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COLD FORMED MACHINE BOLTS AND HEXAGON NUTS

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Case Study Data on
Productivity and Factory Performance

COLD-FORMED MACHINE BOLTS AND HEXAGON NUTS

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The collection of the data presented in this report has been made possible not only by the cooperation of manufacturers in the United States but also by the advice and assistance of many individuals in the industry, in trade associations, and in labor unions. The men who have contributed their time and technical experience deserve particular appreciation for having made available data on man-hours, output, factory operations, production methods, managerial practices, and machinery--data which represent the results of many years of research and observation.

The term productivity is defined as the ratio of a given quantity of production (output) to one or more of the various "input" factors that are required for such production. As used in this report the input factor concerned is labor, the most important and universal factor and the one that provides the most generally useful common denominator for comparing the efficiency of productive methods and techniques in different units of an industry or between the same industries in different geographic locations.

The material in this report constitutes one aspect of the variety of services offered in the Technical Assistance Program of the Foreign Operations Administration. The Factory Performance Reports are prepared and published as a result of a request from the Organization for European Economic Cooperation, under a project designated as TA-OEEC-94.

Full translation and reproduction rights are hereby granted to those groups desiring to translate this report into their own language for distribution to members of their industry and labor groups. Similar reports covering other industries and products are currently being prepared and will be released as soon as they are completed.

Reports in this series published to date and available are listed on the inside back cover of this publication.

FOREWORD

This report is primarily for the use of European production managers, superintendents, and methods engineers who are concerned with productivity problems. A study of the technical portions of this report should make it possible for these plant officials to compare manufacturing operations in their plants with the operations in one or more of the plants surveyed in this report. In addition, the general discussion of productivity and the presentation of man-hours per unit in the manufacture of nuts and bolts undoubtedly will be of interest to government, labor and trade association officials in Europe.

The products covered in this report were selected on the basis of requests made by European industry groups and were transmitted to the Bureau of Labor Statistics by the Foreign Operations Administration. The plants selected for these case studies are intended to provide examples of the manufacture of these products in American plants but are not intended to represent a statistical sample of the American industry. In selecting plants for study the following criteria were considered: That the product made by the plant be similar to the product specified in the original European request, that the plant selected maintain records in sufficient detail to provide data, and that the cost of collecting the data be minimized.

Description of Report

This report is divided into three chapters. Chapter I is directed primarily to the reader who is interested in the less detailed aspects of productivity in the industry. Chapter II contains detailed case studies of each plant and will be of value to the plant superintendent or the production engineer. Chapter III contains a brief discussion of workers earnings, the benefits to the worker which result from increased productivity, and unionization where applicable. The appendixes contain case studies of labor adjustments to technological changes, industry background information, a copy of the questionnaire used, and a glossary of trade and technical terms.

The data used for the case studies were obtained from plant records and from plant officials by representatives of the Bureau of Labor Statistics who visited each plant for the express purpose of making this study. The amount of detail shown in the case studies varies because some information was not obtainable from all plants, and some information was not usable in the form provided. Supplementary information was obtained from other Government agencies and from trade associations.

How To Use This Report

In using this report the following procedure is suggested to plant officials:

1. The plant official should refer to the tables in chapter I and

to the case studies in chapter II, to identify the United States plants in this study with employment, production volume, and integration most nearly approaching the situation of his plant.

2. Appendix III contains a reproduction of the questionnaire used to obtain the information from the United States plants in this study. If the European production official will use this questionnaire to calculate labor requirements in his plant, he will be able to compare performance in his plant with that of the plants discussed in this report, and to isolate areas in which his plant's performance is either relatively good or relatively poor.

3. The European plant official is now ready to compare the machinery and methods described in the report with those existing in his own plant, for those problem areas he has isolated. At this point the report does not give him the precise engineering information needed but it does suggest the approximate requirements in terms of volume, methods, machinery, and manpower necessary to achieve the productivity levels illustrated in the individual case studies.

4. For serious problem areas uncovered in this manner, the expert assistance of engineers, either those within this plant or outside consultants, will be needed. Intensive study must generally be made to correct the conditions found by comparison because these reports cannot replace on-the-spot engineers or other specialists, in the analysis of specific situations.

Case Study Data on
Productivity and Factory Performance

COLD-FORMED MACHINE BOLTS AND HEXAGON NUTS 1/

CHAPTER I: GENERAL REPORT

Highlights.

