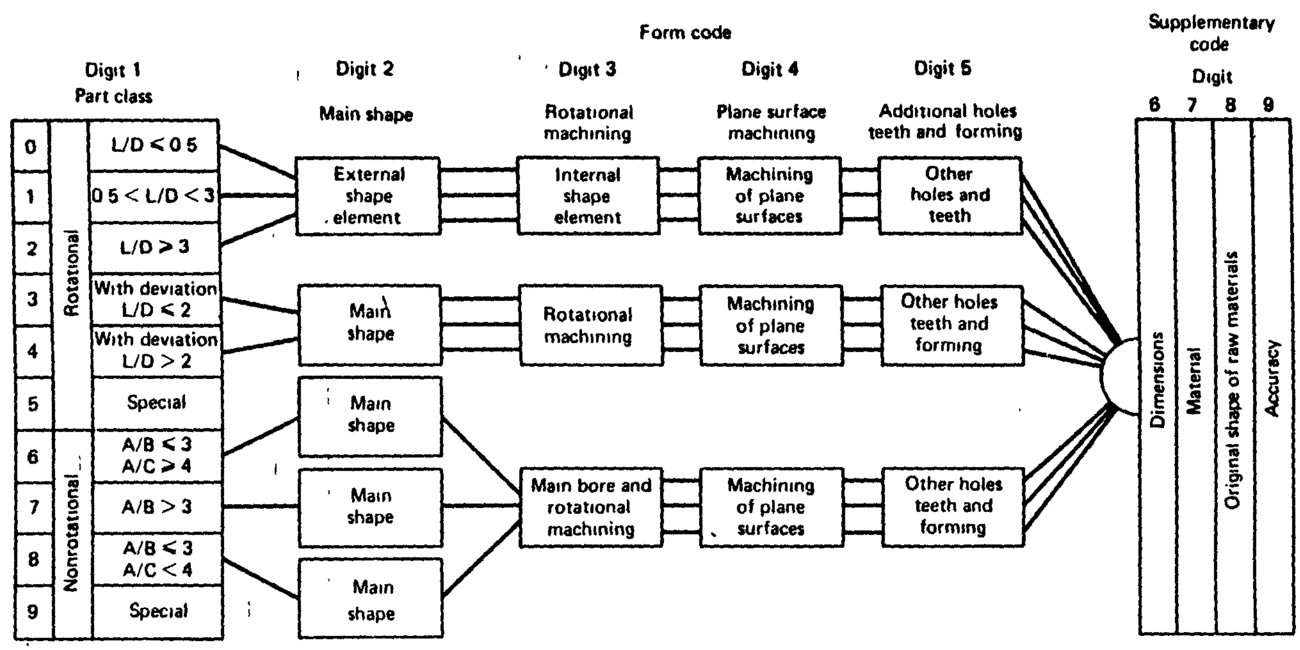


Fig 3.9 STRUCTURE OF THE OPITZ SYSTEM
Ref:[7]

Digit 1

	Part class	
0	Rotational parts	$L/D \leq 0{\cdot}5$
1	Rotational parts	$0{\cdot}5 < L/D < 3$
2	Rotational parts	$L/D \geq 3$
3	Rotational parts	
4	Rotational parts	
5	Rotational parts	
6	Nonrotational parts	
7	Nonrotational parts	
8	Nonrotational parts	
9	Nonrotational parts	

Digit 2

	External shape, external shape elements	
0		Smooth, no shape elements
1	Stepped to one end or smooth	No shape elements
2	Stepped to one end or smooth	Thread
3	Stepped to one end or smooth	Functional groove
4	Stepped to both ends	No shape elements
5	Stepped to both ends	Thread
6	Stepped to both ends	Functional groove
7		Functional cone
8		Operating thread
9		All others

Digit 3

	Internal shape, internal shape elements	
0		No hole, no breakthrough
1	Smooth or stepped to one end	No shape elements
2	Smooth or stepped to one end	Thread
3	Smooth or stepped to one end	Functional groove
4	Stepped to both ends	No shape elements
5	Stepped to both ends	Thread
6	Stepped to both ends	Functional groove
7		Functional cone
8		Operating thread
9		All others

Digit 4

	Plane surface machining
0	No surface machining
1	Surface plane and/or curved in one direction, external
2	External plane surface related by graduation around a circle
3	External groove and/or slot
4	External spline (polygon)
5	External plane surface and/or slot, external spline
6	Internal plane surface and/or slot
7	Internal spline (polygon)
8	Internal and external polygon, groove and/or slot
9	All others

Digit 5

	Auxiliary holes and gear teeth	
0	No gear teeth	No auxiliary hole
1	No gear teeth	Axial, not on pitch circle diameter
2	No gear teeth	Axial on pitch circle diameter
3	No gear teeth	Radial, not on pitch circle diameter
4	No gear teeth	Axial and/or radial and/or other direction
5	No gear teeth	Axial and/or radial on PCD and/or other directions
6	With gear teeth	Spur gear teeth
7	With gear teeth	Bevel gear teeth
8	With gear teeth	Other gear teeth
9	With gear teeth	All others

Fig 3.10 FORM CODE FOR ROTATIONAL PARTS IN THE OPITZ SYSTEM

Ref:[7]

The MICLASS System

MICLASS stands for Metal Institute Classification System and was developed by TNO, the Netherlands Organization for Applied Scientific Research. It was started in Europe about five years before being introduced in the United States in 1974. Today, it is marketed in the United States by the Organization for Industrial Research in Waltham, Massachusetts. The MICLASS system was developed to help automate and standardize a number of design, production, and management functions. These include

Standardization of engineering drawings

Retrieval of drawings according to classification number

Standardization of process routing

Automated process planning

Selection of parts for processing on particular groups of machine tools

Machine tool investment analysis

The MICLASS classification number can range from 12 to 30 digits. The first 12 digits are a universal code that can be applied to any part. Up to 18 additional digits can be used to code data that are specific to the particular company or industry. For example, lot size, piece time, cost data, and operation sequence might be included in the 18 supplementary digits. The workpart attributes coded in the first 12 digits of the MICLASS number as follows:

1st digit	Main shape
2nd and 3rd digits	Shape elements
4th digit	Position of shape elements
5th & 6th digit	Main dimensions
7th digit	Dimension ratio

8th digit	Auxiliary dimension
9th & 10th digits	Tolerance codes
11th & 12th digits	Material codes

One of the unique features of the MICLASS system is that parts can be coded using a computer interactively. To classify a given part design, the user responds to a series of questions asked by the computer. The number of questions depends on the complexity of the part. For a simple part, as few as seven questions are needed to classify the part. For an average part, the number of questions ranges between 10 and 20. On the basis of the responses to its questions, the computer assigns a code number to the part.(attach computerized MICLASS system determination of code number for workpart).

The CODE System

The CODE system is a parts classification and coding system developed and marketed by Manufacturing Data Systems, Inc. Its most universal application is in design engineering for retrieval of part design data, but it also has applications in manufacturing process planning, purchasing, tool, design, and inventory control. The CODE number has eight digits. For each digit there are 16 possible values (zero through 9 and A through F) which are used to describe the part's design and manufacturing characteristics. The initial digit position indicates the basic geometry of the part and is called the Major Division of the CODE system. This digit would be used to specify whether the shape was a cylinder, flat piece, block, or other. The interpretation of the remaining seven digits depends on the value of the first digit, but these remaining digits form a chain-type structure. Hence the CODE system possesses a hybrid structure.

The second and third digits provide additional information concerning the basic geometry and principal manufacturing process for the part. Digits 4, 5, and 6 specify secondary manufacturing processes such as threads, grooves, slots, and so forth. Digits 7 and 8 are used to indicate the overall size of the part (e.g., diameter and length for a turned part) by classifying it into one of 16 size ranges for each of two dimensions. Figure shows a portion of the definitions for digits 2 through 8, given that the part has initially been classified as a cylindrical geometry (Major Division 1 for concentric parts other than profiled).

3.3 Just In Time Management

Just In Time (JIT), Total Quality Control (TQC) and Total Preventive Maintenance (TPM) are projecting their way into the manufacturing plants all over the world galloping over the carefully fashioned manufacturing systems that had been in place. They are replacing the over complex methods of the past in which a high level of waste is permissible and indeed was normal. The present language is on robots, flexibility and automation. Most of the process layout plants are being replaced by cells and automated flow lines manufacturing production families.

The waste is found in conventional approaches to quality, design, purchasing, job assignments, plant configuration, equipment selection, maintenance, purchasing, scheduling, accounting, product-line development, material handling, material control and shop floor control. The waste is found and the interest in JIT is appearing in most of the manufacturing industries through the world.

Just In Time is a production management system designed to provide the right material, at the right place, at the right time, while using a minimum amount of facilities, equipment, materials and human resources. It is a disciplined approach to improve overall productivity and eliminate waste. The JIT philosophy of eliminating waste applies to all kinds of industries, banks, hospitals, services and manufacturing plants. In manufacturing environment, waste may be defective parts, excess inventory, unnecessary material handling, set up and change over times etc. JIT is dependent on the balance between the suppliers flexibility and the users flexibility.

Origin of JIT: JIT has its origin in the Toyota company in Japan. In the 1960's, Toyota worked hard on developing a whole range of new approaches to managing manufacture. The development of these approaches was hastened by the oil shock of the 1960's. By 1972 these new approaches had begun to attract wide attention in Japan and in the mid 1970's other Japanese companies began to experiment with and adopt these approaches. This approach was called Toyota Manufacturing System [27]. By the end of 1970's the Toyota Manufacturing system had begun to attract attention in the West. One of many elements of this system was a pull scheduling technique using 'Kanbans' (Japanese for cards). the system first became known in the western countries as the kanban system. The other names given to this in later stages are 'Zero Inventories', 'World Class Manufacturing' and 'Continuous Flow Manufacturing'. The term that has now become most widely used to describe this approach to manufacturing is Just In Time management.

Just In Time management is not one technique or even a set of techniques for manufacturing but is an overall approach or philosophy which embraces both old and new techniques. The system particularly emphasizes on

1. Enforced problem solving
2. Right the first time philosophy
3. Pull rather than push production.
4. Linear scheduling.

3.4 Pull and Synchronized Manufacturing - KANBAN

Kanban literally means a card. It is a Japanese technique for requesting more manufacturing materials on an as needed basis by issuing a kanban, plus an empty container. Kanban is a pull system of replenishment, as opposed to the push system that governs schedule based systems like material requirements planning (MRP). Toyota's Dual-card Kanban technique, with a productivity improvement feature, is contrasted with a less potent and simpler technique employing a Single Kanban. Kanban techniques are also compared with MRP, reorder point, and continuous replenishment techniques. If the Kanban system is very loosely interpreted to mean any system employing an order card or delivery card, then most companies could claim to have their own card. It has long been standard procedure in industries for a card of some kind to accompany work in process and to order more parts like a traveler, job orders, route sheets, job tickets and some other forms. These do not constitute a Kanban system, because they are part of a PUSH system of parts ordering and control. The distinctive feature of the Toyota Kanban System is that it is PULL system. In reality, a push is simply a schedule based system. That is multi-period master production schedule of future demands for the company's products is prepared, and the computer explodes that schedule into detailed schedules for making or buying the component parts. It is a push system in that the schedule pushes the production people into making the required parts and pushing the parts out and onward. The other name to this push system is Material Requirements Planning (MRP). A push schedule, or MRP system is good management when compared to a pull or expedite system where customers place orders, and manufacturing looks to see if the parts are on hand. Parts not on hand are pulled through, or expedited. Even if substantial amount of parts are kept on hand are pulled through, there will be a few missing ones that must be expedited; this is disruptive and keeps customers waiting. In the Toyota Kanban system every component part type, or part number, has its own special container designed to hold a particular quantity of the part number, preferably a very small quantity. There are two cards, or 'kanban' for each container, and the kanban identify the part number, container capacity, and certain other information. One kanban, the production kanban, serves the workcenter producing the part number; the other called a conveyance kanban, serves the workcenter using it. Each container cycles from the producing workcenter and its stock point to the using workcenter and its stock point, and back, and one kanban is exchanged for the other along the way.

Single Card Kanban System: Most of the companies in the Japan are using single card kanban system, and the single card that they use is a conveyance kanban (C-Kanban), It is very easy to begin with a C-kanban system, and then add P-kanban later. In single card Kanban, parts are produced and bought according to a daily schedule, and deliveries to the user are controlled by C-kanban. In effect, the single card system is a push system for production coupled with a pull system for deliveries. Single card Kanban does not employ a stock point for incoming parts. Instead, parts are delivered right to the point of use in drilling. Also, the stock point for parts just produced tends to be larger than that for dual card Kanban. The reason for the enlarged stock point is that it holds stock produced to a schedule; the schedule pushes milled parts into the stock point even when drilling has been slowed or halted as a result of production or quality problems. So the stock point must be able to hold more containers of parts than in the pull system. Single card Kanban nicely controls deliveries of parts from one stage to the next, and the daily parts schedules, appropriately offset for lead time, provide the parts when needed, with rather small inventory buildups.

Dual Card Kanban System: Dual card Kanban is doubly effective in that it has the productivity improvement feature of removing kanban to expose and solve problems. Unfortunately, single card kanban cannot employ that feature, because there is no control on number of full containers of a given part number. Therefore, companies that use single card kanban must get their productivity improvements in some other way. For example, Kawasaki Motors, Corp., a single-card Kanban company gets productivity improvements by removing workers from final assembly until yellow lights come on signifying problems in need of correction. Nihon Radiator Company [27], also a single card Kanban user, has a vigorous total quality control system, which features a continual succession of improvement projects; the improvement projects that deal with quality, work methods, tools or equipment improve productivity by reducing material and labor per unit and by improving equipment and tool utilization.

3.5 Overall Program to manage Quality- TQM

Quality has different meanings for different people. A sampling of definitions include ‘ doing it right the first time’, ‘ conformance to requirements’, ‘ the degree to which customer expectations are satisfied. Juran describes it as 'fitness for use' where fitness is based on technological, psychological, time-oriented, contractual, ethical quality characteristics.

The overall program to manage quality is Total Quality Management . Such a program needs to be formally introduced in a company and effectively managed, TQM is an approach to continuously, improve the quality of goods and services, and involves the participation of people at all levels an functions in the organization. Quality management in many companies tends to be a single point activity. TQM is multi-point activity and must be implemented in processes, along with upstream and downstream systems. Just In Time management is best supported by TQM. The main components are supplier management, quality assurance and process control, quality control and customer management.

Mostly quality defects arise due to weak performance of suppliers. This is concerned with improving supplier performance, with special reference to incoming quality, on time delivery, and costs. The most phrase of quality assurance is build quality into the product, don't inspect it in. This is concerned with ensuring that quality defects do not occur during production, delivery or use. Many quality defects of Total Quality Control includes in depth not only the activities of the quality control function, but most importantly the interdependent multifunctional quality activities throughout the organization. In brief 'Total Quality Control's organization wide impact involves the managerial and technical implementation of customer-oriented quality activities as a prime responsibility of general management and of the main line operations of marketing, engineering, production, industrial relations, finance, and service as well as of the quality control function itself. The importance of this organization wide impact is that for many organizations much of the quality improvement demand today lies outside the work of the traditional inspection and test oriented quality-control function. Traditional quality control programs have been too limited in the face of some production processes that, in their present form and concept, simply will not produce the needed consistency of quality; in the face of some product designs that were created in overly narrow functional engineering terms and are just not sufficiently reliable in actual customer use; and in the face of product service programs that were developed in Band Aid terms and cannot provide the necessary levels of product maintenance. Truly effective total quality control programs enter deeply into the fundamental concept of such product designs, into the basic setup of such production processes, and into the scope of such product service because there is no other way to achieve the necessary levels of quality in today's market. The quality definition activity of the marketing function, which is intended to determine the quality that users want, often has had an extremely low effectiveness prior to the institution of total quality control programs. Moreover, the design engineering function's quality and reliability definition, in the form of quantifiably meaningful specifications and drawings. Sometimes has been only marginally effective. And when marketing and engineering specifications are not as clear as they should be, the customer satisfaction impact of such activities as factory quality control and vendor control will be limited no matter how much individual emphasis they receive. One essential contribution of total quality programs today is the establishment of customer oriented quality disciplines in the marketing and engineering functions as well as in production. Thus, every employee of an organization, from top management to the production line worker, will be personally involved in quality control. This is vital to establish the basic attitudes required for a positive approach to business quality achievement. Indeed, many people have been conditioned by experience and education to think primarily of business as price and production and sales, with quality perhaps sometimes more in the background. This conditioning begins in certain aspects of the more traditional forms of business training, which have sometimes dealt with price as the principal determinant of economic activity, with quality normally touched on as a more incidental business interest. Similar attitudinal establishment can also be important throughout much of what might be though of as the infrastructure of modern business organization. The production planning activities of the marketing function were sometimes likely to treat quality requirements in only a general way. And, even the most important of technical components product and design engineering-was sometimes likely to make technology and newness its overriding product development target, with quality thought to be a perhaps less challenging and less interesting technical demand. A powerful total quality control capability is one the principal managerial and engineering strengths for a company today, providing a central hinge for economic viability. The institution of total quality control significantly broadens and deepens the work and the very concept of quality control in a modern company. It permits what might be called Total Quality Management to cover the full scope of the product and service "life cycle" from product conception through production and customer service.

Advantages and disadvantages of cellular Manufacturing and Group Technology:

The benefits associated with this type of layout and manufacturing include:

1. Better lead times give a fast response and more reliable delivery.

2. Reduction in Queue, setup, and Throughput Times. In the traditional job-shop layout, the time delays jobs experience due to their routings can be reduced or eliminated. Jobs no longer have to travel great distances through a congested shop in order to be processed. Because they move quickly through the production cycle, it is less likely that parts and WIP will accumulate.

3. Output is improved because of improved resource utilization.

4. Reduction of Manual Handling of Inventory. Since the workflow is more standardized and centrally located, the materials handling requirements are reduced. Normally, materials are moved along a conveyor system requiring little or no movement of materials by hand. This enables the workers to concentrate on the more important production process instead of taking time to carry parts to other machines.

5. Better space utilization: Since machines are closely linked within the cell, additional floor spaces may become available for other uses.

6. Better production, planning and control.

7. A small variety of tools, jigs and fixtures.

8. Improved quality and reduced scrap: Parts are normally inspected with in each cell by the person responsible for making the part, so that defects are spotted close to the point of production. If defects begin to occur, the number of bad parts can be reduced since quicker response is possible. Since families of parts flow continuously across groups of dedicated machine centers, workers are rarely faced with an unfamiliar part. Therefore, production is more consistent, and the scrap associated with the start up of a new part is reduced.

9. Simplified estimating, accounting and work measurement.

10. Reduced product design variety.

11. Increases in Operator Mobility and Responsibility. Normally workers in a cell are very versatile, each worker can operate more than one machine and can move to the machines requiring more attention. Workers have the responsibility of deciding, which machines need focusing on in order to avoid bottlenecks. Employees become aware of their contribution to the final product, which improves morale and satisfaction.

Disadvantages of Cellular Manufacturing

1. Organizational change and associated human resistance.
2. Classification and coding of parts.
3. Planning and execution of the manufacturing cell concept.
4. Problems in the determination of part families and machine cells.
5. Applicability of production cells.
6. Additional investment in equipment.
7. Rearrangement of existing facilities.
8. High initial cost of implementing these concepts.
9. Union resistance to one operator, several machines.
10. Supervisor unfamiliarity with cell concept.
11. Difficulty of maintaining the new manufacturing discipline.
12. Existing job classification and work rules precluded maximum exploitation of the cell configuration.
13. Planners try to sneak non-cell items into the cells, since throughput is faster.
14. Load balancing problems.
15. Work Load fluctuations.
16. Traditional commitment to dedicated set-ups.
17. Conflict resulting when a machine tool is used most effectively on non-cell parts.
18. Inability of traditional job or flow shop scheduling procedures to prove effective for cell scheduling.
19. Costing is difficult when a cell part does not require all the machines in the cell.
20. Lack of space in which to relocate machines.

Cellular manufacturing and Group Technology are philosophies calling for simplicity and Standardization. They cannot be casually decided on or instantaneously implemented. A cellular manufacturing and group technology could require two or three years to install and will have far reaching ramifications inside the organization.

1. Resistance to change, of course, is a universal problem in any organization. Resistance can take different forms, depending on the employee's perception of job status and security, understanding of the new situation, and ability and willingness to adapt. The firms reported that regardless of the type of application (i.e product design, manufacturing engineering), human resistance to change was the most serious impediment to successfully introducing group technology. For instance, in manufacturing problems commonly stem from the changing roles of operators and the new areas of Responsibility for supervisors. Working as a team and participation in decision making puts employees in a new sociological setting. Operators should be able to move from work station to work station and to perform quality inspection. This requires additional skills and constitutes a new job design. Both workers and labor union representatives often resist these changes. The foreman's role expands to cover many functions. The foreman must, therefore, know several manufacturing processes instead of only one and be responsible for the completion of the whole part and not only for only a single operation.

2. Approximately 80 % of the firms which used group technology in product design had encountered problems or obstacles. One manager noted that there was a "problem of inertia" in first meeting designers to code parts and second, in convincing them to used the coded information as an aid to design. There is a resistance of design engineers to use the data base by check existing designs and to

accept the discipline required to seek a satisfactory solution with a new combination for existing designs or minor modifications. In the past, recognition for engineers had been based on the number of new parts created, rather than on the number of new designs avoided. For instance, the mandate for designers to reduce the number of new parts can conflict with a company's long standing evaluation and reward system. In one company, designers had been evaluated on the number of new drawings they created. Instituting the variety reduction concept, therefore, necessarily meant changing the incentive system.