This report analyzes the case studies of 5 plants in the bolt and nut industry. These include 2 with fewer than 300 production workers, 2 with between 500 and 1,000 production workers, and 1 with over 1,000 production workers. Two major managerial factors have enabled smaller plants in this industry to compete profitably with larger plants: first, the ability to group machines in the plant so as to keep materials movement and handling to a minimum, and second the ability to staff the machines so as to secure a maximum degree of operating efficiency.

Ordinarily, smaller plants would prefer to manufacture special or non-standard items with their higher per unit profit especially since larger plants have the advantages of longer production runs. However, the fact that small plants can compete with large firms has provided the incentive for them to compete on an increasingly efficient basis in the manufacture of standard types of bolts and nuts.

The development of specialized machines in this industry has made possible longer production runs with its attendant decrease in machine setup time and materials handling. Examples of such machines are: wire drawing machines, boltmakers, semiautomatic cold headers, combination headers and pointers, thread rollers and pointers, and punching and chamfering machines.

Constant effort is being made in the United States, both by industry and by government agencies, to standardize the specifications of bolts and nuts as to form of thread, classification and tolerances, gage, pitch and taper; and to reduce the number of types of fasteners which duplicate or overlap the functions of others. This has had a tendency to make production in this industry highly automatic, and makes possible a high degree of job specialization, and an increasing use of unskilled and semiskilled labor in place of skilled labor.

The incentive pay system, an increasing use of mechanical materials-handling equipment, and the most efficient use of men and machines are additional factors which have contributed to the present high level of productivity in the United States in bolt and nut factories.

1/ This report was prepared by Seymour Rand from notes by Norman Salenger, Division of Productivity and Technological Developments, Bureau of Labor Statistics, U. S. Department of Labor.

Cold-Formed Machine Bolts and Hexagon Nuts

A bolt is a metal fastening device having a head on one end and a screw thread cut or rolled upon the shank. Bolts are given various names according to (1) the general shape of the head, such as square, slotted, eye, or ring; (2) the mode of securing, as expansion, tap, or key; and (3) the method of application, for example; carriage, coupling, elevator, hanger, stud, and stove bolts.

Although there is a large variety of nuts and bolts manufactured, only two of the more popular sizes were selected for the study. These are: 1/4-inch x 1-inch, 2/ and 3/8-inch x 1-1/2-inch bolts cold headed, rolled thread; and 1/4-inch and 3/8-inch cold punched, hexagon nuts. 3/

The machine bolt which has a partly or fully threaded shank is most often used in conjunction with square or hexagon nuts. The major parts of a bolt are the head and the shank. The shank is the body of the bolt upon which the thread is impressed or cut. The tip of the bolt, the end opposite the head, is usually pointed slightly to provide an easier fit and greater interchangeability between mass-produced bolts and nuts.

A cap screw is similar to a finished hexagon-head bolt except that its fastening function is generally used in conjunction with a thread tapped into the object to be held rather than through the use of a nut. (See chapter II for a detailed description of the reported products in this study.)

Manufacturing Processes

There are two manufacturing methods in general use for the production of machine bolts; the so-called conventional method, and the "Boltmaker" method. In the conventional method each of the 4 main operations, head, trim, point, and thread, is performed on a separate machine designed to perform 1 or 2 of these operations. The Boltmaker method consists of the use of a machine called a Boltmaker in which the 4 operations named above are performed concurrently on the 1 machine.

One advantage in the use of the conventional method over the Boltmaker is that with the use of individual machines, the breaking of a die will cause a loss of output in only one machine whereas the other machines continue to build up a supply of materials. The breaking of a die on the Boltmaker causes production to stop on all work stations of the machine. The advantages of the Boltmaker are: greater output per unit of time owing to the fewer materials handling operations and the need for less floor space than for the individual machines used in the conventional method. This provides economies in materials handling and allows for more working and storage area.

2/ The first measurement represents the major diameter; the second measurement represents the length of the bolt. The length of the bolt is measured from the underside of the head to the end of the bolt.

3/ The diameter of the nuts refers to the size of the bolts on which they fit.

Material Preparation

Steel strip or rod is used for nuts. Rod or wire is the raw material used for making bolts and the rod is purchased in coils weighing about 450 pounds and having a length of approximately 120 feet. Rod preparation consists of pickling, removing scale, and drawing the rod to a required size in preparation for cold forging. Cleaning is done by a pickling operation in which the coils or rods are dipped in an acid solution that removes rust, scale, and dirt. After a water rinse to remove the acid and residue, the rod is dipped into a lime solution which neutralizes the acid and acts as a lubricant and carrier for the wire drawing compounds such as aluminum or calcium stearate. Such lubricating compounds are necessary in drawing the wire down to the required size. In some instances, the lime tends to become a powder as the rod is drawn and this powder has a tendency to settle on oiled parts of the header. Attempts to substitute other ingredients for lime have failed because lime is the most nearly perfect carrier for the compounds used.