3. Group Technology's use in product design, the most commonly encountered obstacle to the successful group technology applications in manufacturing engineering was resistance to change, that is, the difficulty of getting individuals to adopt a new discipline. One firm noted that material mangers were tempted to change the monthly quantities which had been established for the part families, and another manager reported that "old school' thinking on set-up and inventory trade offs caused frequent conflicts.

4. The most frequently reported problems focused on the difficulty of getting human beings to change. In cellular manufacturing, however these problems were frequently confounded by the existence of labor unions and the necessity, in many cases, of negotiating the substantive changes in the work arrangement which group technology cells require. In some firms, skepticism on the part of supervisors was a problem and several respondents mentioned that once cells had actually been setup it was difficult to get supervisors, operators and even process planners to follow the new game plan.

5. The most common problem companies faced in the area of coding and classification stems from the inability of codes to describe the material adequately. Some companies, for example, found that their coding systems were suitable for design but not for manufacturing purposes. Other problems included that the coding system most appropriate for the design area did not necessarily meet the needs of manufacturing and process planners.

6. Production planners and schedulers are also directly affected by Cellular Manufacturing. Once a cell has been established, parts not belonging to the appropriate family must be routed elsewhere.

6. High initial cost of introducing Group Technology in manufacturing engineering. The benefits will not be realized until after major changes are made, such that the level of commitment required was very big and must be made before significant savings materialize.

7. One direct implication of cellular manufacturing is that the more rigid, flow oriented system with drastically reduced work in process requires a strong emphasis on machine maintenance. When a manufacturing cell is designed, one obvious goal is to achieve a high utilization of all machines in the cell. The variation in the productive capacities of the machines, however, can create a restriction, especially if existing machines are relocated to form a cell. The result is usually that one or two machines end up being bottlenecks, while the others are underused.

8. The problem concerned is buffer inventories, which usually stack up between work stations, and the operators ability to eliminate these inventories in a balanced fashion.

9. Machine utilization is another frequently cited problem area. The most common specific machine utilization problem was the difficulty of load balancing on individual machines with in cell.

Chapter 4

IMPLEMENTATION OF WORKCELL LAYOUT

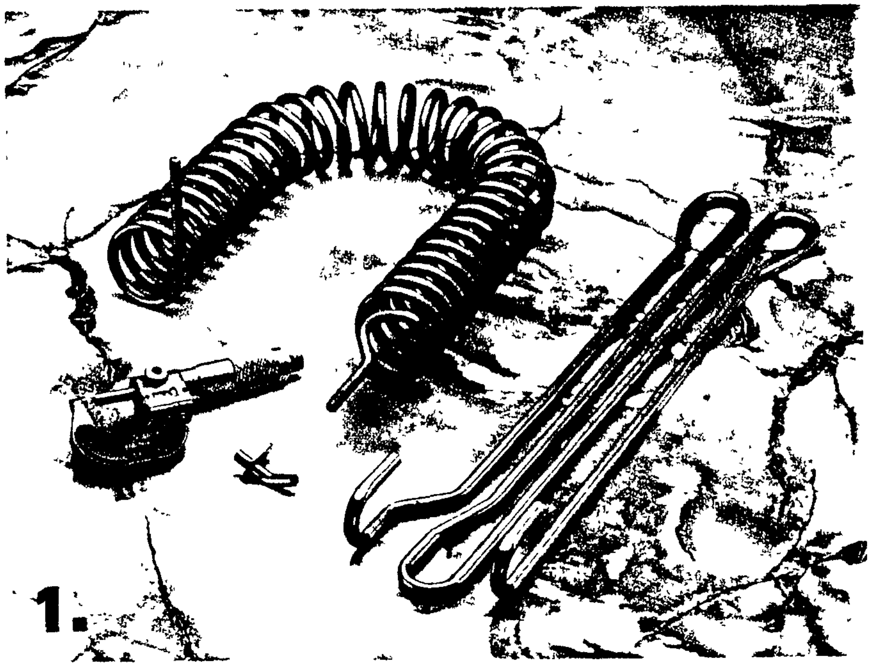
4.1 Company Profile and Products

G & J Steel and Tubing Inc., is a parent company of 'Die Form Tube Corporation' and 'Masterson Metal Products Inc'. Masterson Metal Products has been a reliable tubing fabricator since 1958 and later acquired 'Die Form Tube' in 1970's to meet the high speed production cut-off.

G & J Steel and Tubing Inc was formed in 1975 and from its inception has taken up the challenge to meet each and every tubing problem whether it be one of Quality, Engineering or Production. G & J supplies raw material like stainless steel, copper, brass, aluminum, carbon alloys, nickel alloys, titanium and other metals. The services and most of the work is fabrication, bending, coiling, end forming like flaring, expanding, swaging, beading, notching, punching, piercing and brazing. The production capacities of cutting tubing on machines range from small diameter of 0.020 inches through 2.000 inches. G & J has automated shear form high speed tube cut off and end form equipments, where millions of pieces can be cut and end forming operations are done in few seconds.

Most of the parts manufactured, fabricated are:

1. Automobile parts: Radiator coils, exhaust system tubing, mufflers, air conditioning system tubing, fuel system tubing, shock absorber components etc.
2. Aerospace Industry: Cable connectors, heater coils, air conditioning system tubing, valve stems etc.

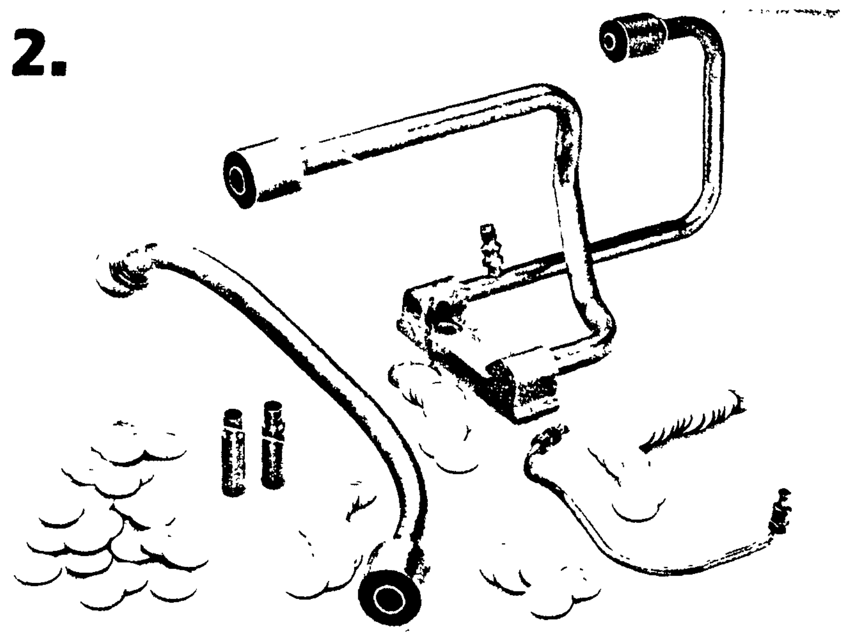


1.

Fig 4.1 COILERS, HEAT EXCHANGER MADE FOR EASTMAN KODAK
Courtesy: G & J Steel and Tubing, Inc.

Fig 4.2 AUTOMOBILE PARTS
Courtesy: G & J Steel and Tubing, Inc.

2.



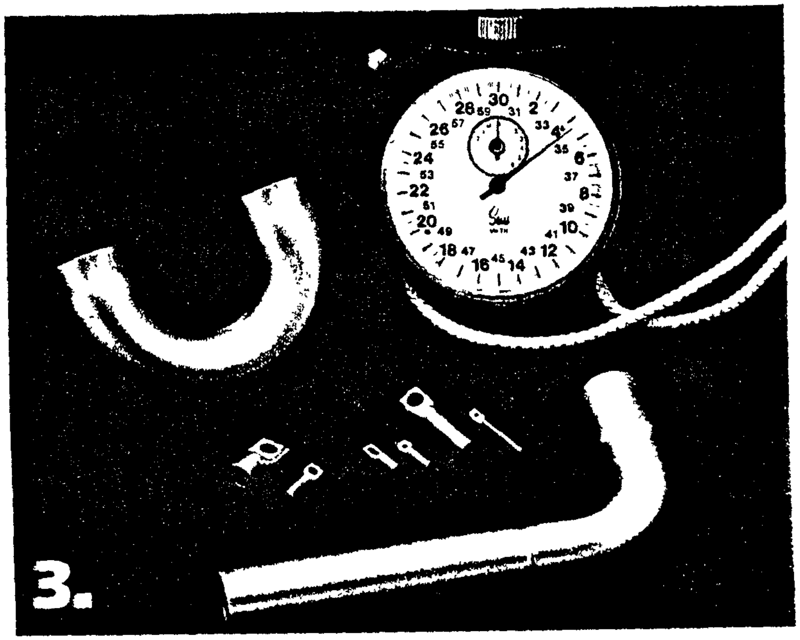
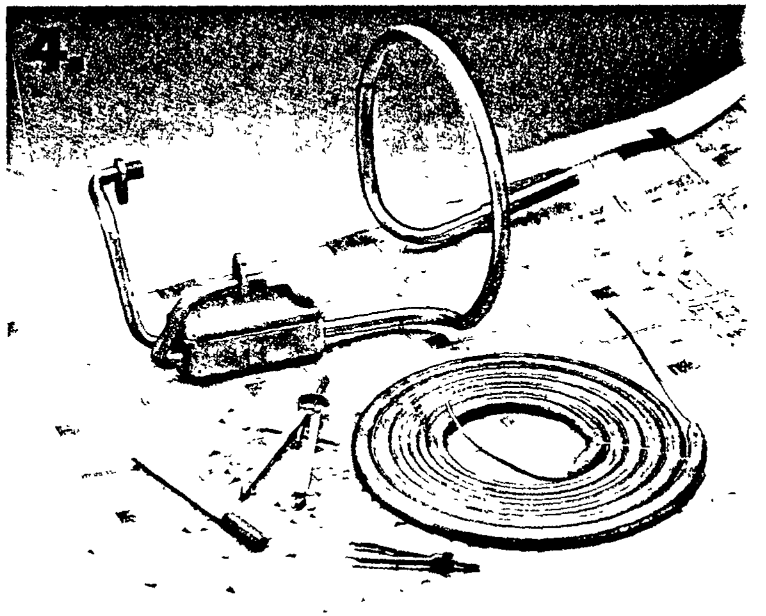
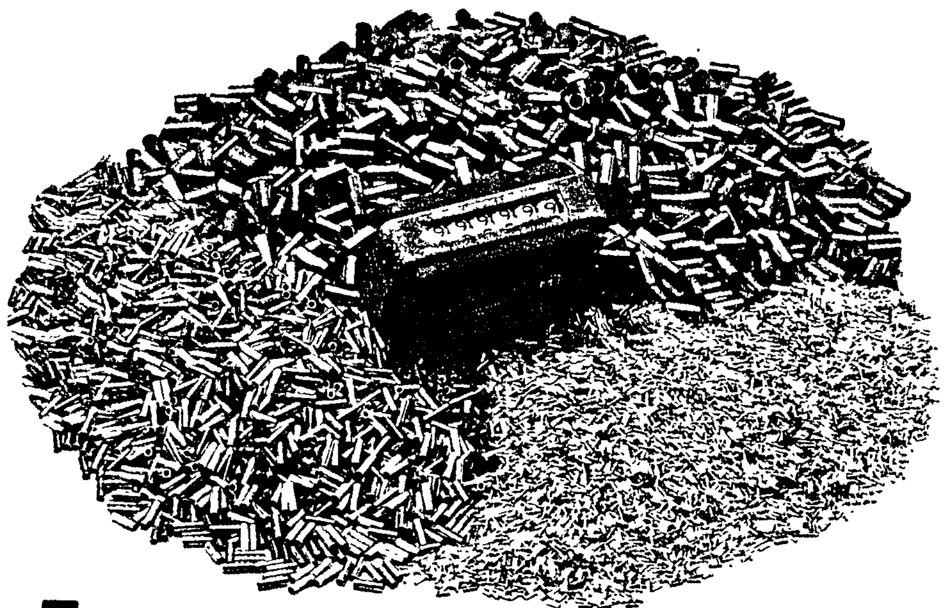


Fig 4.3 TERMINAL CONNECTORS AND LUGS
Courtesy: G & J Steel and Tubing, Inc.

Fig 4.4 SPIRAL COILS
Courtesy: G & J Steel and Tubing, Inc





5.

Fig 4.5 ELECTRONIC INDUSTRY PARTS
Courtesy: G & J Steel and Tubing, Inc

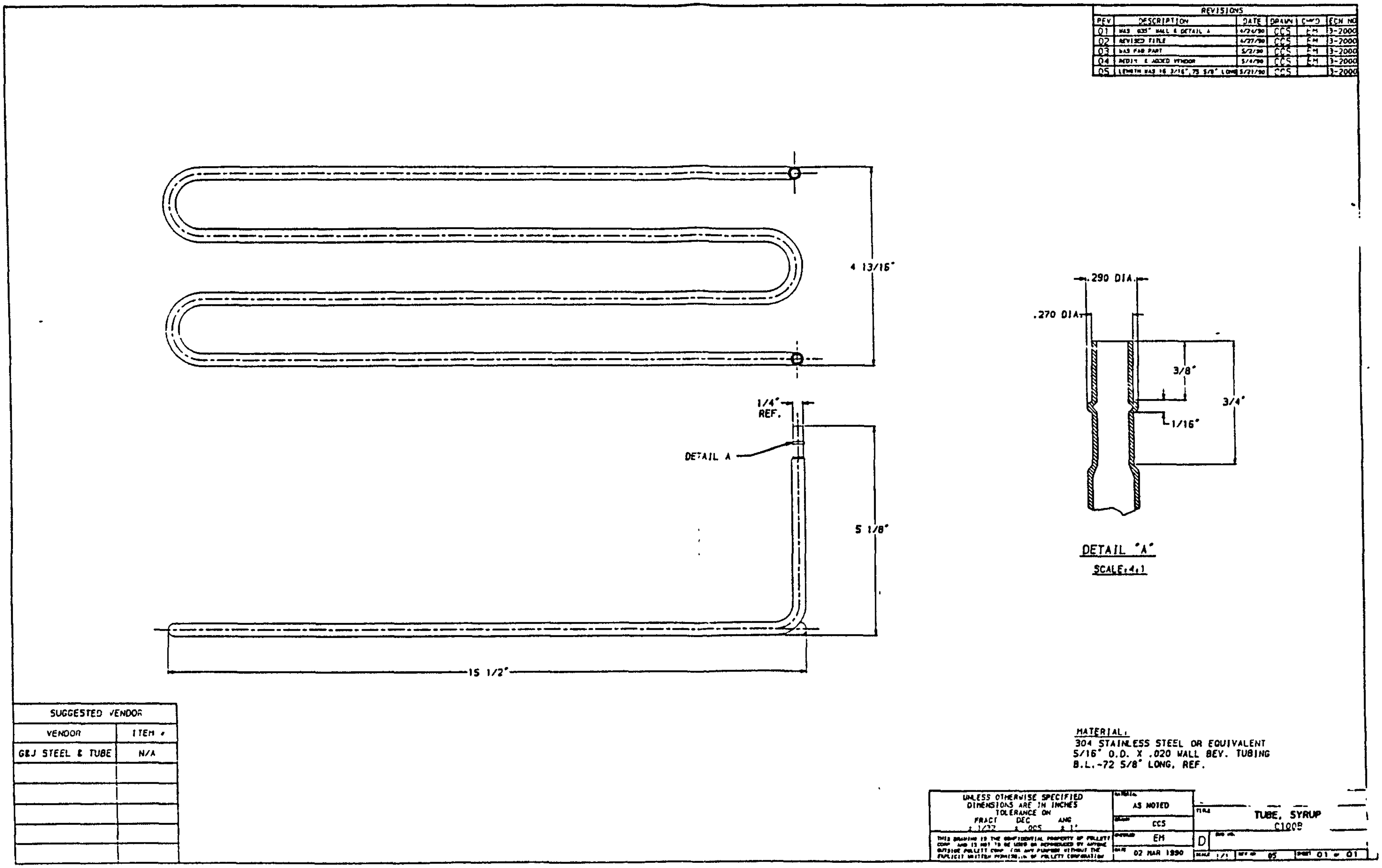


Fig 4.5.a G & J's Other Fabrication Works

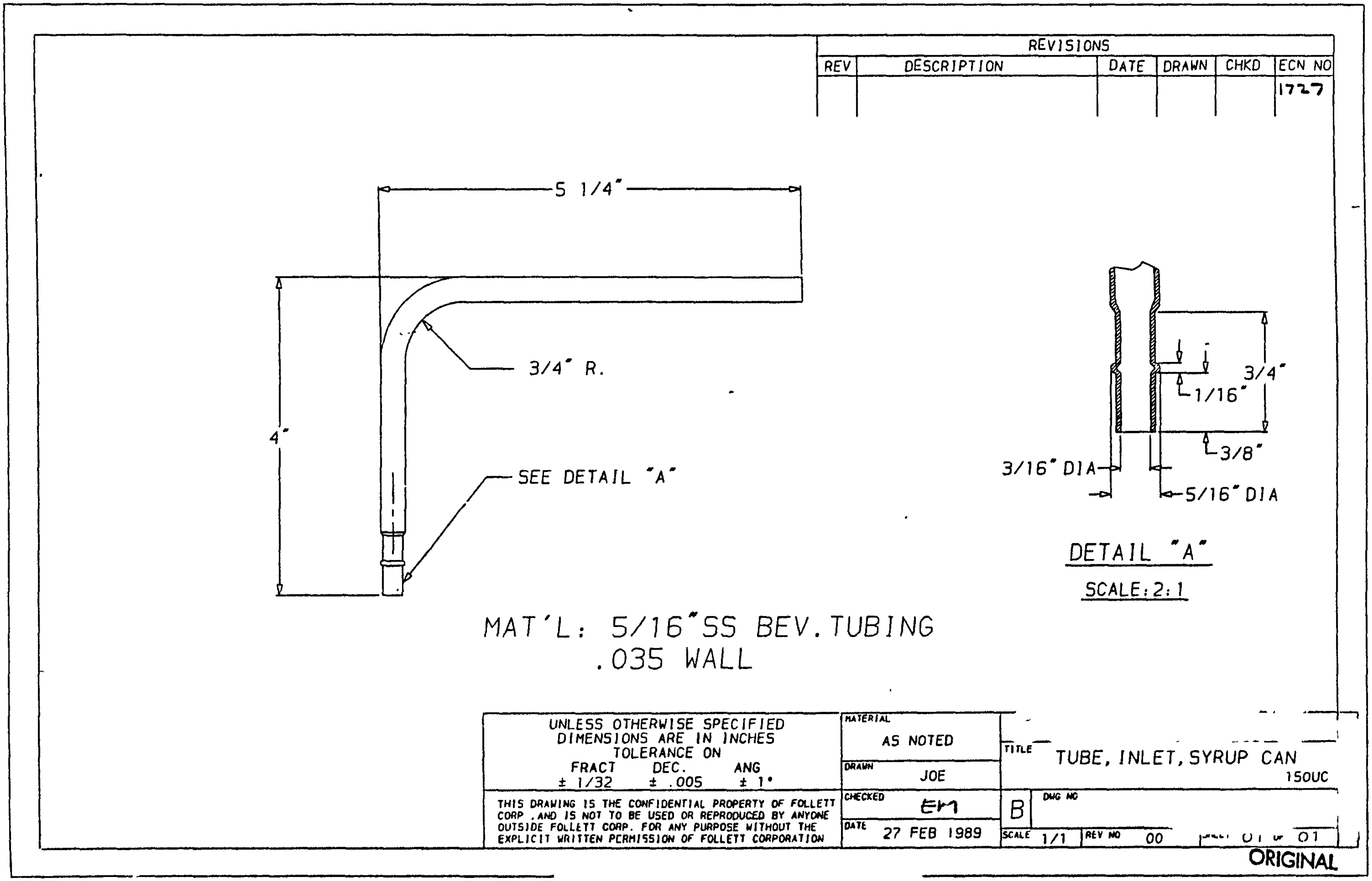


Fig 4.5.b G & J's Other Fabrication Works

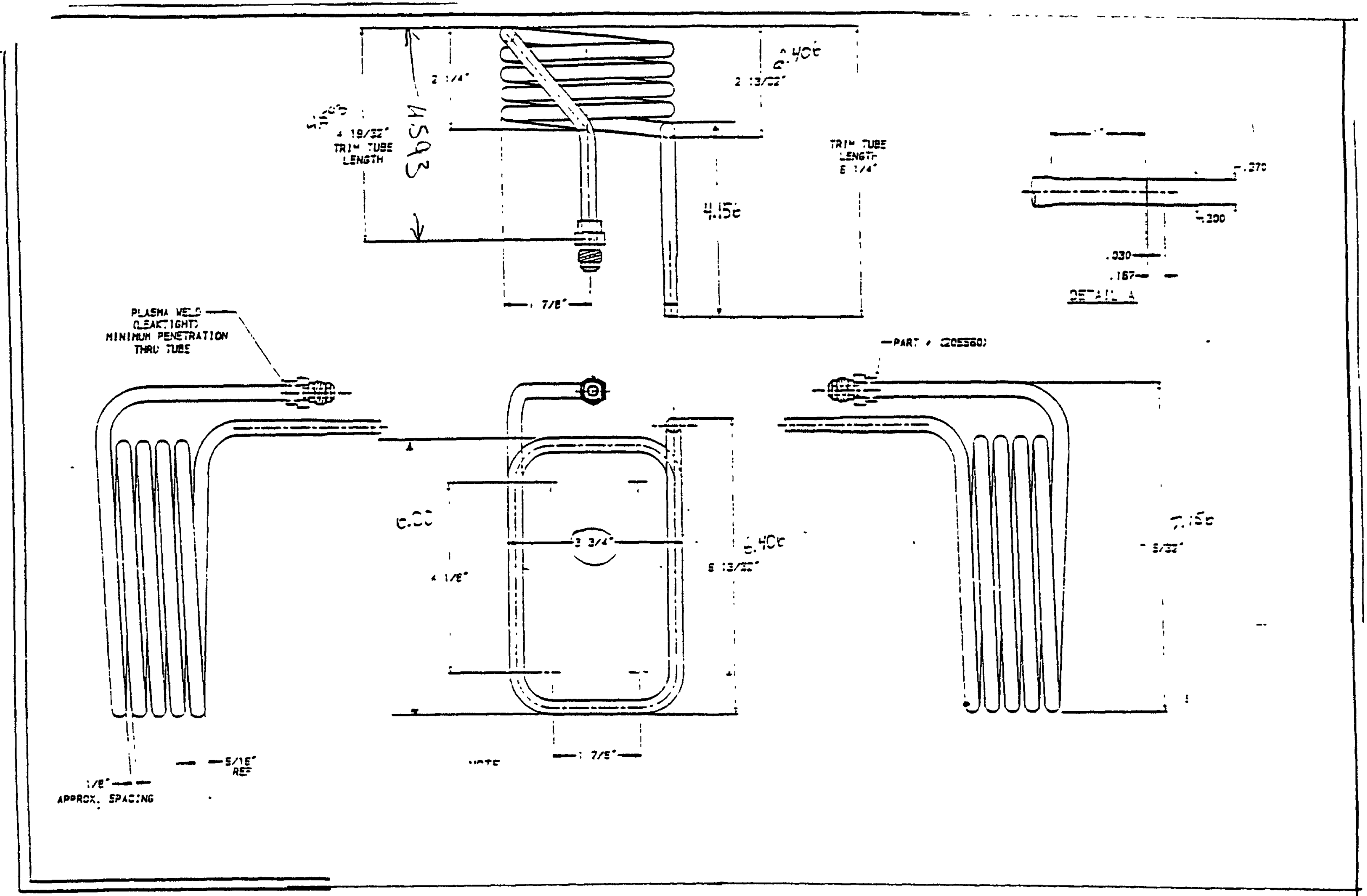


Fig 4.5.c G & J's Other Fabrication Works

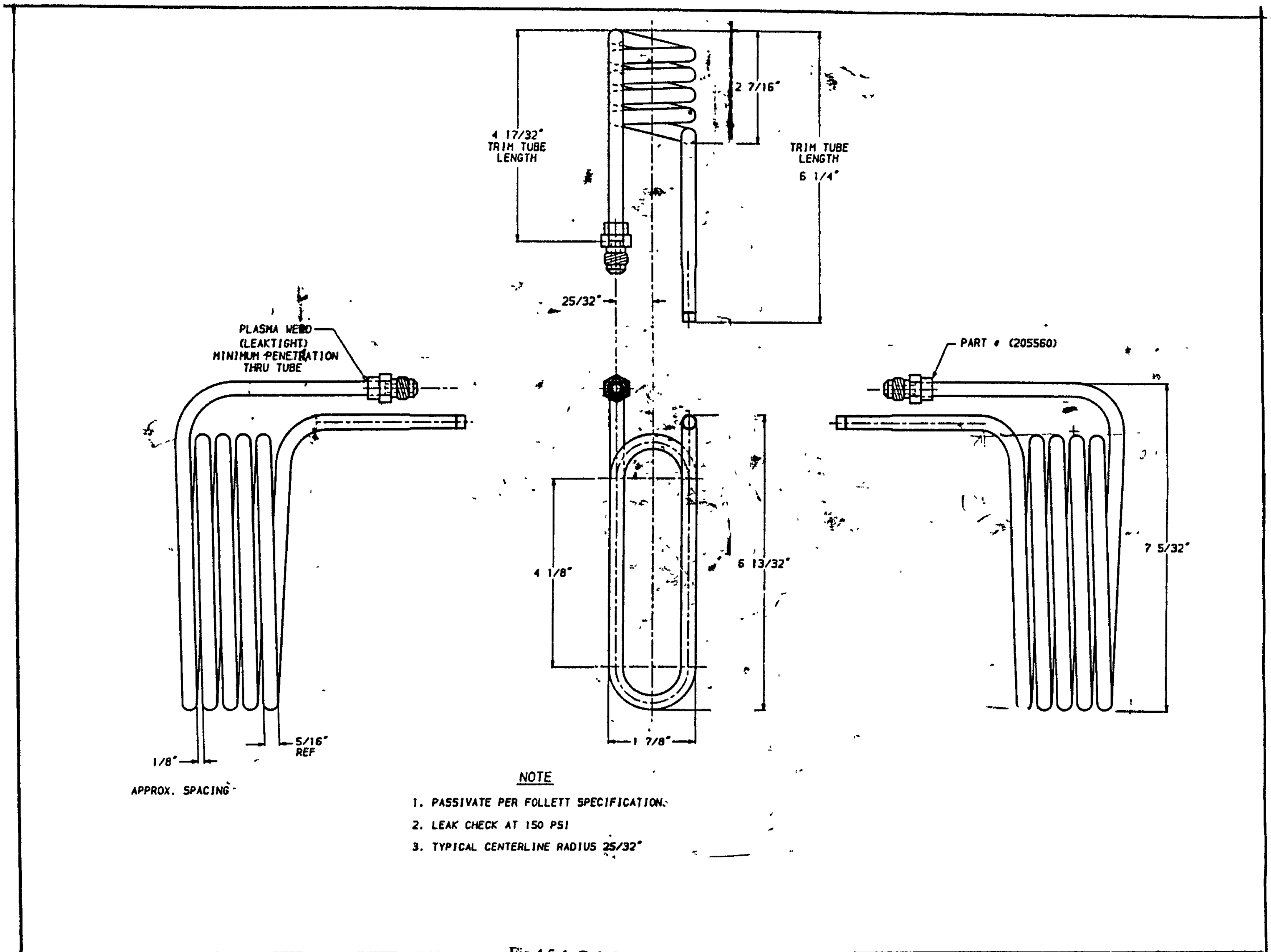


Fig 4.5.d G & J's Other Fabrication Works

3. Electronic Industry: Flatten and pierced terminal part, telephone parts etc. (figure 4.5)
4. Beverage Industry: Syrup lines, soda water tube supplies etc.(Figures 4.5.a,b,c,d)
5. Thermal Power Station - Heat Exchanger Coils (Figure 4.1)
6. Air Conditioning Industry

4.2 Data On Existing Layout and Systems followed at G & J

G & J Steel and Tubing Inc is a fabricator and manufacturer of Automobile, Electronic, Aerospace and beverage industry parts. Large scale parts fabrication/production is for beverage and automobile industries.

The machinery at G & J are shown in the figure 4.6 which gives the picture of partial company layout, serial numbers have been used to designate the machine.

1. Lathe machines - 3
2. Surface Grinder - 3
3. Milling machines - 2
4. Drilling - 1
5. Shaper - 1
6. Hydraulic bending machines - 8
7. Pneumatic bending machines - 3
8. Hand benders - 6
9. Abrasive Cutting machines - 3
10. Electrolytic Abrasive cutting - 1
11. Four slide machines - Model 00 - 6
12. Four slide machines - Model 01 - 4

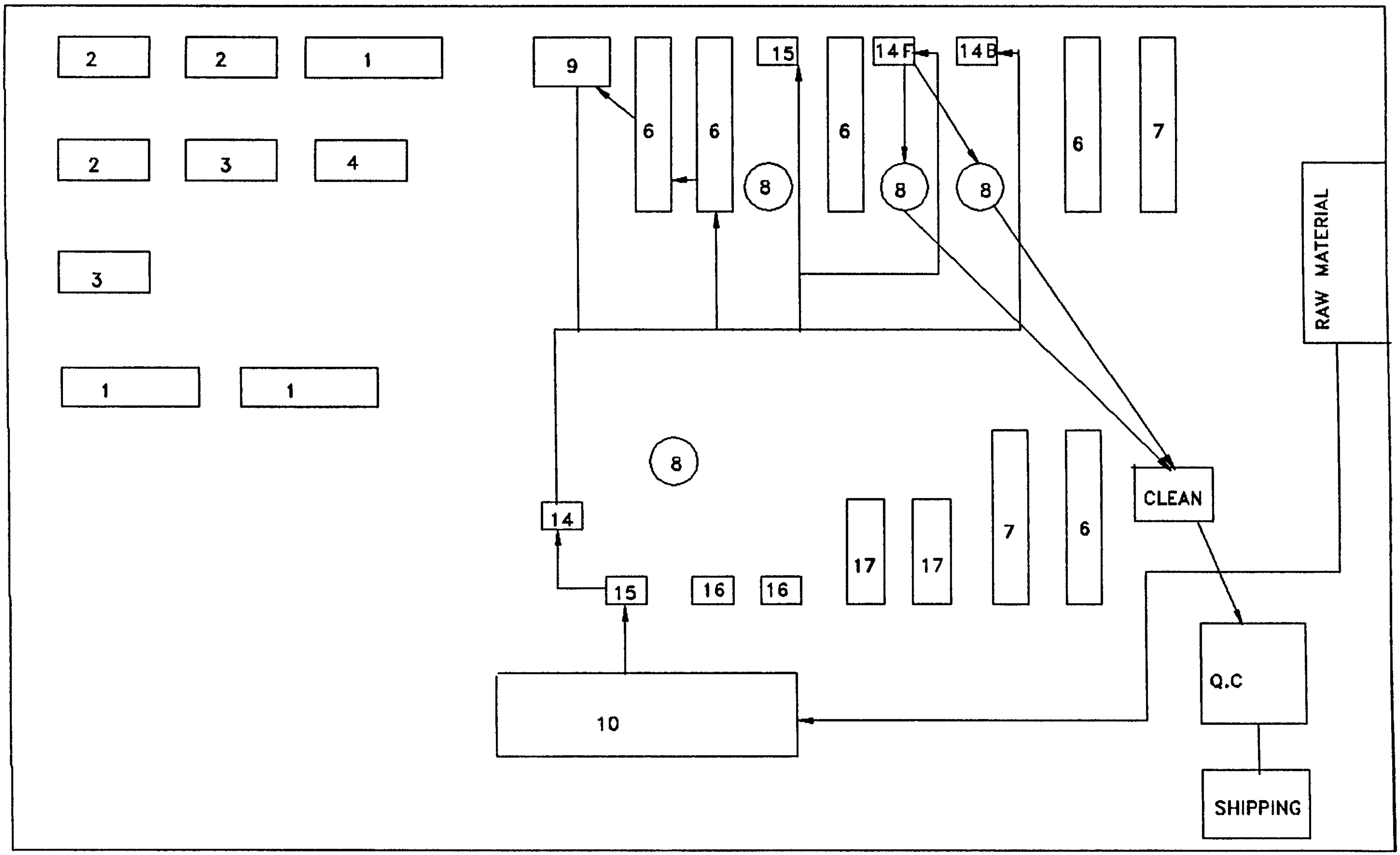


Fig 4.6 G & J STEEL AND TUBING LAYOUT

13. Four slide machines - Model 02 - 3
14. End former machines - 3
15. Deburr machines - 3
16. Piercing machines - 2
17. Coilers - 3
18. Transfer presses - 2

4.3 Grouping and Coding the Parts.

Group Technology is very simply a philosophy holding that managers should exploit similarities and achieve efficiencies by grouping like problems. In most cases, a prerequisite for the recognition of similarities is a system by which the objects of interest can be classified and coded. In design engineering, parts can be classified by geometric similarities using codes that contain design attributes. The purpose could be to retrieve all parts with certain features, such as rotational parts with a length to diameter ratio of less than 2. If one of these fits the need at hand, the engineers can thereby avoid having to design a new part. Similarities between parts, captured in the GT code, can in like manner be used by manufacturing engineering, manufacturing, purchasing, and sales. For example, a manufacturer can drastically reduce the time and effort spent deciding how a part should be produced if this information is available for a similar part. Among the range of materials that manufacturers handle - raw materials, purchased components, fabricated parts, subassemblies, and complete items. *Group Technology is predominantly applied to purchased items and fabricated parts.* Informal parts classification techniques have been employed in companies where the sole intent was to identify families with similar manufacturing requirements to create dedicated lines or cells of machines. While informal ways of grouping parts are not uncommon, the greatest potential of GT comes via a formal coding system in which each part gets a numeric or alphanumeric code describing the attributes of interest. For the widest use, the code should be able to describe the part from both a design and a manufacturing point of view. Such characteristics as the external and internal shapes, dimensions, and any threads, groves, and splines describe the geometric shape.

Grouping is done using PFA method and the following codes:

1.	Electrolytic automatic cut off machine	01
2.	Hydraulic Bending machine	02
3.	End forming machine # 1	03
4.	End forming machine # 2	04
5.	End forming machine # 3	05

<u>Different Operations On Tubing</u>

6.	cut off	06
7.	Deburr - Outer Diameter	07
8.	Deburr - Inner Diameter	08
9.	Flare	09
10.	Reduce	10
11.	Bead	11
12.	Cleaning the parts	12
13.	Assemble	13
14.	Inspect	14
15.	Package	15
16.	Polish	16
17.	Bending	17

18.	Chemical treatment	33
19.	Deburr ID & OD	35
20.	Expansion	36

GENERAL FABRICATIONS PERFORMED ON TUBING

1. Electrolytic abrasive cutting
2. Deburr inside the tube.
3. Deburr outside the tube.
4. Reduce the outer diameter.
5. Expand the outer diameter.
6. Flaring - end forming operation
7. Beading - end forming operation.
8. Bend the tube at different degrees in different rotations.
9. Assembly of the tubing
10. Trimming
11. Chemical cleaning.

PRODUCTION FLOW ANALYSIS

Production flow analysis is a system for identifying the part families and associated groupings of machine tools. It does not use a clarification and coding system and it does use part drawings to identify families. Instead, PFA is used to analyze the operation sequence and machine routing for the parts produced in the given shop. It groups parts with identical or similar routings together. These groups can then be used to form logical machine cells in a group technology layout. Since PFA uses manufacturing data rather than design data to identify part families, it can overcome two possible anomalies. First, parts whose basic geometries are quite different may nevertheless require similar or identical process routings. Second, parts whose geometric are similar may nevertheless require process routings that are quite different.

PROCEDURES FOR ANALYSIS

1. Data Collection: The first step in the PFA procedure is to decide on the scope of the study and to collect the necessary data. The scope defines the population of parts to be analyzed. The minimum data needed in the analysis are the part number and machine routing (operation sequence) for every part. These data can be obtained from the route sheets. Additional data, such as lot size, time standards, and annual production rate, might be useful for designing machine cells of the desired productive capacity.

2. Sorting of Process Routings: The second step is to arrange the parts into groups according to the similarity of their process routings. For a large number of parts in the study, the only practical way to accomplish this step is to code the data collected in step 1 into computer cards. The format is follows:

2 3 5 6 9 01 05 10 19 12 500 12

23569	Part Number
01, 05, 10	Machine code numbers indicate process sequence
500, 12	Indicates lot size, other necessary instructions

Configuration: Figure shows the configuration used to bend the tubing in their respective planes.

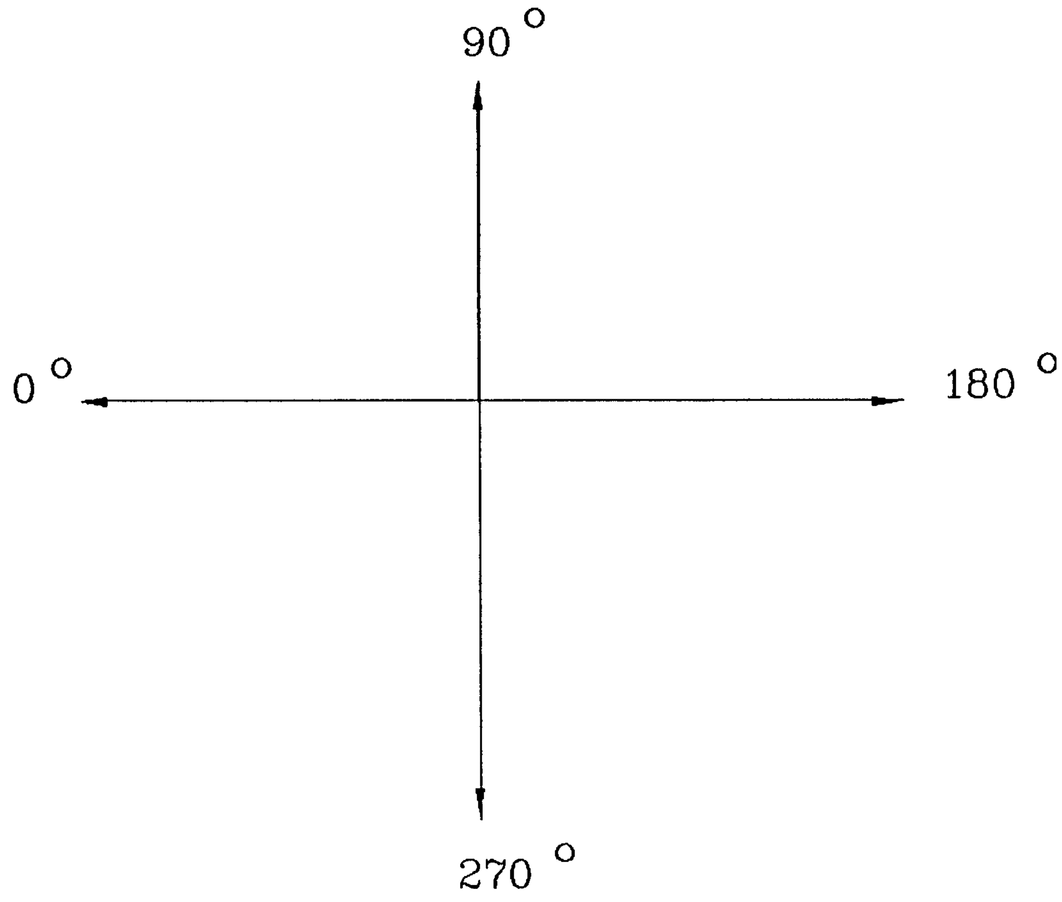


FIG: Configuration for Tube Bending in Angles and Planes

Different Operations performed on the part

1. Electrolytic Automatic cut off
2. Deburr inside diameter
3. Deburr outside diameter
4. Reduce one end to 0.270 inches
5. Bead on the diameter
6. Bend 90 degrees in 180 degrees plane at 2.750 ref.
7. Bend 90 degrees in 270 degrees plane at 2.188 OD to OD
8. Bend 90 degrees in 0 degrees plane at 10.906 OD to OD.
9. Bend 90 degrees in 270 degrees plane at 36.156 OD to OD.
10. Bend 90 degrees in 0 degrees plane at 1.656 OD to OD.
11. Bend 90 degrees in 90 degrees plane at 2.500 OD to OD.
12. Trim leg to 1.843 OD
13. Deburr inside
14. Deburr outside
15. Flare to 45 degrees at deburred end.
16. Clean
17. inspection
18. Packing
19. Shipping

CODE: 2 0 5 5 4 01 35 10 11 17 06 500 12

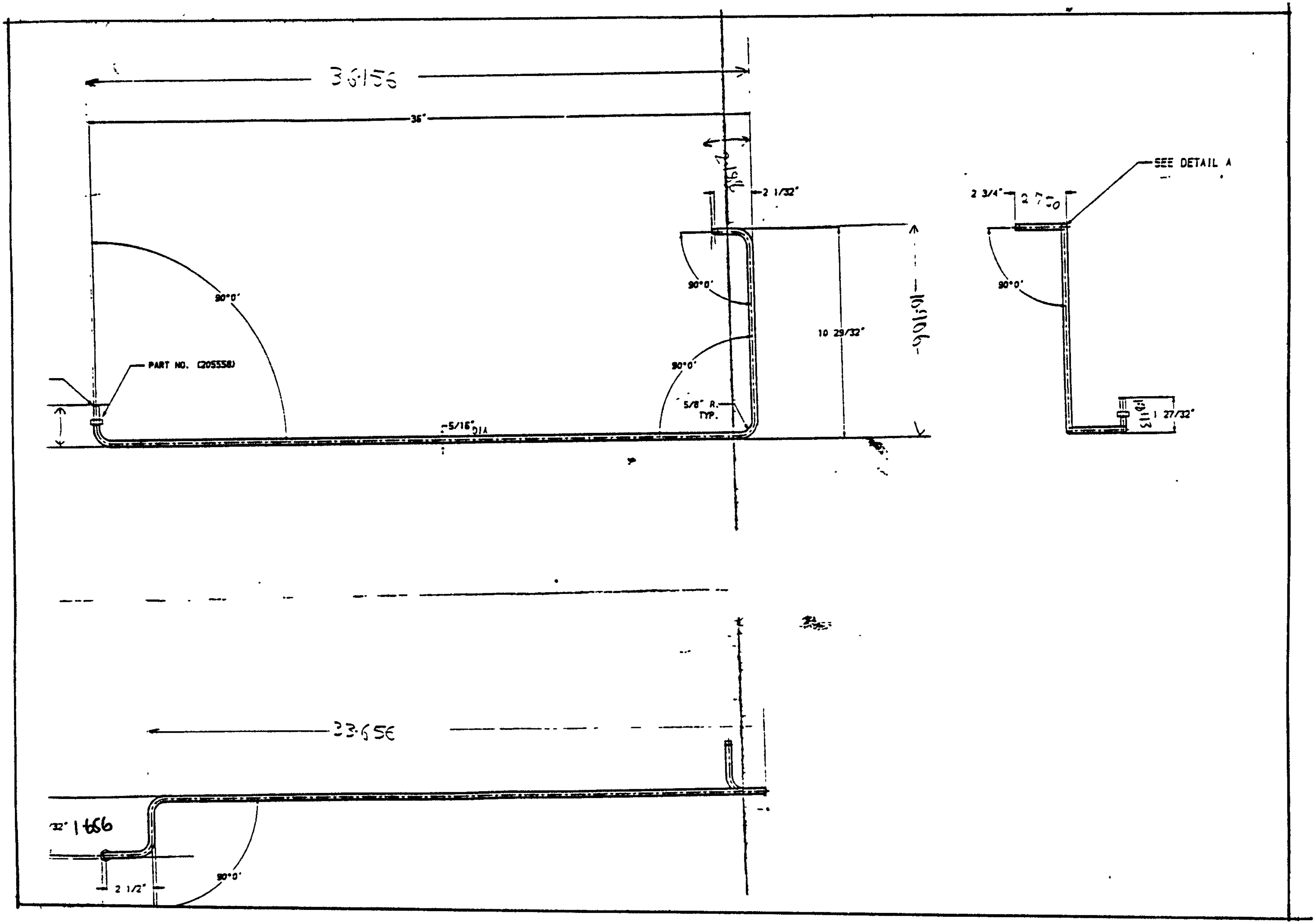


Fig Code: 20554 01 35 10 11 17 06 500 12

Different Operations on part shown in the figure

1. Electrolytic Automatic cut off according to the blank size.
2. Deburr inside.
3. Deburr outside.
4. Reduce on end to 0.270 inches
5. Bead on the diameter.
6. Bend 90 degrees in 180 degrees plane at 2.656 reference.
7. Bend 90 degrees in 270 degree plane at 1.750 OD to OD.
8. Bend 90 degrees in 0 degree plane at 7.562 OD to OD.
9. Bend 90 degrees in 270 degree plane at 35.687 OD to OD.
10. Bend 90 degrees in 0 degree plane 1.719 OD to OD.
11. Bend 90 degrees in 90 degree plane at 2.500 OD to OD.
12. Trim leg to 1.843 inches.
13. Deburr inside
14. Deburr outside
15. Flare to 45
16. Clean
17. Inspection
18. Packing
19. Shipping