Wire Drawing

If the material used to make bolts or nuts has been made by a hot-rolling process, it is called rod. If it has been cold-drawn, it is called wire. (See glossary for more complete definition of rod and wire.) As a rule, most firms purchase rod which is then cold-drawn in wire-drawing machines to a required size. Some of the very small companies which do not have their own wire-drawing equipment purchase steel wire which has already been drawn to a specified size and can be fed into the header without a previous drawing operation. Rod must always be pickled prior to use to remove scale regardless of how smooth it looks. Wire does not require cleaning as the scale is removed together with the surface metal in the drawing operation.

Some plants draw rod in a separate drawing operation through the use of a powered drawing machine. Others use a special rod-drawing and straightening machine (Hogue wire-drawing machine) which is used in conjunction with the cold-heading machines. This drawing machine imparts a smooth surface to the rod, thus prolonging the life of the header die and permits the header to operate at greater speed. Other advantages of combining wire drawing and heading are that no additional labor time is required for the drawing operation because the helper on the heading machine can handle the wire and also attend to his other duties in the allotted cycle time, thus eliminating the need which arises in the separate drawing operation for space to store the drawn wire.

Some firms perform butt-welding of wire coils prior to feeding the wire into the header. Butt-welding is a process in which the end of one coil is welded to another to form a continuous wire. This insures a steady flow of materials into the header. Firms which prefer the practice of feeding individual coils into the header in preference to butt-welding claim that if the weld is imperfect, the welded section of wire has a tendency to break the forming dies in the header.