CODE: 2 0 5 5 4 01 35 10 11 17 06 400 12

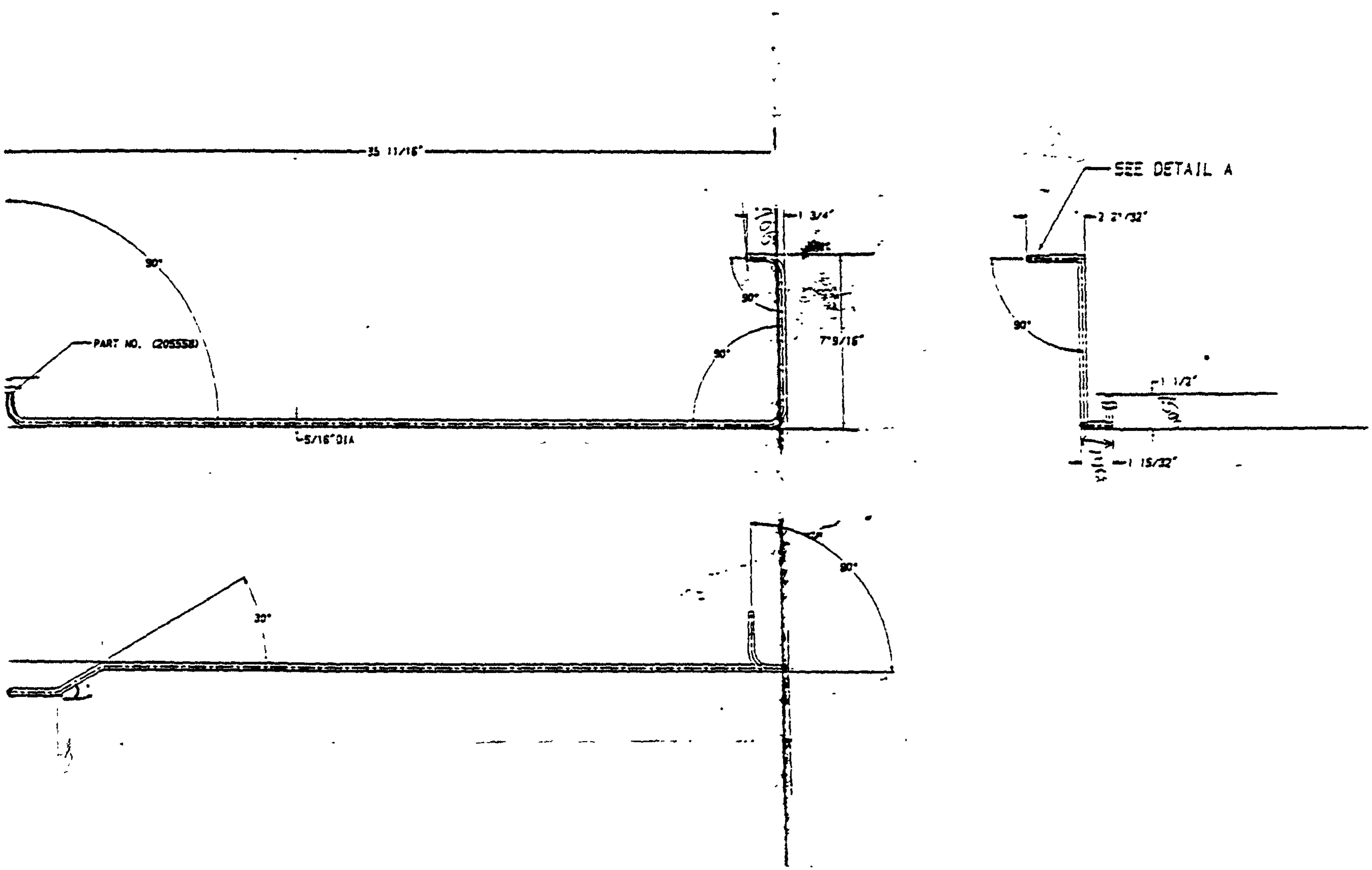


Fig Code: 20554 01 35 10 11 17 06 400 12

Different Operations on part shown in the figure

1. Electrolytic automatic cut off to blank size specified on the routing sheet.
2. Deburr inside diameter.
3. Deburr outside diameter.
4. Reduce on end to 0.270 inches.
5. Bead on the diameter.
6. Bend 90 degrees in 180 degrees plane at 2.125 reference.
7. Bend 90 degrees in 270 degrees plane at 1.812 OD to OD.
8. Bend 90 degrees in 0 degrees plane at 14.031 OD to OD.
9. Bend 90 degrees in 90 degrees plane at 35.750 C to OD.
10. Trim leg at 1.281
11. Deburr inside.
12. Deburr outside.
13. Flare at 45 degrees.
14. Clean.
15. Inspection
16. Packing
17. Shipping

CODE: 2 0 5 5 3 01 35 10 11 17 06 2500 16

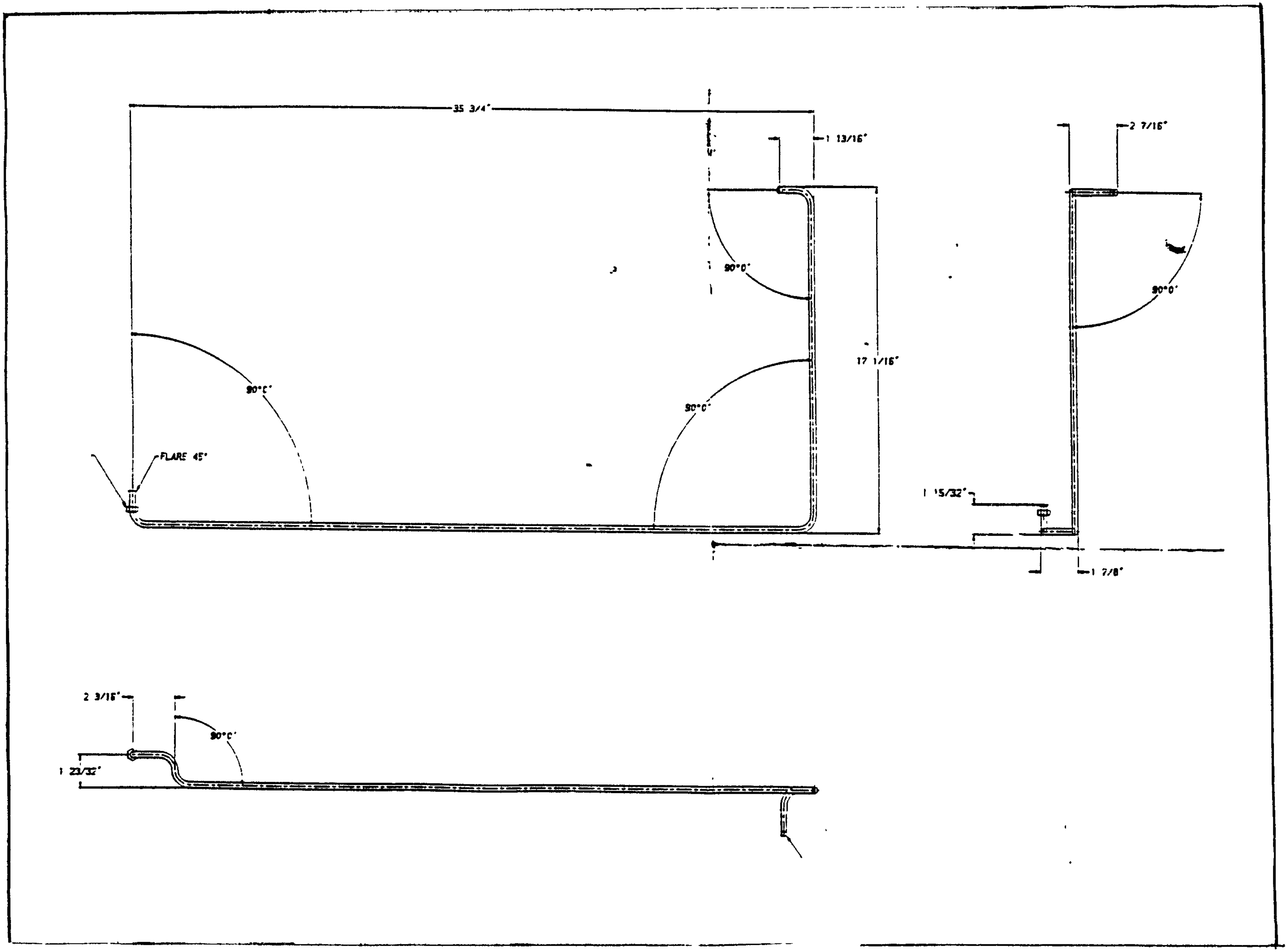


Fig Code: 20553 01 35 10 11 17 06 2500 16

Different Operations on part shown in the figure.

1. Electrolytic Automatic Cut off to blank size specified on the routing sheet.
2. Deburr inside diameter.
3. Deburr outside diameter.
4. Reduce on one end to 0.270 inches.
5. Bend 90 degrees in 180 degrees plane at 2.4375 Ref.
6. Bend 90 degrees in 270 degrees plane at 1.812 from OD to OD.
7. Bend 90 degrees in 0 degrees plane at 17.062 OD to OD.
8. Bend 90 degrees in 90 degrees plane at 33.563 ref.to C.
9. Bend 90 degrees in 0 degrees plane at 1.718 O to C.
10. Bend 90 degrees in 90 degrees plane at 2.187 C to C.
11. Trimming at 1.468 inches.
12. Deburr inside.
13. Deburr outside.
14. Flare at 45 degrees on end former.
15. Clean the parts.
16. Final inspection.
17. Packing
18. Shipping.

CODE: 2 0 5 5 0 01 35 10 11 17 06 750 16

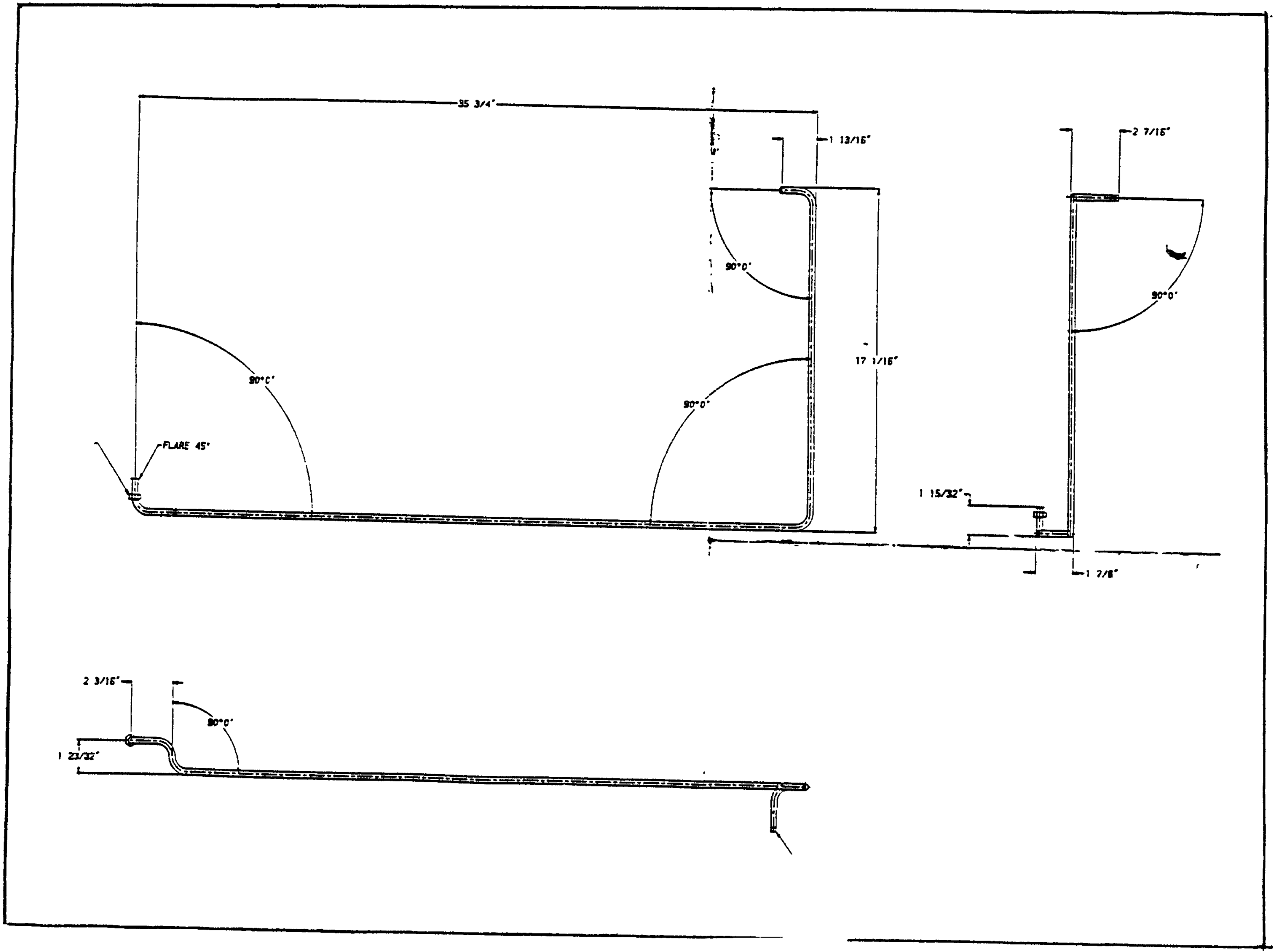


Fig Code: 20550 01 35 10 11 17 06 750 16

Different operations on part shown in the figure:

1. Electrolytic Automatic cut off.
2. Deburr inside the tubing.
3. Deburr outside the tubing.
4. Reduce on end of the diameter to 0.270 inches on end former machine.
5. Bead on the diameter.
6. Bend 90 degrees in 180 degrees plane at 2.718 reference.
7. Bend 90 degrees in 270 degrees plane at 1.968 C to OD.
8. Bend 90 degrees in 0 degree plane at 20.250 OD to OD.
9. Bend 90 degrees in 90 degrees plane at 33.406 OD to C.
10. Bend 90 degrees in 0 degrees plane at 3.437 O to C.
11. Bend 90 degrees in 90 degrees plane at 2.500 O to O.
12. Trim leg at 1.562 inches.
13. Deburr inside diameter.
14. Deburr outside diameter.
15. Flare - 45 degrees angle.
16. Clean the parts.
17. Final inspection on the parts.
18. Shipping.

CODE: 2 0 5 5 0 01 35 10 11 17 06 800 16

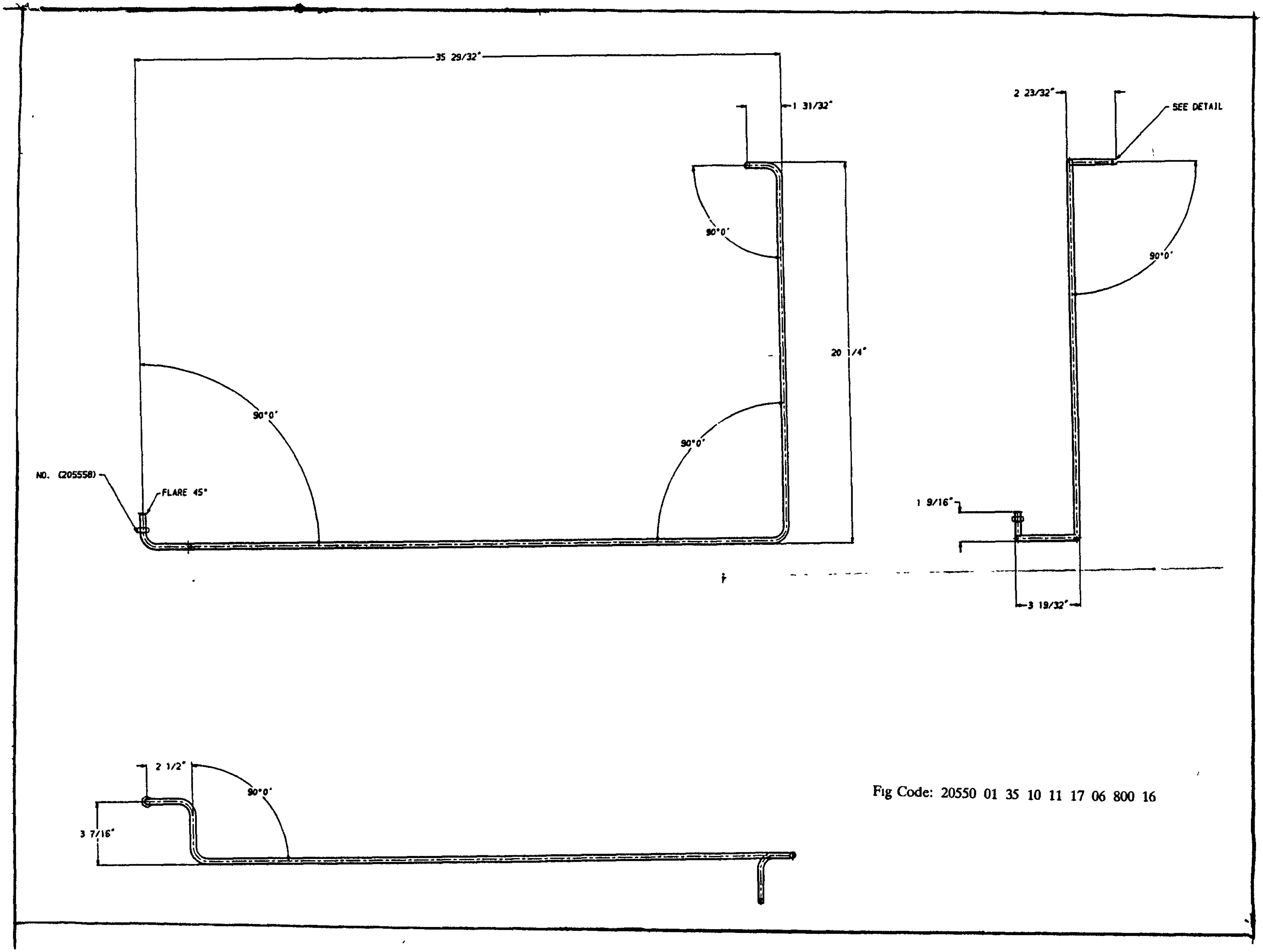


Fig Code: 20550 01 35 10 11 17 06 800 16

Different operations on part shown in the figure:

1. Electrolytic automatic cut off to the blank size.
2. Deburr inside the tubing.
3. Deburr outside the tubing.
4. Reduce on one end to 0.270 inches.
5. Bead on the diameter.
6. Bend 180 degrees in same plane at 2.451 O to O.
7. Bend 90 degrees in 270 degrees plane at 2.281 O to O.
8. Bend 90 degrees in 0 degrees plane at 13.406 C to O.
9. Bend 90 degrees in 90 degree plane at 35.750 O to C Ref.
10. Trim leg to 1.281 inches.
11. Deburr inside diameter.
12. Deburr outside diameter.
13. Clean the parts.
14. Inspection.
15. Packing
16. Shipping

CODE: 2 0 5 4 9 01 35 10 11 17 06 2700 15

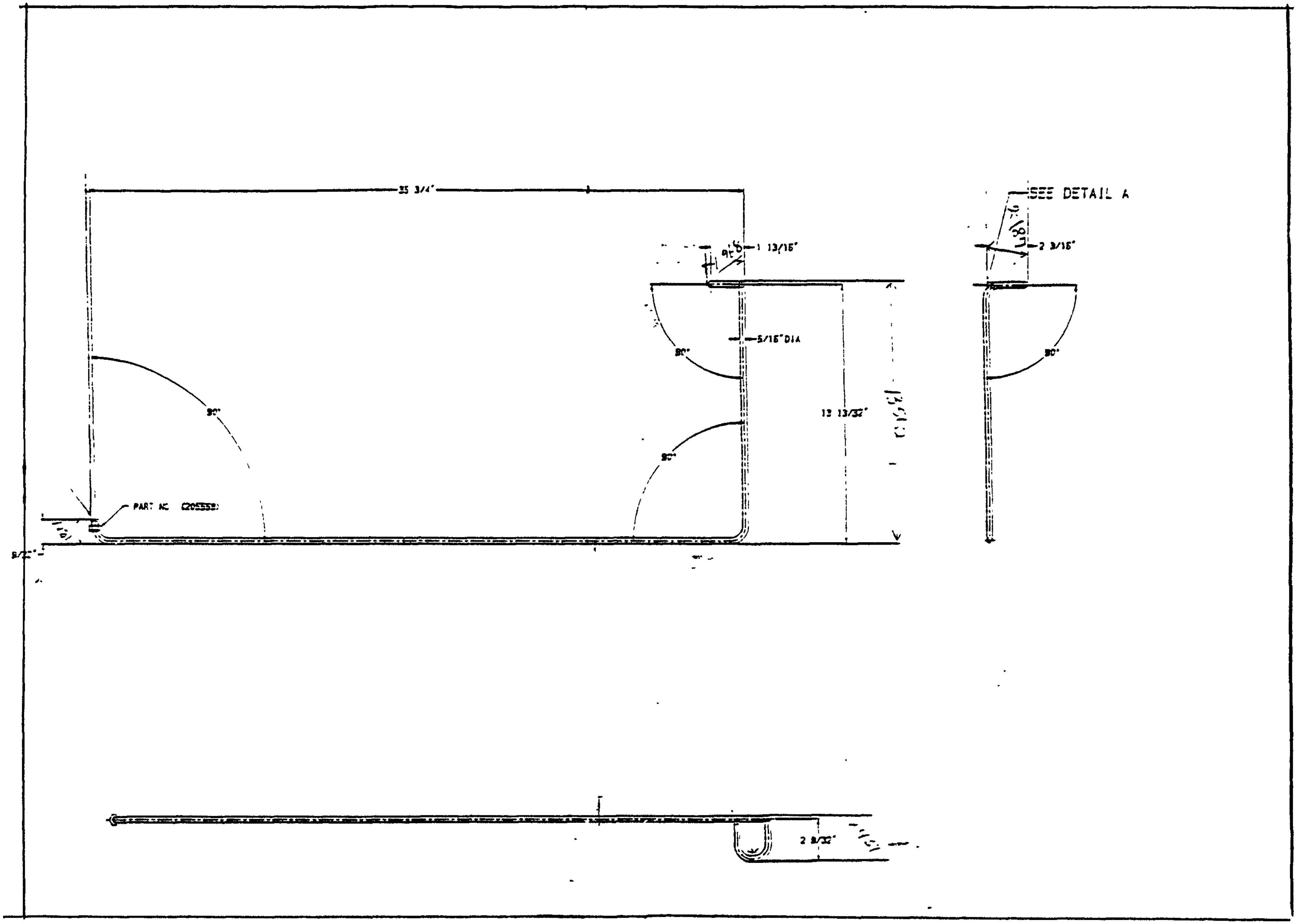


Fig Code: 20549 01 35 10 11 17 06 2700 15

Different Operations on Part Shown in the figure:

1. Electrolytic Automatic Cut off to the blank size.
2. Deburr inside the tubing.
3. Deburr outside the tubing.
4. Reduce on end to 0.270 inches.
5. Bead on the diameter.
6. Bend 180 degrees in same plane at 2.187 ref.
7. Bend 90 degrees in 270 degree plane at 2.593 O to O.
8. Bend 90 degrees in 0 degrees plane at 16.437 C to O.
9. Bend 90 degrees in 90 degrees plane at 33.251 O to O.
10. Bend 90 degrees in 0 degree plane at 1.718 O to O.
11. Bend 90 degrees in 90 degrees plane 2.343 C to O.
12. Trim leg at 1.468 inches.
13. Deburr inside the tubing.
14. Deburr outside the tubing.
15. Flare at 45 degrees
16. Clean the parts.
17. Inspection
18. Packing
19. Shipping

CODE: 2 0 5 4 9 01 35 10 11 17 06 550 16

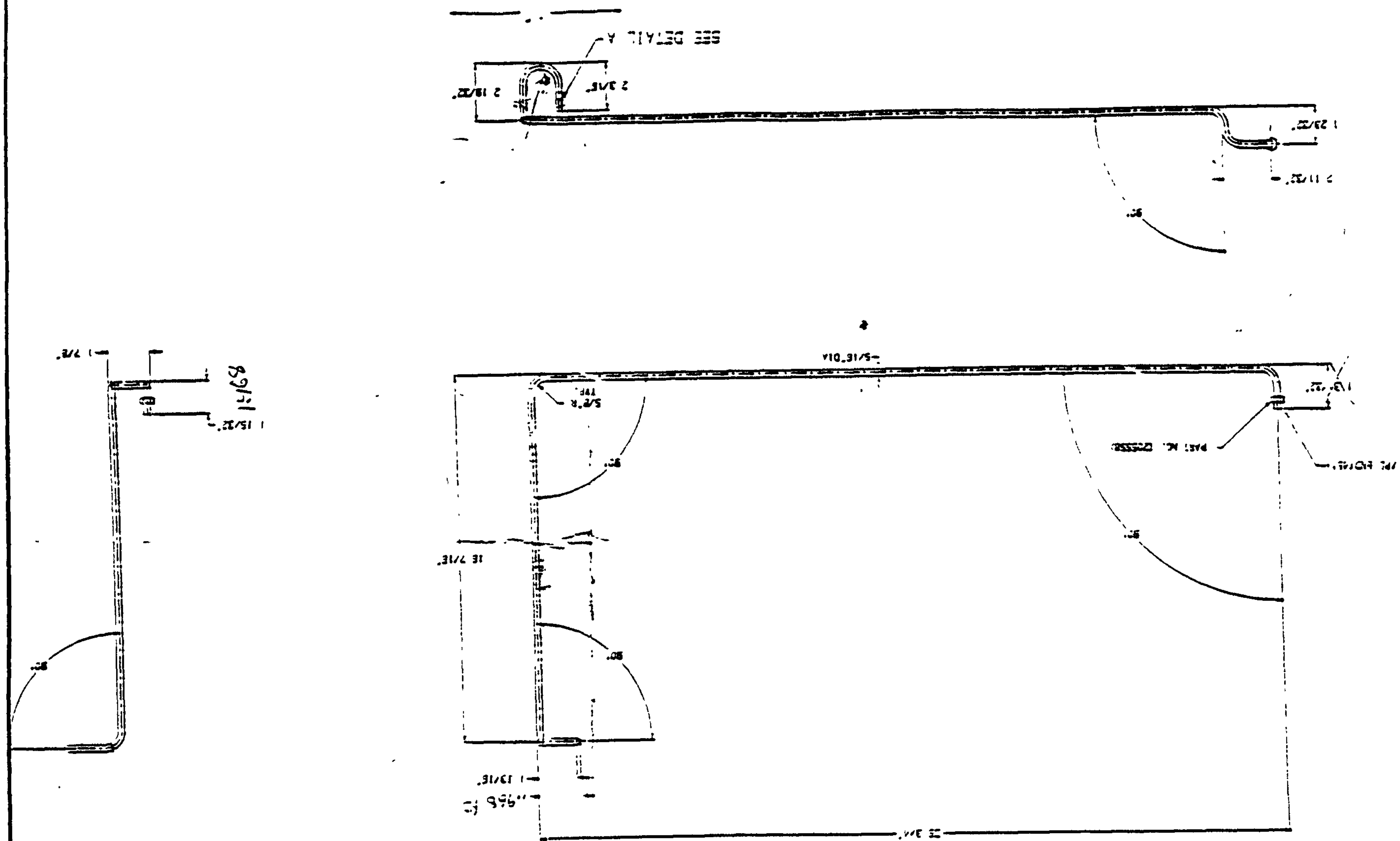


Fig Code: 20549 01 35 10 11 17 06 550 16

Different Operations on part shown in the figure:

1. Electrolytic automatic cutoff.
2. Deburr inside
3. Deburr outside
4. Reduce on end of the tubing.
5. Bead on the diameter.
6. Bend 180 degrees in 90 degrees plane at 2.093 O to O.
7. Bend 90 degrees in 90 degrees plane at 2.781 O to O.
8. Bend 90 degrees in 0 degrees plane at 19.781 O to O.
9. Bend 90 degrees in 90 degrees plane at 33.125 O to O.
10. Bend 90 degrees in 0 degrees plane at 1.718 O to D.
11. Bend 90 degrees in 90 degrees plane at 2.812 O to O.
12. Trim leg at 1.562 inches.
13. Deburr inside the tubing.
14. Deburr outside the tubing.
15. Flare at 45 degrees angle.
16. Clean the parts.
17. Inspection
18. Packing
19. Shipping

CODE: 2 0 5 4 8 01 35 10 11 17 06 600 15

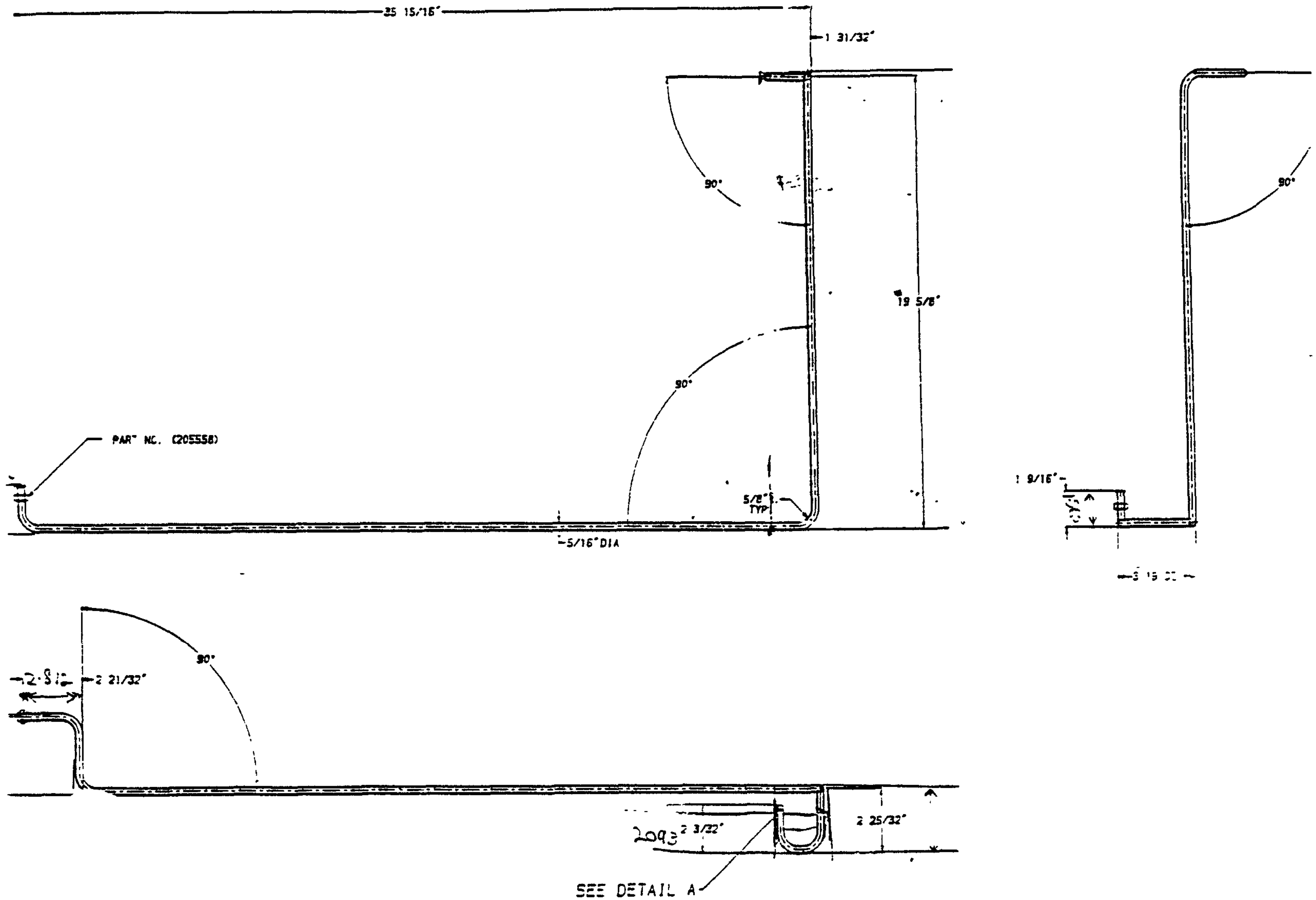


Fig Code: 20548 01 35 10 11 17 06 600 15

Different Operations on part:

1. Electrolytic Automatic cut off.
2. Deburr inside the diameter.
3. Deburr outside the tubing.
4. Reduce on one of the tubing to 0.270 inches.
5. Bead on the diameter.
6. Bend 180 degrees in 270 degrees plane at 2.156 ref.
7. Bend 90 degrees in 270 degrees plane at 2.468 C to O.
8. Bend 90 degrees in 0 degrees plane at 4.937 O to O.
9. Bend 75 degrees in 105 degrees plane at 33.532 C to O.
10. Bend 75 degrees in 0 degrees at 2.218 base distance C to C.
11. Bend 90 degrees in 90 degrees at 0.781 C to C.
12. Trim leg at 1.468 inches.
13. Deburr inside the tubing.
14. Deburr outside the tubing.
15. Flare at 45 degrees.
16. clean the parts.
17. Final Inspection
18. Packing
19. shipping

CODE: 2 0 5 4 5 01 35 10 11 17 06 575 16

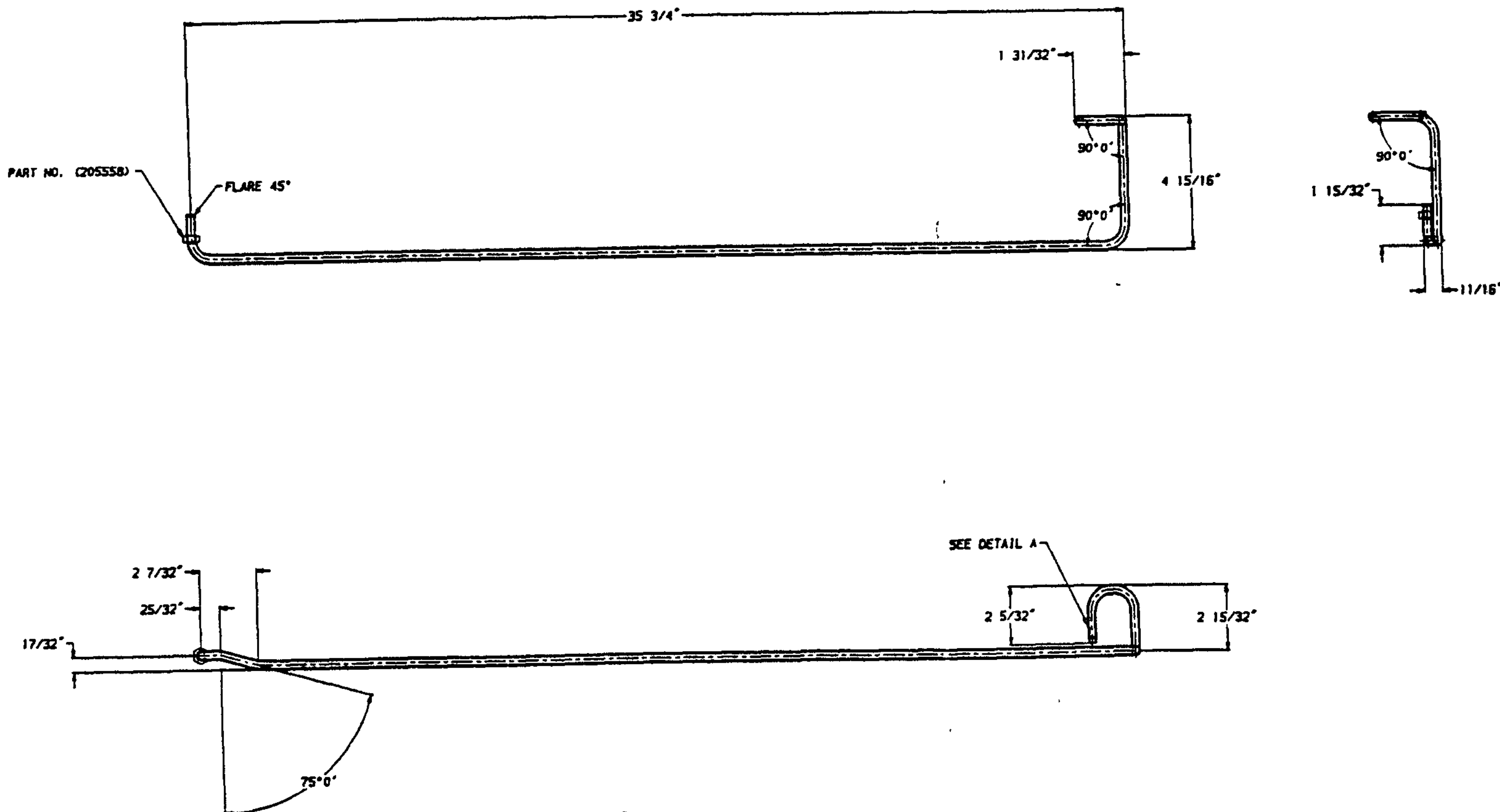


Fig Code: 20545 01 35 10 11 17 06 575 16

Different Operations on part coded

1. Electrolytic Automatic cut off to the blank size.
2. Deburr inside the tubing.
3. Deburr outside the tubing.
4. Reduce on end to 0.270 inches.
5. Bead on the diameter.
6. Bend 180 degrees in 270 degrees plane at 2.156 reference.
7. Bend 90 degrees in 270 degrees plane at 2.937 O to O.
8. Bend 90 degrees in 0 degrees plane at 8.031 O to O.
9. Bend 30 degrees in 320 degrees plane at 31.219 O to O.
10. Bend 30 degrees in 0 degrees plane at X horizontal distance O to O.
11. Bend 90 degrees in 90 degrees plane at 2.187 O to O.
12. Trim leg to 1.531 inches.
13. Deburr inside the tubing.
14. Deburr outside the tubing.
15. Flare at 45 degrees.
16. Clean
17. Inspection
18. Packing
19. Shipping

CODE: 2 0 5 4 5 01 35 10 11 17 06 800 15

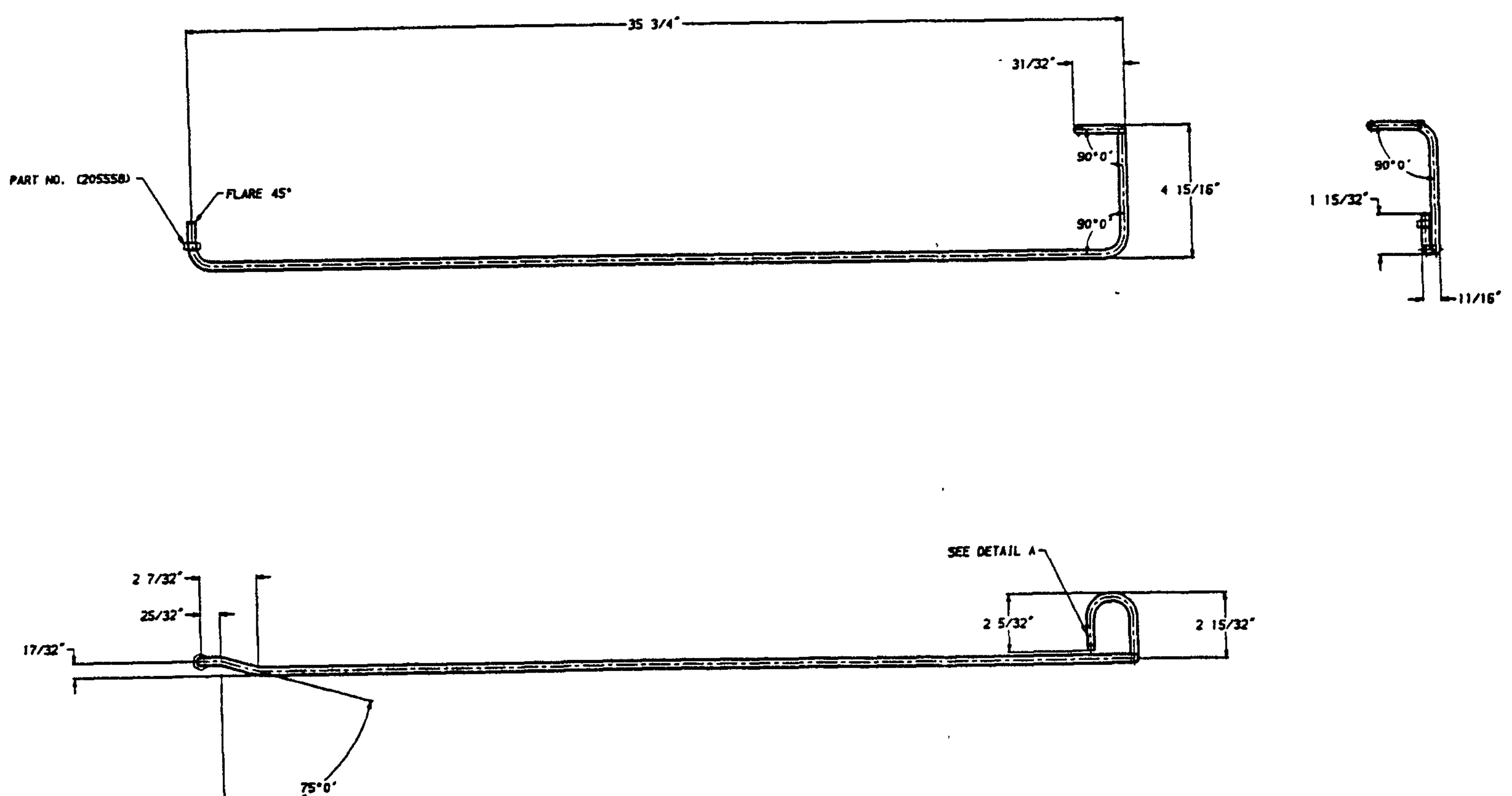


Fig Code: 20545 01 35 10 11 17 06 575 16

REVISIONS					
REV	DESCRIPTION	DATE	DRAWN	CHKD	ECN NO
01	3 7/8" WAS 3 11/16"	[illegible]			
02	4" WAS 3 7/8"	[illegible]	[illegible]		
02	REL FOR PROD	[illegible]	[illegible]		1969
03	35 3/4" WAS 35 5/16"	[illegible]	SM		2043