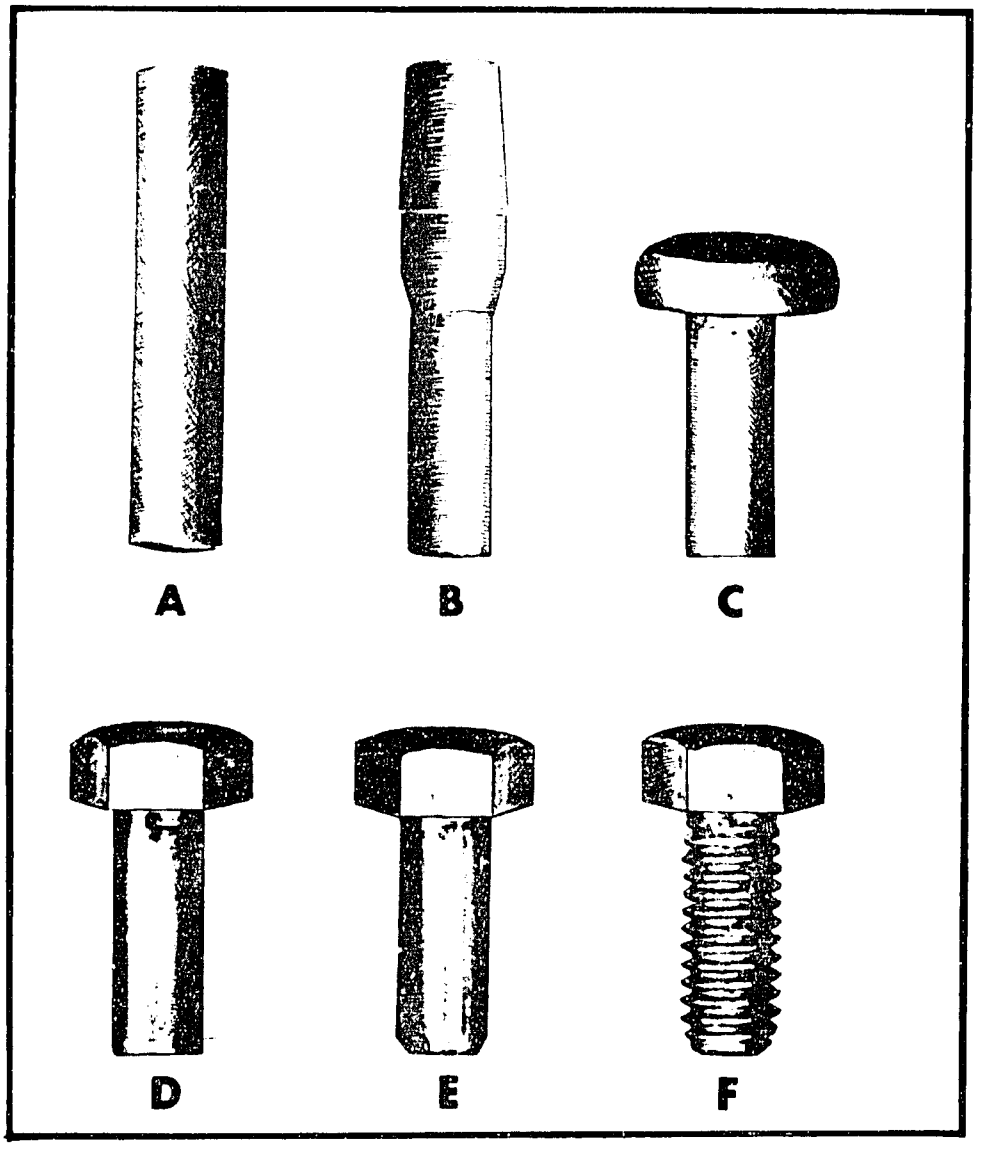

Figure A Steps in the processing of a cold-formed machine bolt:

A - Blank cut to length
B - After first header stroke
C - After second header stroke
D - After trimming operation
E - After pointing
F - Completed bolt after threading

Processing Bolts and Nuts

Four main operations - head, point, trim, and thread - are performed in making cold-rolled machine bolts (fig. A). Punching and tapping are the two main operations performed in making nuts.

In forming cold-headed bolts the rod is fed automatically into a machine which cuts the rod into blanks approximately the length of the required bolt plus an amount required to form the head. These blanks are automatically moved to one or more forming presses which, by a single pass of the dies, form a round head on the bolt and eject the formed blank into a container. The following operations vary somewhat by plant but the sequence in the conventional method is generally as follows: the bolt head is "trimmed" or cut to shape by one stroke of a cutting die in a trimming machine. The bolt shank is then pointed. The final operation consists of rolling the tread on the bolt shank. Thread rolling is a method in which the threads are formed by means of a die or roll having threads or ridges which are forced into the material to be threaded, and, by displacement of the metal, produces a thread of required form and pitch. This is followed by a heat-treatment to harden the metal. Each of these operations is usually preceded or followed by one or more of the following, depending upon individual plant practice: weighing, tumbling, annealing, washing, and inspection.

The Boltmaker method follows the same general manufacturing steps except that in this method a single machine called the Boltmaker performs the sequence of operations necessary to head, trim, point, and thread on the one machine.

Nuts are formed from round wire by a nutmaker (fig. B), or stamped from flat steel strip (fig. C). Nuts are blanked out of flat steel strip on a punch press. (See p.15 for description of manufacturing procedure.) After being formed, the blanks are tapped or threaded on the inside. This is done on an automatic threading machine in which a revolving tap threads and ejects the nuts. Chamfering, tumbling, and weighing are other operations performed in some plants depending upon the practice of the manufacturer.