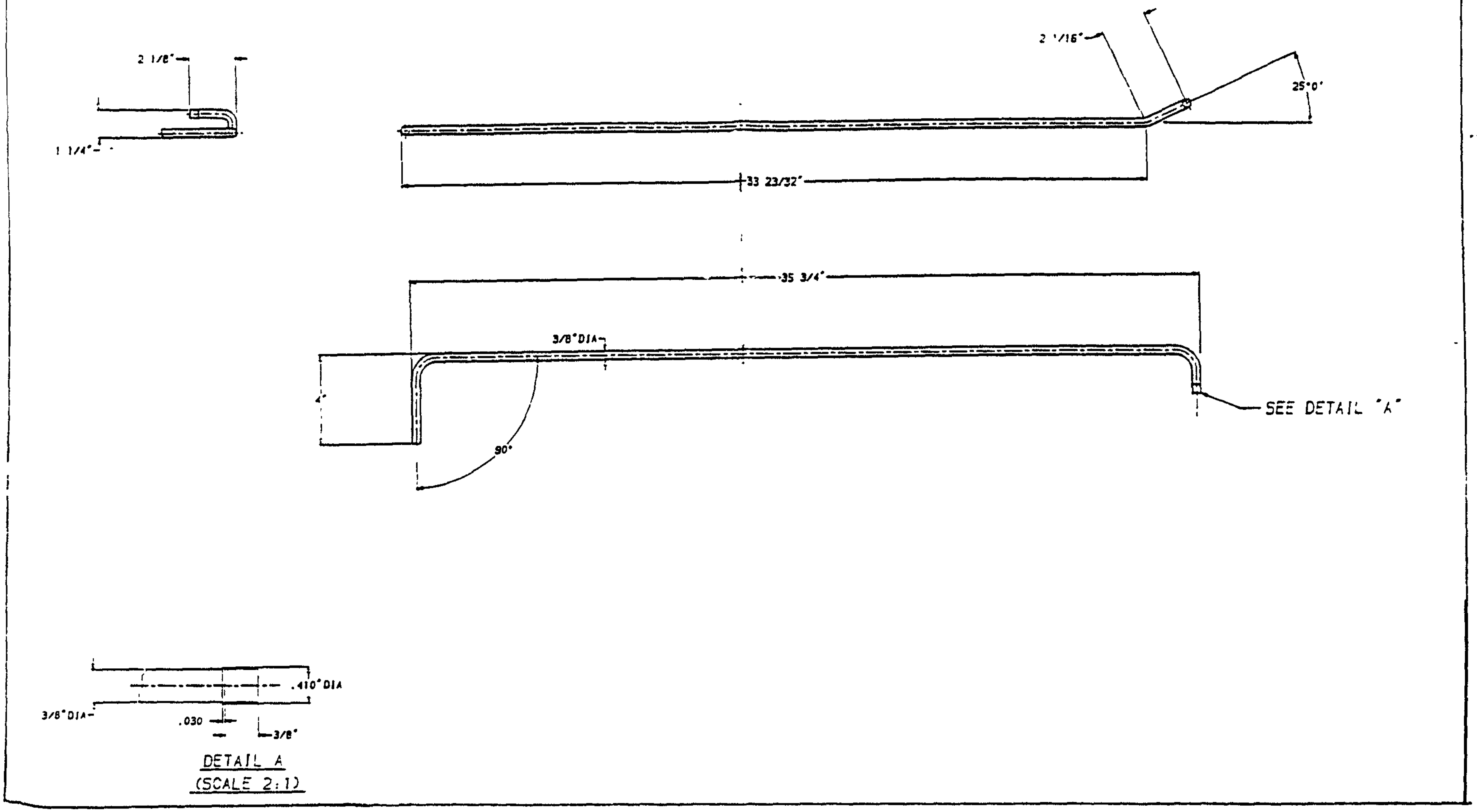


Fig Code: 20540 01 35 36 17 06 35 750 16

Different Operations on part coded

3/8 Tubing

1. Electrolytic Automatic cut off.
2. Deburr inside the tubing.
3. Deburr outside the tubing.
4. Expansion on Outer diameter from 0.375 to 0.410
5. Bend 90 degrees in 285.5 degrees plane reference.
6. Bend 19.5 degrees in 0 degrees plane at 2.062 hyp.
7. Bend 90 degrees in 90 degrees plane at 35.750 O to O ref.
8. Trim to 4.000 inches.
9. Deburr inside the tubing.
10. Deburr outside the tubing.
11. clean
12. Inspection
13. Packing
14. Shipping

CODE: 2 0 5 4 0 01 35 36 17 06 35 750 16

Different Operations On Part Coded

1. Electrolytic automatic cut off
2. Deburr inside the tubing.
3. Deburr outside the tubing.
4. Expansion from 0.375 to 0.410 inches on OD.
5. Bend 90 degrees in 285.5 plane at 2.125 ref.
6. Bend 19.5 degrees in 0 degrees plane at 1.625 base C to C.
7. Bend 90 degrees in 90 degrees plane at 37.468 C to O.
8. Trim leg to 2.500 inches.
9. Deburr inside the tubing.
10. Deburr outside the tubing.
11. Clean the parts.
12. Inspection
13. Packing
14. Shipping

CODE: 2 0 5 4 0 01 35 36 17 06 35 800 15

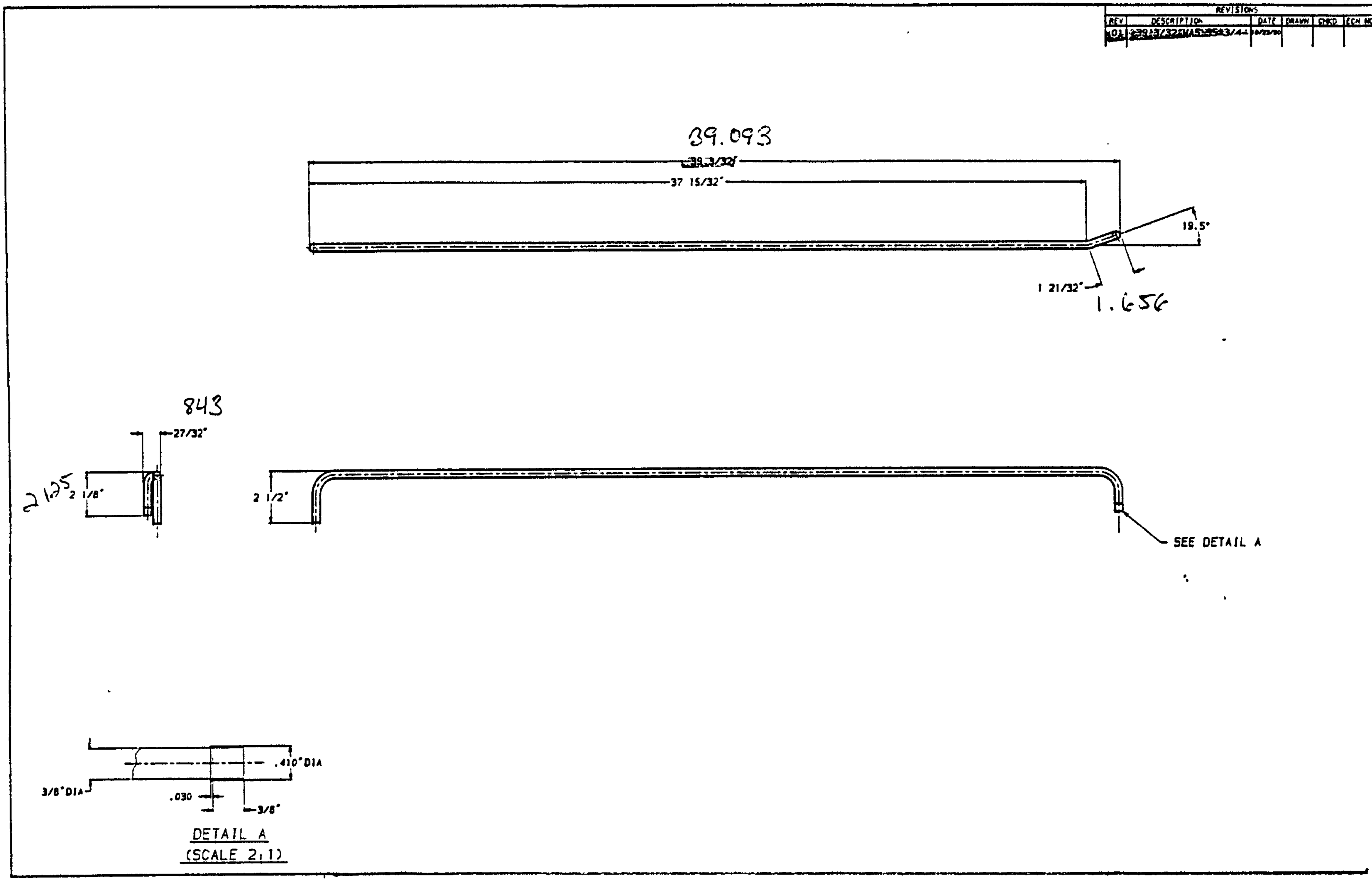


Fig Code: 20540 01 35 36 17 06 35 800 15

Operations on part coded

1. Electrolytic automatic cut off
2. Deburr inside the tubing.
3. Deburr outside the tubing.
4. Expansion from 0.375 to 0.410 inches on diameter.
5. Bend 90 degrees in 249 degrees plane at 2.125 O to O.
6. Bend 41 degrees in 0 degrees plane at 2.656 hyp C to O.
7. Bend 90 degrees in 90 degrees plane at 36.437 C to O.
8. Bend 90 degrees in 270 degrees plane at 24.218 O to O.
9. Trim leg to 1.6875
10. Deburr inside the tubing
11. Deburr outside the tubing
12. Clean
13. Inspection
14. Pack
15. Shipping

CODE: 2 0 5 3 5 01 35 36 17 06 35 750 16

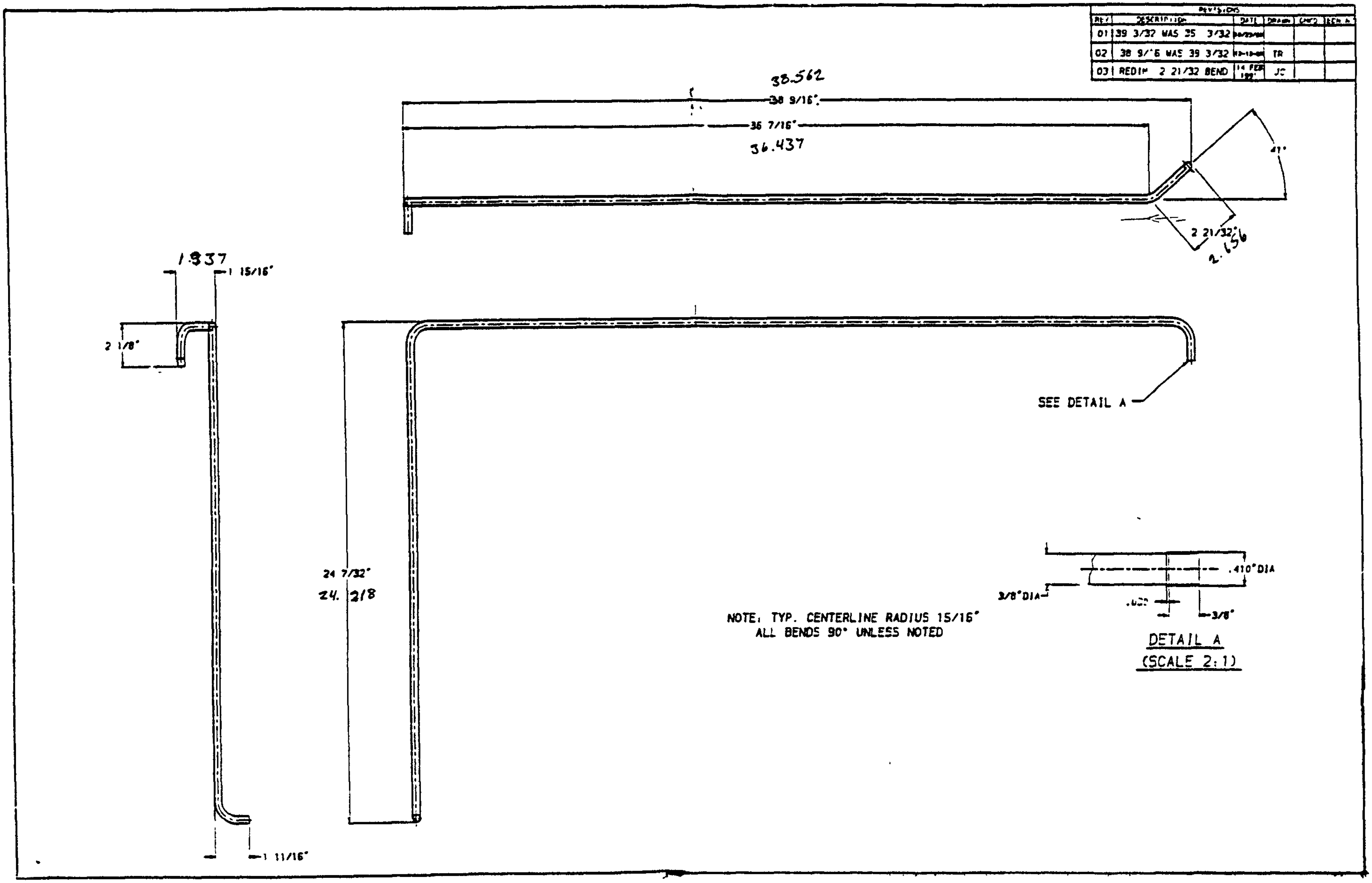


Fig Code: 20535 01 35 36 17 06 35 750 16

Different Operation on Part Coded

1. Electrolytic Automatic Cut Off.
2. Deburr inside the tubing.
3. Deburr outside the tubing.
4. Expansion from 0.375 to 0.410
5. Bend 90 degrees in 245 degrees plane at 2.125 O to O.
6. Bend 45 degrees in 0 degrees plane at 2.681 height O to O.
7. Bend 90 degrees in 90 degrees plane at 37.750 Ref. O to O.
8. Bend 90 degrees in 270 degrees plane at 22.598 O to O.
9. Trim leg to 1.687
10. Deburr inside the tubing
11. Deburr outside the tubing
12. Clean the parts.
13. Inspection
14. Packing
15. Shipping

CODE: 2 0 5 3 5 01 35 36 17 06 35 950 15

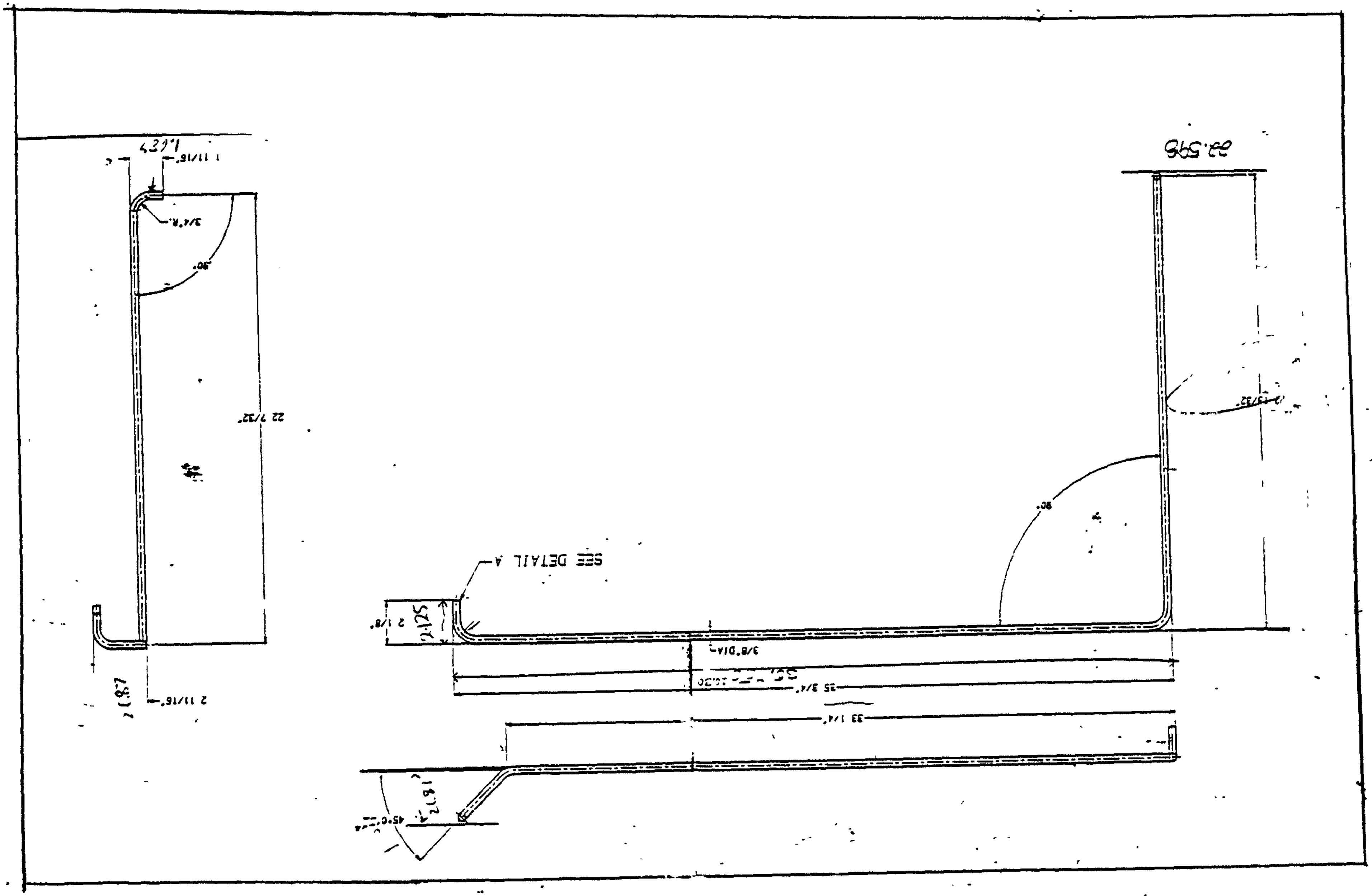


Fig Code: 20535 01 35 36 17 06 35 950 15

Different operation on part coded

1. Electrolytic automatic cut off.
2. Deburr inside the tubing.
3. Deburr outside the tubing.
4. Expansion
5. Bend 30 degrees in 0 degrees plane at 2.687 hyp O to C.
6. Bend 90 degrees in 270 degrees plane at 35.968 C to O.
7. Bend 90 degrees in 90 degrees plane at 24.218 O to O.
8. Trim leg at 1.718 inches.
9. Deburr inside the tubing
10. Deburr outside the tubing.
11. Clean the parts.
12. Inspection
13. Packing
14. Shipping

CODE: 2 0 5 3 0 01 35 36 17 06 35 1000 16

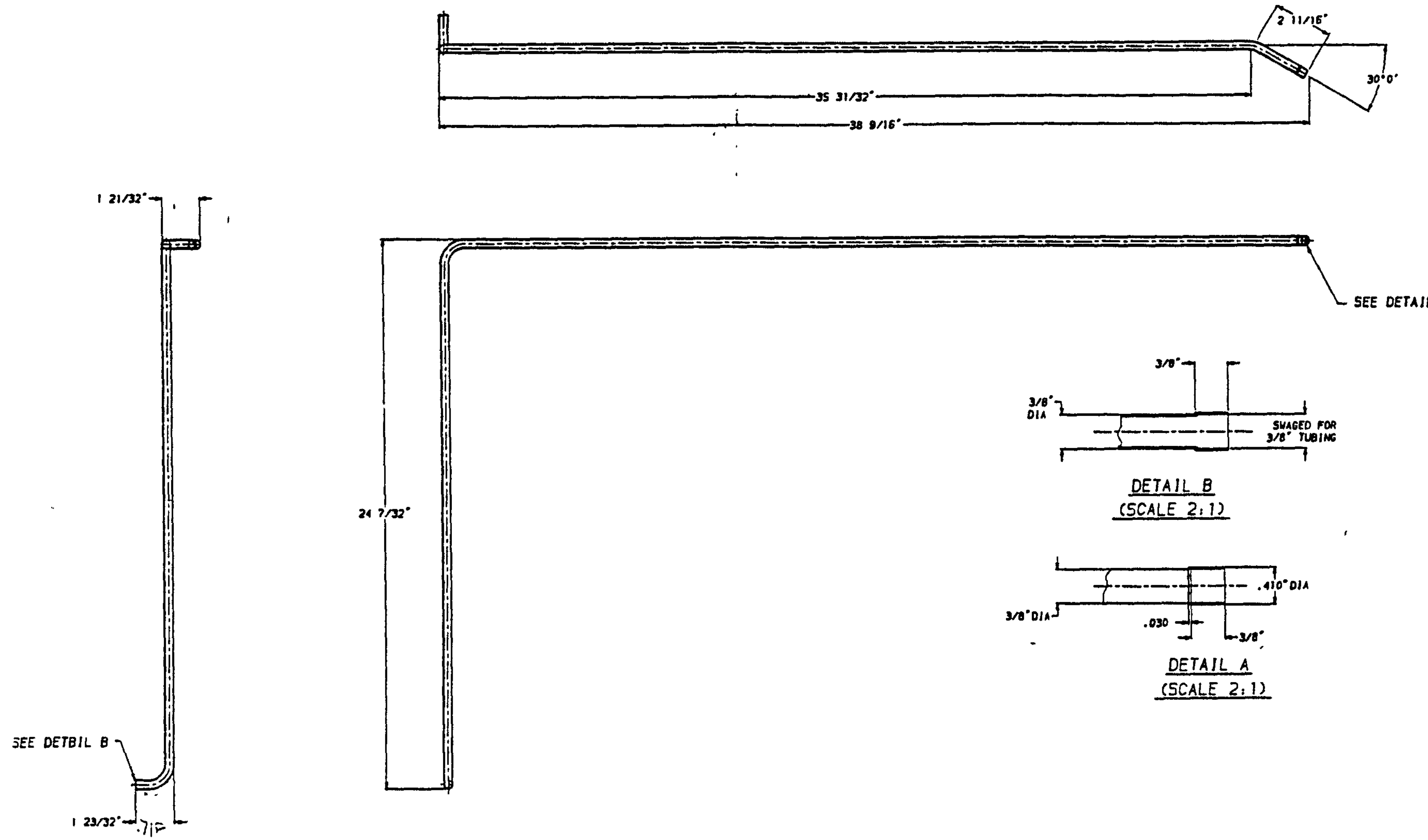


Fig Code: 20530 01 35 36 17 06 35 1000 16

Different Operations on part coded

1. Electrolytic automatic cut off
2. Deburr inside the tubing
3. Deburr outside the tubing
4. Expansion
5. Bend 30 degrees in 0 degree plane at 1.062 base C to O.
6. Bend 90 degrees in 270 degrees plane at 34.875 C to C.
7. Bend 90 degrees in 90 degrees plane at 22.406 O to O.
8. Trim leg to 1.718 inches
9. Deburr ID
10. Deburr OD
11. Clean the parts.
12. Inspect the parts.
13. Packing
14. Shipping

CODE: 2 0 5 3 0 01 35 36 17 06 35 650 15

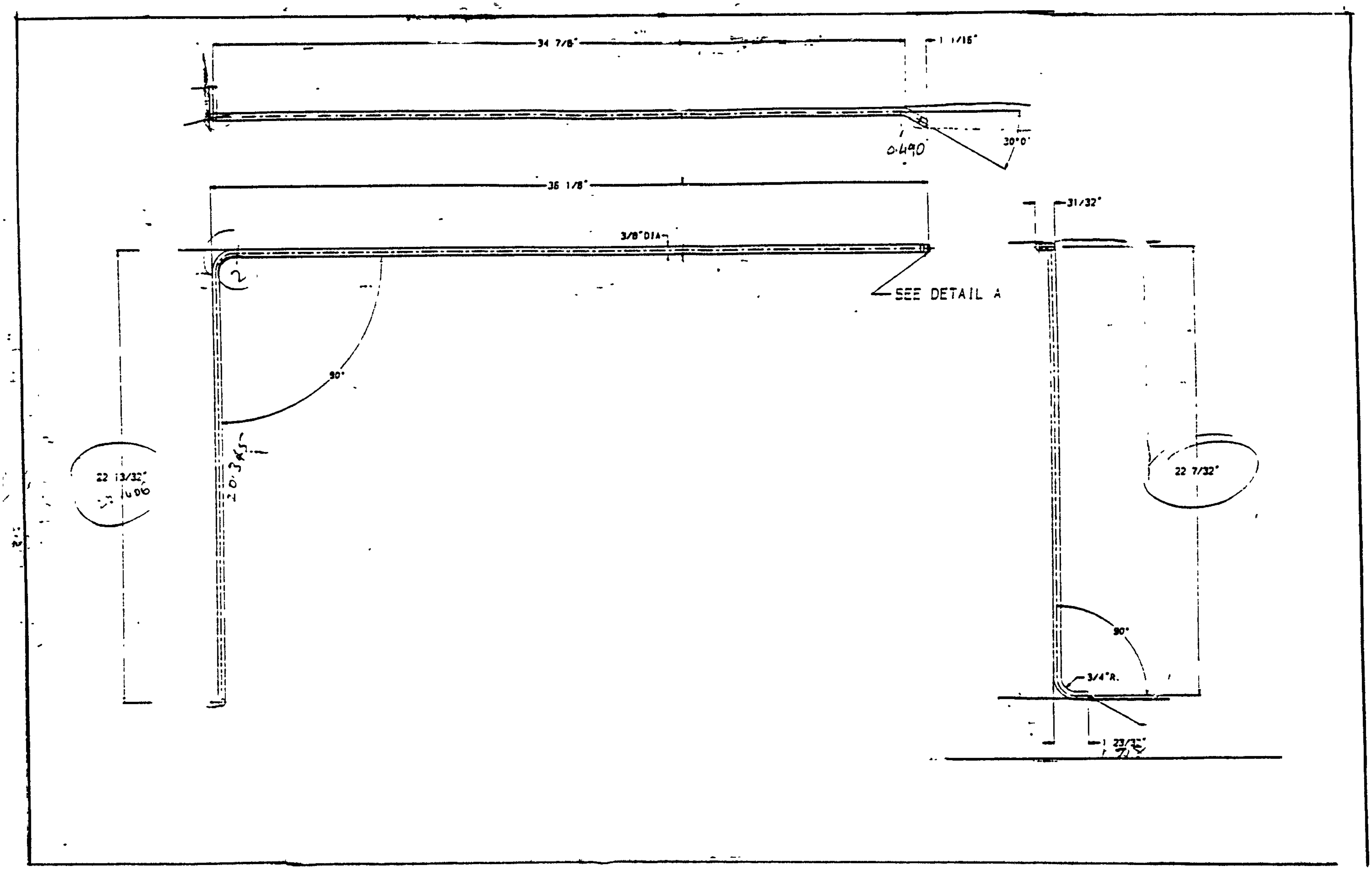


Fig Code: 20530 01 35 36 17 06 35 650 15

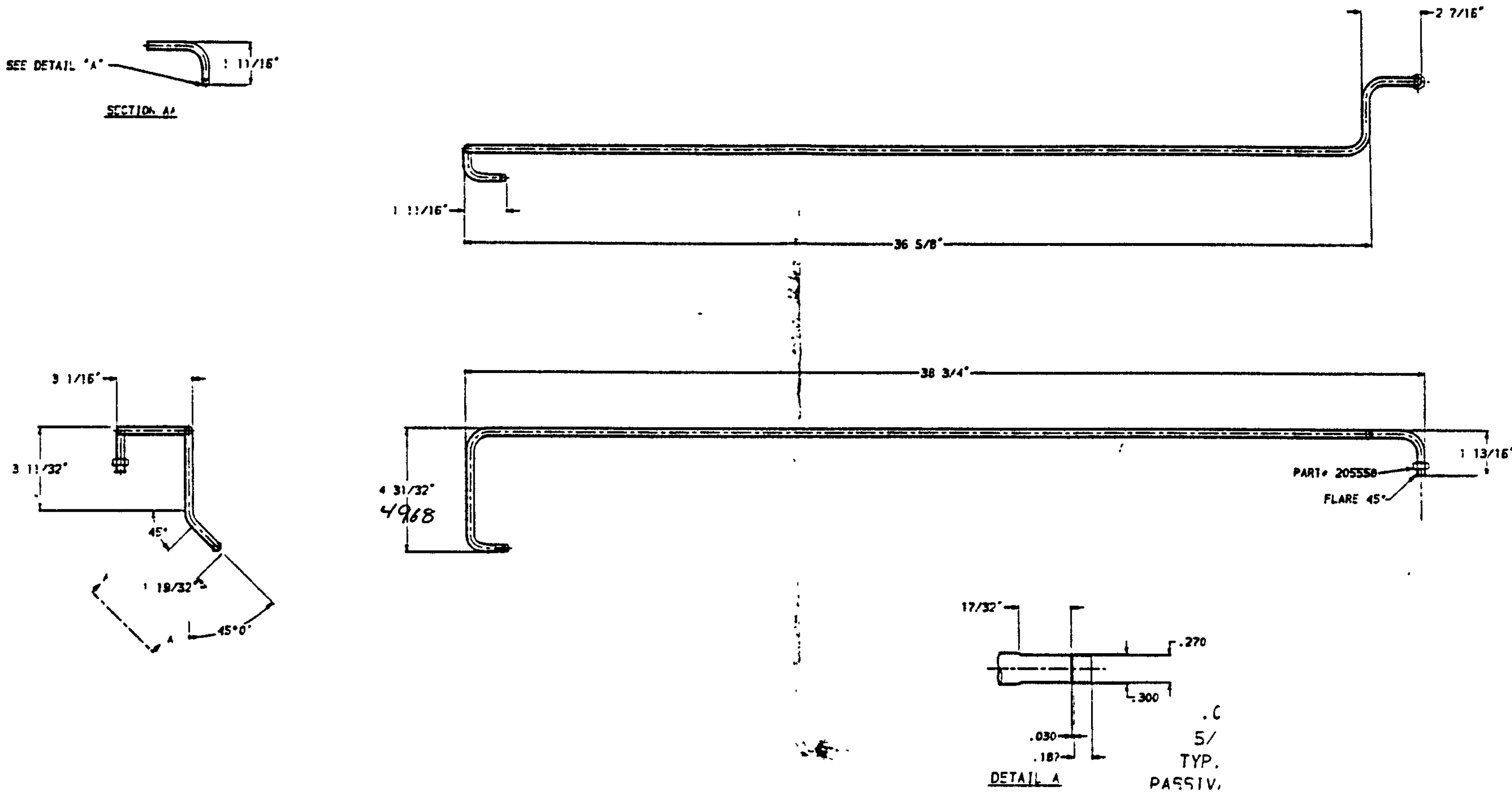
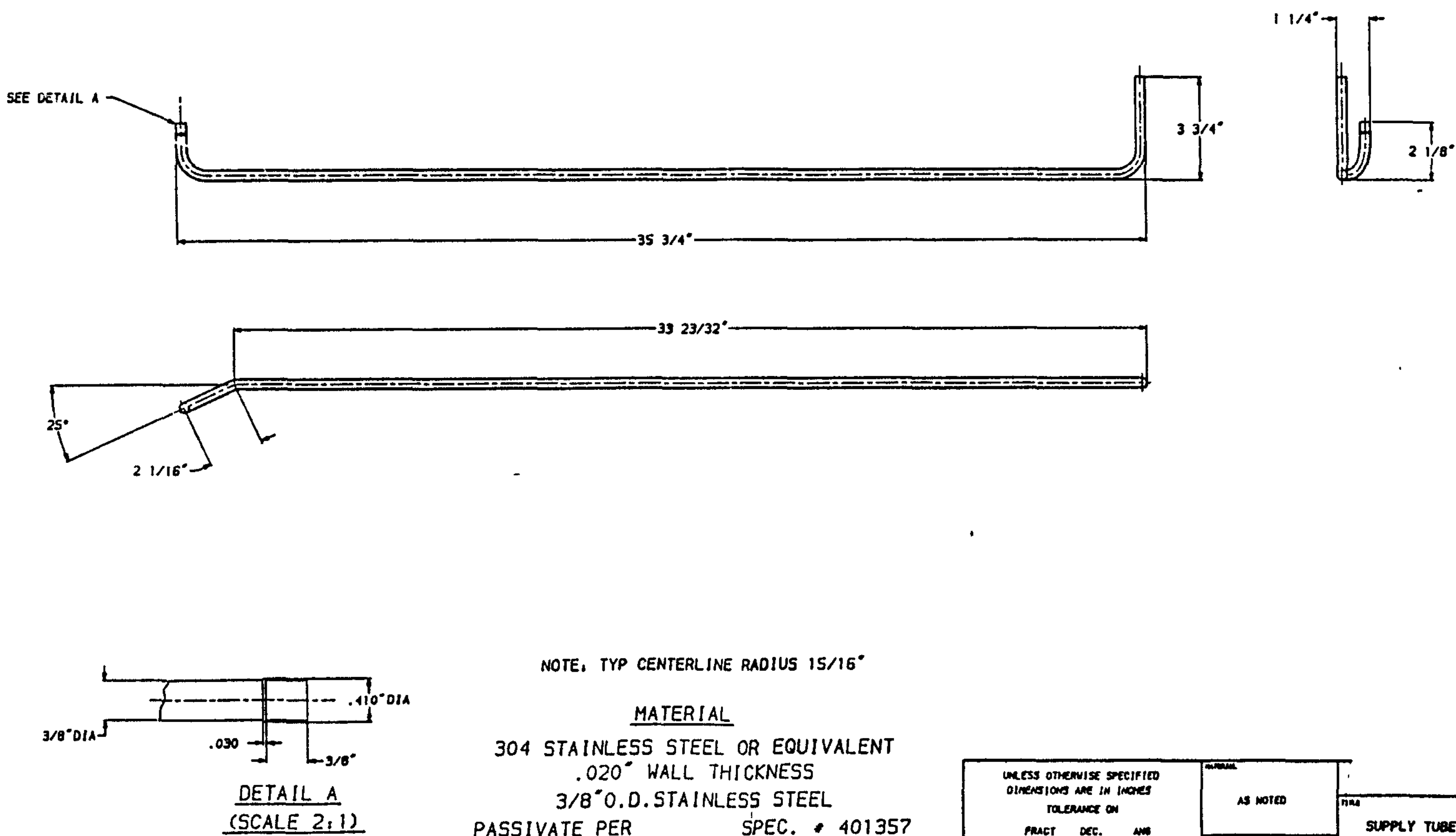


Fig Code: Other Part Family

REVISIONS					
REV	DESCRIPTION	DATE	DRAWN	CHKD	ECN NO
01	3 1/4" WAS 3 3/8"	[illegible]	SM		
01	REL. FOR PROD.	[illegible]	[illegible]		1969
02	3 3/4" WAS 3 1/4"	[illegible]	SM		
03	35 3/4" WAS 36 5/16"	[illegible]	SM		2043



NOTE: TYP CENTERLINE RADIUS 15/16"

MATERIAL

304 STAINLESS STEEL OR EQUIVALENT
.020" WALL THICKNESS
3/8" O.D. STAINLESS STEEL
PASSIVATE PER SPEC. # 401357

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCE ON
FRACT ± 1/32 DEC. ± .005 ANG ± 1°

AS NOTED
SM
07 MAR 1990

SUPPLY TUBE, SODA WATER
150 R.H.

D 205554
1/2 03 01 OF 01

205554

Fig Code: Other Part Family

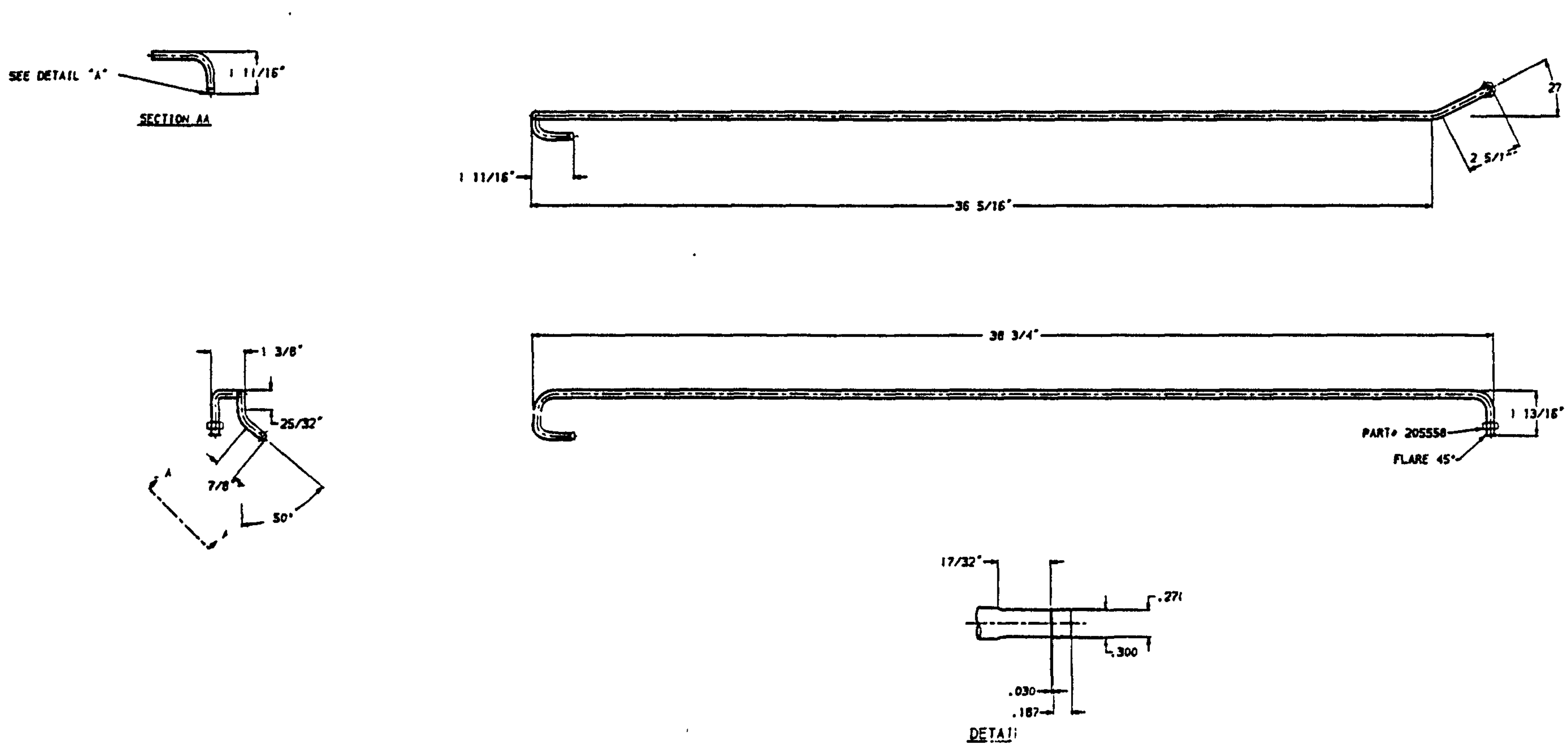


Fig Code: Other Part Family

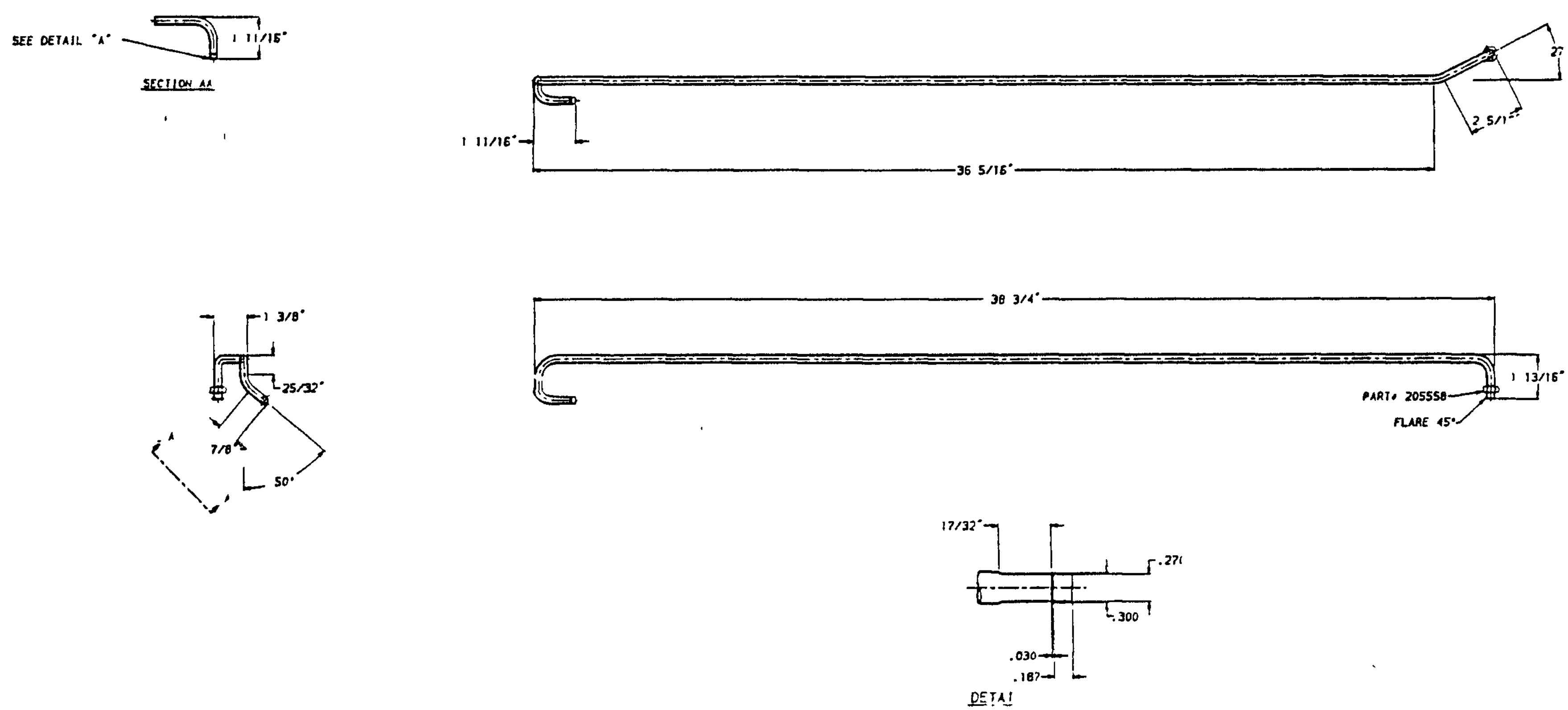


Fig Code Other Part Family

4.4 IMPLEMENTATION OF KANBAN , JIT AND OTHER PHILOSOPHIES

To make the principles of Cellular Manufacturing and Group Technology really work in each subdivision of the company, each department head must have a commitment. Usually this commitment can only be obtained by top management who should be indoctrinated as soon as possible.