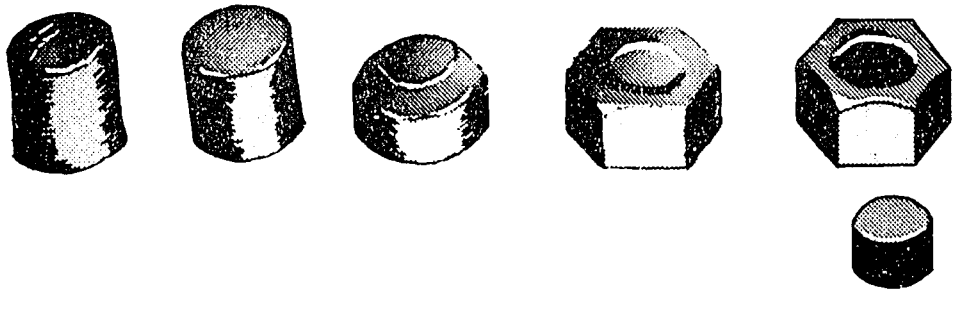

Figure B Nuts formed from steel rod

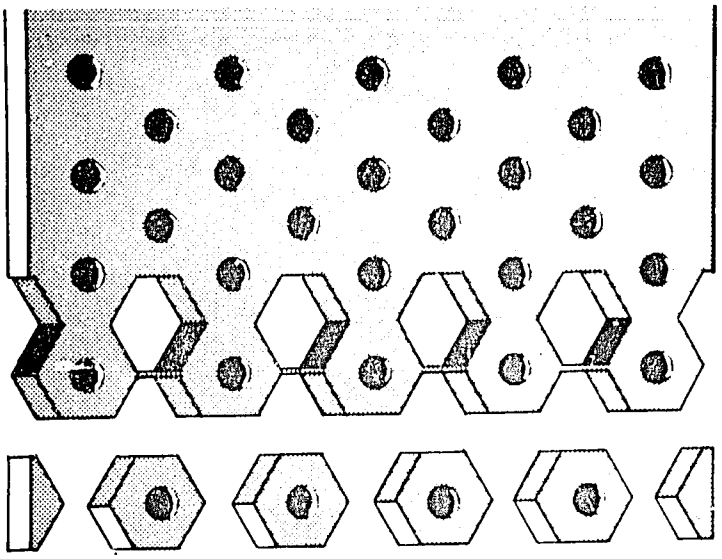

Figure C Nuts formed from steel strip

Flow of work in a typical plant producing cold-formed machine bolts and hexagon nuts is illustrated in figure D.

Measurement of Output Among Plants

Output of the reported products for the plants in the survey is reported in machine time per 1,000 pieces. The reason for the use of this type of output measurement rather than the customary productivity determinant, production per unit man-hour, is that age, quality, and operating efficiency of machines largely determine output, assuming the operators have normal skill and efficiency. Output in terms of unit man-hours is not always the most meaningful method of comparison, especially in plants which have so broad a product mix that it is uneconomical to attempt to allocate man-hours to a single product. However, for those who wish to review a plant's operations on a unit man-hour basis, table 13 in chapter II shows the standard man-minutes per 1,000 pieces of a specified product made in plant B, the only plant from which these data were obtained.

Output per hour in this report means the number of standard units produced an hour per machine based upon normal operating experience. The difference between this output figure and the machine cycles per hour, the machine's rated capacity, are losses which are due to setups, and downtime which is due to repairs and adjustments to the machine. The average loss caused by repairs and maintenance is 20 percent of rated capacity. The remaining loss is due to setup and other operating interruptions.

In plants A, B, C, and D in the survey the reported products were 1/4-inch x 1-inch, and 3/8-inch x 1-1/2-inch machine bolts with their corresponding hexagon nuts. In plant E the reported products were similar sizes of cap