All production personnel must be given necessary training, education about group technology and cellular manufacturing. Another most important is necessary training must be provided for the workers/production personnel, because parts are normally inspected within each cell by the person responsible for making the part, so that defects are spotted close to the point of inspection. If defects begin to occur, the number of bad parts can be reduced since quicker response is possible.

The layout must be changed from the present to cellular. Jobs no longer will travel great distances through a congested shop in order to be processed, thereby reducing time in throughput times and lead times.

ROUTING SHEET

At G & J Steel and Tubing Inc all operations are done following the routing sheet. It's a type of kanban system in developing stages. The Routing sheet is a complete, permanent list of all instructions on how a part(s) is fabricated, assembled, inspected, cleaned, tested, packed, shipped or other special instructions. The Routing sheet is to be used with customer supplied documentation to verify that the part(s) is manufactured to all tolerances specified, and all inspection points checked.

G & J STEEL AND TUBING, INC
SOMERVILLE, NEW JERSEY 08876

ROUTING SHEET

CUSTOMER : FOLLETT CORPORATION
PART No/NAME: 205510 REV:
MATERIAL : 3/8 X .035
DESCRIPTION : BIG COIL
G&J NO :

APPROVED:
DATE 02-27-1990
SOURCE G&J

CONTROL
11/4/91

OPERATION # 1: CUT OFF
MACHINE#/DESC: KI SAW
TOOLING :
INSPECTION :
REMARKS : 16 FEET LONG

OPERATION #2 : DEBURR
MACHINE #/DESCR: WIRE BRUSH
TOOLING :
INSPECTION :
REMARKS : DEBURR ONE END ONLY

OPERATION # 3 : EXPAND
MACHINE #/DESCR: MANCHESTER
TOOLING :
INSPECTION :
REMARKS : EXPAND .375 +/- .030

OPERATION # 4 : COIL
MACHINE #/DESCR: LATHE
TOOLING :

INSPECTION :
REMARKS : GRIP 2.750 REF. HOLD 4.000 OVERALL
COIL OVERALL 12.718

OPERATION # 5 : TRIM LEG
MACHINE #/DESCR: KI SAW
TOOLING :
INSPECTION :
REMARKS : TRIM LONG LEG TO 9.250 FROM BACK OF LAST COIL

OPERATION # 6 : DEBURR
MACHINE #/DESCR: WIREBRUSH
TOOLING :
INSPECTION :

OPERATION # 7 : BEAD
MACHINE #/DESCR: MACHESTER
TOOLING :
INSPECTION :
REMARKS : BEAD TO .437 +.015 -.000

OPERATION # 8 : BEND 90 DEGREES
MACHINE #/DESCR: 1A DIACRO
TOOLING : 15/16 CLEARANCE
INSPECTION :
REMARKS : GRIP 1.750 REF CHECK 2.937 AND 7.125

OPERATION # 9 : BEND 8 DEGREES APPROX
MACHINE #/DESCR: 1A DIACRO
TOOLING :
INSPECTION :
REMARKS : APPROX BEND 8 DEGREES WITH A PIN EXPANDED END

OPERATION # 10 : TWEAK
MACHINE #/DESCR: BY HAND
TOOLING :
INSPECTION :
REMARKS : 100%

OPERATION # 11 : CLEAN
MACHINE #/DESCR:
TOOLING :
INSPECTION :
REMARKS : CLEAN OIL ETC.

OPERATION # 12 :
MACHINE #/DESCR:
TOOLING :
INSPECTION :
REMARKS :

SHIPPING :

G & J STEEL AND TUBING, INC
SOMERVILLE, NEW JERSEY 08876

ROUTING SHEET

QUALITY G&J CONTROL

CUSTOMER : FOLLETT CORPORATION
PART No/NAME: 205515 REV:02
MATERIAL : 0.312 X .028 W S.S. TUBIN
DESCRIPTION : COIL, SYRUP LINE
G&J NO :

APPROVED :
DATE : 1[illegible]-[illegible]1-199[illegible]
SOURCE : WEBCO

OPERATION # 1: CUT 92.0"
MACHINE#/DESC: KI SAW
TOOLING :
INSPECTION : 92.0 INCHES
REMARKS :

OPERATION #2 : DEBURR
MACHINE #/DESCR: WIRE BRUSH
TOOLING :
INSPECTION :
REMARKS : INSIDE AND OUTSIDE

OPERATION # 3 : REDUCE END
MACHINE #/DESCR: MANCHESTER
TOOLING : 5/16 REDUCING PUNCH, 2" LONG GRIPS, EXTENSION STOP
INSPECTION : 0.270 O.D +/- .005
REMARKS : USE SPECIAL STOP EXTEND TUBE 1 1/8 PAST FACE OF JA
WS. USE HEAVY OIL. REDUCE 1/2 FIRST HIT, FINIS

OPERATION # 4 : BEAD
MACHINE #/DESCR: MANCHESTER
TOOLING : 5/16 JAWS, BEAD TOOL M107

INSPECTION :
REMARKS : EXTEND TUBE APPROX 1/2 TO 15/32 PAST 0.270 JAWS TO
GET BEAD 0.300 DIA

OPERATION # 5 : BEND 90 DEG.
MACHINE #/DESCR: 1A DIACRO
TOOLING : 3/4 CLR
INSPECTION : EXTEND 4.375
REMARKS : START BEND 2.750 PAST CLR OF DIE REVERSE BEND

OPERATION # 6 : BEND 90
MACHINE #/DESCR: 1A DIACRO
TOOLING :
INSPECTION :
REMARKS : START BEND 6.625 FROM BACK OF 90 DEG. REVERSE

OPERATION # 7 : BEND 90 DEG.
MACHINE #/DESCR:
TOOLING :
INSPECTION :
REMARKS : START BEND 3.969 FROM BACK OF 90 DEG. REVERSE

OPERATION # 8 : BEND 90 DEG.
MACHINE #/DESCR:
TOOLING :
INSPECTION :
REMARKS : START BEND 6.219 FROM BACK OF 90 DEG.

OPERATION # 9 : BEND 90 DEG. C.C.W
MACHINE #/DESCR:
TOOLING :
INSPECTION :
REMARKS : START 6.250 FROM BACK OF 90 DEG.
37 DEG. ROLL OVER

OPERATION # 10 : BEND 90 DEG. 37 DEG ROLL OVER
MACHINE #/DESCR:
TOOLING :
INSPECTION : CHECK 37 ROLLOVERAND 90 DEG. BEND HOLD OVERALL
REMARKS : START BEND 2 11/16 FROM BACK OF 90 DEG.

OPERATION # 11 : TRIM
MACHINE #/DESCR:
TOOLING :
INSPECTION : DIMENSION 4.593
REMARKS :

OPERATION # 12 : DEBURR
MACHINE #/DESCR:
TOOLING :
INSPECTION :
REMARKS :

SHIPPING :

The routing sheet will be generated for first run part(s) when the Traveler is issued to the Foreman. The routing sheet will stay with the part(s) throughout the fabrication process. The routing sheet will be generated by the Foreman, Lead, or set-up person. The routing sheet will contains information.

1. The part number and revision
2. The customer
3. The size and type of material to be used in the fabrication of the part(s).
4. The source for the material, if known.
5. A complete description of the part(s)
6. Complete chronological list of all the operations to be performed in the fabrication of the part(s).
7. Complete list of machines and tooling required.
8. Inspection procedures.
9. Remarks for any part of each operation.

The list of machines for each operation on the routing sheet will also include any and all set up instructions and illustrations. The list of tooling will also include special fixturing used in the fabrication of the part(s). The routing sheets are approved by the quality assurance department for the production.

TRAVELER

The traveler is the document which will travel with the material(s) of a part(s) through its fabrication process to insure that the part(s) to be fabricated meets the quality standards. The traveler will route the material from its manufacturing order to final shipment. Travelers are generated from the office of the director of manufacturing, after a manufacturing order for a part(s) has been received from the sales department.

TRAVELER

GJ 2032

CUSTOMER FOLLETT CORP. P.O. # 73606 DATE 11/09/91

PART NUMBER 205527 QTY. 50 DUE DATE 12/06/91

PRINT NO. ______ REV. 02

PRINT NO. ______ REV. ______

FIRST RUN ______ PAST RUN X M X D ______ G ______ PROD. LOT 55

HEAT # ______

MATERIALS AND SUBCONTRACTING

	ITEM	P.O. #	DATE REC'D.	INSP./DATE
1.	MAT STOCK .312 X .028 T304		11/12/91	11/13/91 Bw
2.				
3.				
4.				
5.				

FABRICATION OPERATIONS

	CODE	OPERATION	ESTM. HRS.	INSP./DATE	APPROVED
1.	SCU	SET UP CUTTING	.5		
2.	CUT	CUTTING - ABRASIVE	.3		
3.	DBR	DEBURRING - BRUSH	.7		
4.	SRE	SET UP REDUCE	.5		
5.	RED	REDUCE	1.0		
6.	SBE	SET UP BEAD	.5		
7.	BEA	BEADING	1.0		
8.	SBN	SET UP BEND	.5		
9.	BND	BENDING OP. #1	.4		
10.	SB2	SET UP BEND #2	.5		
11.	BN2	BENDING OP. #2	.4		
12.	SB3	SET UP BEND #3	.5		

SPECIAL INSTRUCTIONS ______

FINAL INSPECTION ______ DATE ______ BY ______

TRAVELER

***** CONTINUED *****

GJ 2032

CUSTOMER FOLLETT CORP. P.O. # 73606 DATE 11/09/91

PART NUMBER ________ QTY. ________ DUE DATE 12/06/91

PRINT NO. ________ REV. ________

PRINT NO. ________ REV. ________

FIRST RUN ____ PAST RUN ____ M ____ D ____ G ____ PROD. LOT ________

HEAT # ________

MATERIALS AND SUBCONTRACTING

	ITEM	P.O. #	DATE REC'D.	INSP./DATE
1.				
2.				
3.				
4.				
5.				

FABRICATION OPERATIONS

	CODE	OPERATION	ESTM. HRS.	INSP./DATE	APPROVED
1.	BN3	BENDING OP. #3	.4		
2.	SB4	SET UP BEND #4	.5		
3.	BN4	BENDING OP. #4	.4		
4.	SB5	SET UP BEND #5	.5		
5.	BN5	BENDING OP. #5	.4		
6.	STM	SET UP TRIM	.5		
7.	TRM	TRIM	.3		
8.	DB2	DEBURING - BRUSH #2	.7		
9.	SFR	SET UP FLARE	.5		
10.	FLR	FLARING	1.0		
11.	SB6	SET UP BEND #6	.5		
12.	BN6	BENDING OP. #6	.4		

SPECIAL INSTRUCTIONS ________

FINAL INSPECTION DATE BY

The Traveler will be issued to the foreman with the routing sheet by the production department after adequate material to fabricate the part(s) has passed incoming inspection and approved documentation received. The Traveler must accompany the part(s) through out the in-house fabrication process. Different production lots will be accompanied by separate travelers. The Traveler will be returned to the production department when the part(s) is sent for outside services by the shipping/receiving department. The production department will be accountable for attaining inspection data and certification for the fabrication performed by the outside services. Once the part(s) has completed final inspection, the traveler will be returned, with all inspection data and routing sheet, to the production department where it will be reviewed and filed. The information contained on the traveler:

1. Part Number: The part number will be filled out from the written order and will include revisions, if any.
2. Print Number and Revision: The print number and revision will be filled out from the written order. If no revision is given "REL" will be filled in.
3. Materials and Sub-Contracting: The material(s) required to fabricate or manufacture a part(s) will be listed. This information will come from an print approved by the Quality Assurance.
4. Quantity: The quantity and the delivery dates will be listed. This information will come from the manufacturing order.
5. Fabrication Operations: All the fabrication operations to be performed both by in-house and outside services. This will be done by listing each operation with sign off areas for each completed operation.
6. Fabrication: The part(s) will be defined as either a First Run or Past Run parts. First run parts are those which are run for the first time, first article inspection and approval is must and necessary for the these parts. First article

inspection is approved by the quality engineer. Past run parts are those which are run already (old job), all setups are approved by quality inspector or foreman.

7. Inspection: Incoming, inprocess and final inspections will be signed off and dated by the Engineer/Inspector/Foreman after completion. The inspection sheets will be attached to the Traveler.

May be, G & J Steel and Tubing, Inc is a medium company but it is in the developing stages. The systems followed and proposed at G&J are Just In Time, Kanban, Total Quality Management. The customer orders will be reviewed and material is ordered in Just In Time of seven to eight days of time. Most of the tooling ordered, fabricated outside is also Just In time. By using Just In Time management the company saves lot of inventory and investment. The incoming material is thoroughly inspected, tested according to the Military Standards.

PROPOSED CELLULAR LAYOUT

All the machines can be laid out as shown in the figure 4.7. These layout is done based on the part families and their grouping using Production Flow Analysis method. Most of the fabrication works are the same, only the bending angles and planes in which they are bend are different. The tubing is brought from raw material shed, then it is fed into the automatic electrolytic abrasive cutting machine where it cuts the tubing according to the set up. Then, the tubes are deburred outside and inside of the tubing to get rid of burrs caused in the cutting. The tubing follows to the end former machine, where it can be reduced or expanded according to the specifications mentioned on the routing sheet. All 3/8 inches tubing follows to the hydraulic bending machine for the bending, and 5/16 inches tubing follows to the end former machine to get beading done on the tubing.

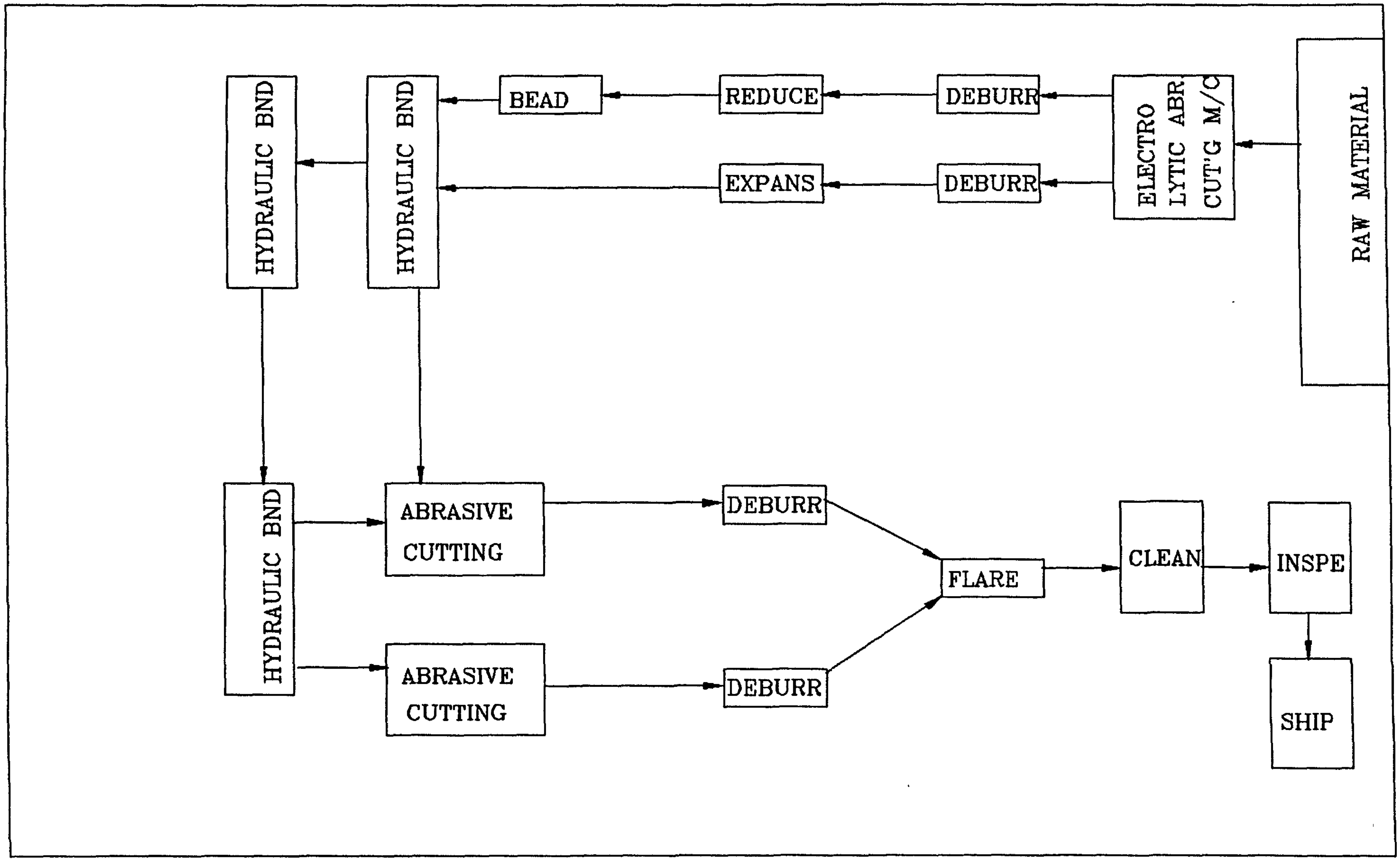


Fig 4.7 G & J STEEL AND TUBING PROPOSED CELLULAR LAYOUT

Then, it follows for the bending specified on the routing sheet. After all the process done, the tubing is send for trimming to the specified length, this is done on the abrasive cutting machine. Again, the tubing is deburred, flared, cleaned and are made ready for shipping. The machines are laid according to the operations performed on the tubing, this layout can also be used for alternative routing and alternative jobs. The layout is made such that the material handling is minimized, minimum number of machines used. This layout can be specified as Grouping machine cell with manual handling. where arrangement is made for more than one machine usage collectively to produce one or more part families. There is no provision for mechanized parts movement between the machines in the cell. Instead, the human operators who run the cell perform the material handling function. Depending on the size of the parts and the arrangement of the machines in the cell, this function may require the assistance of the regular material handling crew in the shop floor. This layout is considered appropriate when there is a variation in the work flow among the parts made in the cell. It also allows the multifunctional workers in the cell to move easily between machines.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The following is the data of the present system:

1. The total setup time is 7-8 hours for each part, considering 11 setups on the average.
2. Lot of material is wasted in this setups.
3. Unnecessary labor.
4. Poor quality, which is resulting in
   a. Reworks, again rescheduling the machines.
   b. Labor charges, 15-20% additional payroll.
   c. Extra setups and waste of time.
   d. Wastage of time in production.
5. Huge inventories, resulting in unnecessary investments on inventories which can be saved.
6. Extra machinery and space in use.

Implementing Cellular manufacturing at G&J will result in:

1. Preventing inventory loss by at least 30-40%.
2. Reduce set up times from 8 hours to 3 hours.
3. Reduce queue and throughput times 30-40 %.
4. Improvement in the Quality of the products upto 80% thereby saving in labor and their additional charges, which is 15-20%.
5. Reduce material handling atleast by 30%
6. Increased floor space by 25% (estimated)

7. Increases operator mobility and responsibility.

8. Reduction of scrap losses (60%), since families of parts flow continuously across groups of dedicated machine centers, workers are rarely faced with an unfamiliar part. Therefore production is more consistent and the scrap associated with the start up of a new part is reduced.

9. Reducing tooling and fixture expenses.

10. Reduce in the production, planning and control efforts.

11. Reduce in the design effort.

12. Easy and more accurate cost estimates.

The human resistance in implementing Cellular Manufacturing and Group Technology can be overcome by extensive education about Group Technology and Cellular concepts, hands on training, and the early involvement of the affected individuals are the best ways to implement new work roles. Selling the idea of Group Technology cells to labor unions can require great efforts, including restructuring payment systems. Personnel policies and training systems must change as well. Because of different requirements of working in a cell, companies commonly rely on volunteers when forming teams.

The unbalanced workload can become an advantage, however, by focusing capacity planning on these few bottlenecks. Even if the additional, dedicated machines cause a lower overall machine usage, the increased throughput times, lower inventory levels, increased productivity, and higher quality associated with cells represent a net gain.

By reducing setup times and clustering all the processes close together in a machine cell layout, small batches will become economical for the company. For example, if the company works on large lot sizes, which takes three to four months to complete the job, results in inventory turns of only three per year. Decreasing the lot size, shipping the parts weekly on time pushes the company's inventory turns to more than 13 per year.

Work and workers must be organized around the cell concept. A goal must be set for the operators in a cell to cross train and knowledgeable in the operation, setup and maintenance of all machines in the cell. This includes the ability to perform the Statistical Process Control checks on each process.

RECOMMENDATIONS

1. Educating, training the production personnel is important in the implementation of cellular manufacturing.

2. Regular meetings with the operators, supervisors and engineers and management to resolve the problems, improving the system etc.

3. Introduction of conveyor system will enable the workers to concentrate on the more important production process instead of taking time to carry parts to other machines.

4. Machines must be scheduled using some of the best softwares or techniques.

5. Must use simulation modeling to help develop and evaluate new methods.

6. Disciplinary action must be taken on the planners who try to sneak non-cell items into the cells, since throughput is faster.

7. Improve work load fluctuations by using MRP and shop floor control.

8. Informal procedures for identifying and grouping similar items may be inadequate for pursuing Group Technology applications. Consequently, formal classification and coding schemes must be used to aid in identifying and exploiting item similarities.

9. The disadvantage of using production flow analysis is that it provides no mechanism for rationalizing the manufacturing routings. It takes the route sheets the way they are, without any consideration being given to whether the routings are optimal or consistent or even logical. Future work can be done using other methods of grouping the parts.

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