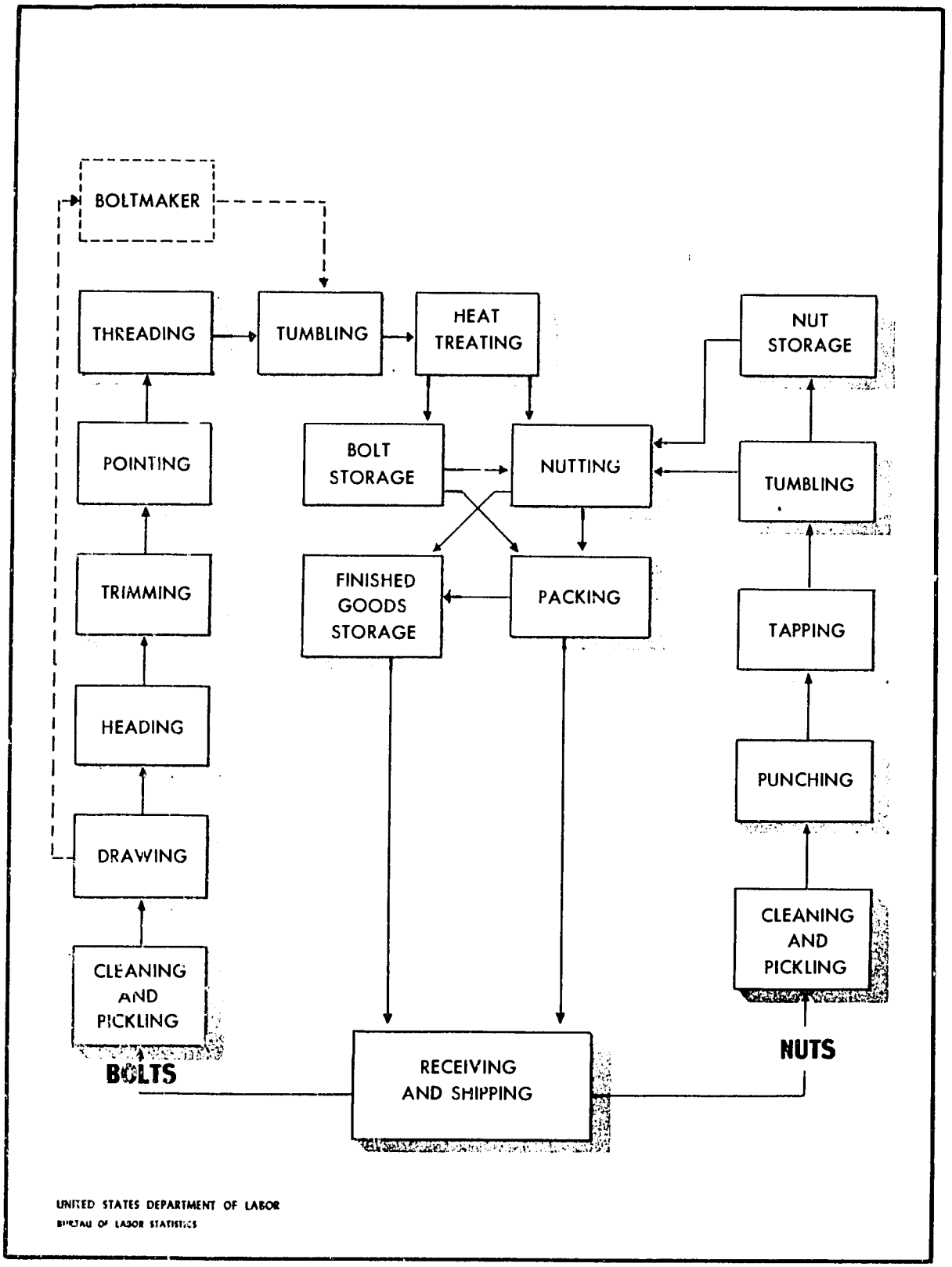

Figure D Flow of work in a typical plant producing cold-formed machine bolts and hexagon nuts

screws. Hexagon bolts and cap screws are generally identical products except that cap screws do not require nuts. However, since both are produced by the same methods on the same machines, the output of both is comparable.

Examination (table A) of the number of minutes per machine required to produce 1,000 of the reported bolts and nuts in the surveyed plants by the conventional, and Boltmaker methods, readily shows the considerable difference in the average times required in the different plants using conventional methods. The smaller time requirement in some plants is the result of the combination of two or more operations in the same machine. For example, in plant E, the pointing and heading operations have been combined in one machine called the header, by a redesign of the die which performs both functions simultaneously with one stroke of the machine. Similarly, in plant B, pointing of the 3/8-inch x 1-1/2-inch bolts is done on the thread-rolling machine. In plant A, the chamfering operation in the making of hexagon nuts is done on the punching machine. This is made possible by the redesign of a die which permits it to do the punching and chamfering operations simultaneously.

There are two primary advantages in combining operations such as these. First, increased output at lower cost arises owing to fewer materials-handling operations, reduced setup time, and a reduction in the number of machines and employees necessary. Second, the combination of two complementary operations prevents a complete stoppage of production which occurs in the Boltmaker where the breakdown of one component of the machine or a setup for a new production run stops production on all phases for a considerable length of time.

Table A. Machine minutes required to produce 1,000 bolts and nuts, in 5 selected plants, U. S. A., 1952

Product	Plant				
	A	B	C	D	E
Bolt 1/4" x 1"					
Conventional method	78.50	69.13	63.03	40.21	56.87
Boltmaker	13.43	(1/)	15.69	24.10	18.37
Bolt 3/8" x 1-1/2"					
Conventional method	98.21	51.18	75.49	59.63	84.09
Boltmaker	15.61	(1/)	17.02	24.10	19.84
Nut: 1/4"	37.44	40.99	(2/)	44.55	(3/)
Nut: 3/8"	44.40	41.26	(2/)	(4/)	(3/)

1/ Boltmaker not used in this plant.
2/ This plant did not manufacture the 1/4" or 3/8" nuts.
3/ Nuts not made for cap screws, the reported product of plant E.
4/ This plant made only 1/4" nuts.

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CHAPTER II: CASE STUDIES

COLLECTION AND PRESENTATION OF DATA

The detailed information presented in this report was secured from five selected plants in the fasteners industry through the use of a questionnaire (appendix IV). In this report plants are designated by the letters A through E. Plants A and B reported on 1/4-inch x 1-inch and 3/8-inch x 1-1/2-inch machine bolts and 1/4-inch and 3/8-inch nuts. Plant C reported on 1/4-inch x 1-inch and 3/8-inch x 1-1/2-inch machine bolts. Plant D reported on 1/4-inch x 1-inch and 3/8-inch x 1-1/2-inch bolts and 1/4-inch nuts. Plant E reported on 1/4-inch x 1-inch cap screws and 3/8-inch x 1-1/2-inch cap screws for which no nuts are manufactured.

MANUFACTURING OPERATIONS BY DEPARTMENT

Each operation in the manufacture of bolts and nuts is usually performed in a department of the plant which takes its name from the operation performed there. The major operations performed in manufacturing cold-formed machine bolts by the conventional method are: heading, trimming, pointing and thread-rolling; for nuts - punching, chamfering, and tapping.

Although these are the major operations performed, several others such as cleaning, annealing, nutting, and packaging are done, depending upon the specific product and upon individual plant practices.

Conventional Method of Bolt Manufacture

Machine bolts or cap screws made by conventional method are manufactured in the following departments: heading, trimming, pointing, and threading.

Heading. Conventional type cold heading of the reported machine bolts is done on horizontal presses which have automatic feed and automatic cutoffs In the surveyed plants, the machines used for heading 1/4-inch and 3/8-inch bolts are double-stroke, solid-die types. The rod or wire stock is fed from automatic-feed rolls and advances to a clamping device where it is held until a cutoff blade shears it to the required length. The blanks are carried by transfer fingers to the front of the heading die where a ram strikes against the blank. The piece then is transferred to a second die and the ram strikes the piece again. Knockout pins located in the rear of the die openings push the piece out after each stroke. The piece may be extruded in this operation by building a reduced opening into the die. In the extrusion process, a section of the bolt shank may be reduced in diameter so that when the bolt is threaded the outside diameter of the thread does not exceed the shank diameter.

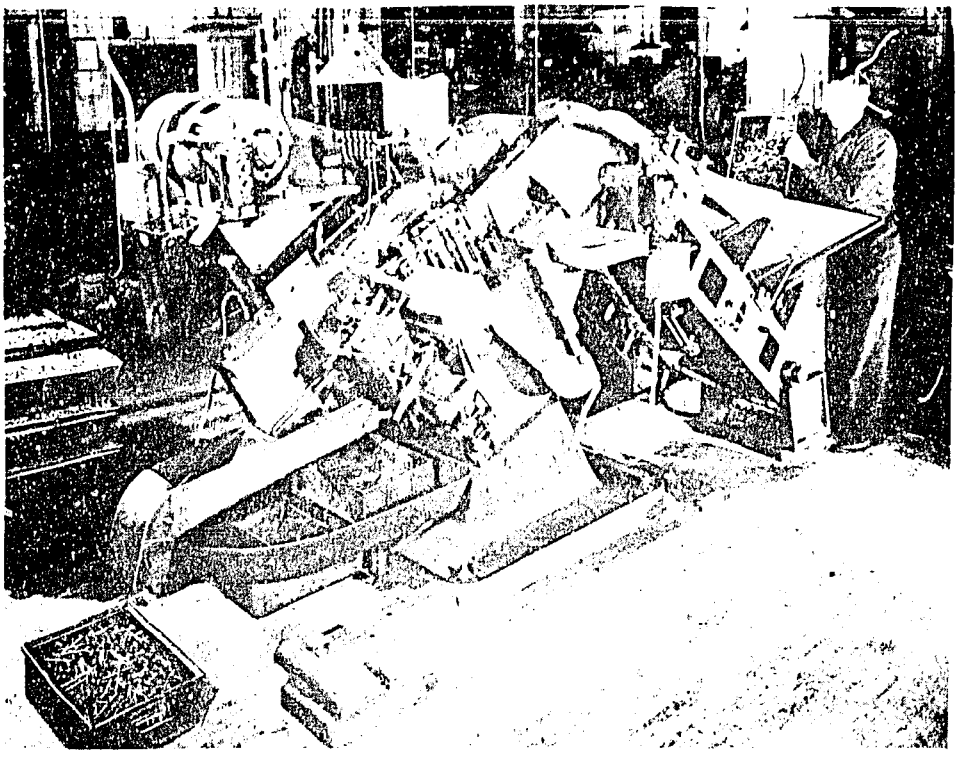

Figure 1 Reciprocal thread rolling machine

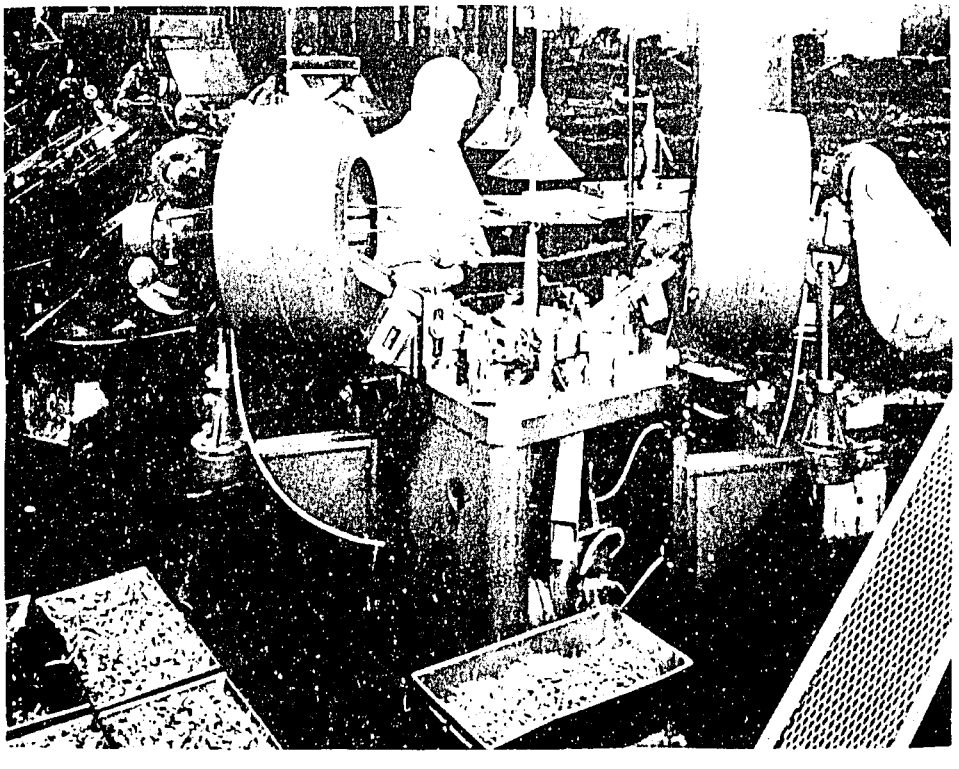

Figure 2 Planetary thread rolling machine

Trimming. The trimming operation shapes the head of the blank to either a square, hexagonal, or special shape, as desired. The blanks are trimmed by passing a moving die against a stationary punch. They enter the machine from a chute which is stacked with a column of blanks. This chute is adjustable to accommodate several diameters thus permitting the heading of several sizes of blanks on one machine. Spring fingers position the blank for the stroke of the die and an ejector pin forces the trimmed blank back through the die and out through the gate dropping it into a container. The trimmed-off waste is dropped into a scrap container.

Pointing. Pointing is an operation in which a chamfer is put on the end of a blank prior to rolling the thread. This is done automatically on pointing machines constructed to point several diameter bolts with only the slightest machine adjustment needed between sizes. A blank is fed into a hopper where it proceeds down a conveyor in single file to a gripper. A pointing die comes up to the positioned piece and chamfers the end. The piece is then dropped into a container.

Thread rolling. Threads which are rolled are generally stronger than those which are cut because the rolling process removes no metal and the metallurgical structure in the core of the blank is undisturbed. In addition to producing a stronger thread, the rolling process causes no scrap. The threads also have greater uniformity and accuracy and the process is faster. Rolling is done by forcing a blank between two dies, the faces of which contain thread grooves corresponding to the helix angle of the thread. The movement of the die or dies displaces the surface metal in the blank to form the thread. Another method makes use of a process of reciprocal thread rolling (fig. 1) in which one die remains stationary while the other die moves. On each downward stroke of the die a blank is threaded. At the end of the stroke, the threaded blank falls into a container.

Recently, a planetary thread rolling machine (fig. 2) has been developed which used 4 convex dies attached to a cylinder that rotates in one direction only. By rolling a blank between the convex die on the rotating cylinder and 1 of 2 concave stationary dies, each of the curved dies rolls 2 blanks per stroke making a total of 8 blanks rolled for each revolution of the cylinder. The machine speed in this method is the same as the speed of the reciprocal thread rolling machine except that by continually moving in one direction and using 4 die stations mounted on 1 cylinder the output is correspondingly greater. Outstanding features are that the machine occupies considerably less floor space than reciprocating machines; two different bolts of the same diameter may be threaded at the same time since they are rolled on opposite stationary dies and do not mix as they are ejected on opposite sides of the machine; and output is several times greater than that of reciprocating machines.

Bolt Manufacture by the Boltmaker Method

The Boltmaker is a machine that has been developed to perform all metalworking operations necessary to transform rod into finished bolts (fig. 3). By use of transfer stations this machine combines the operation of the header,

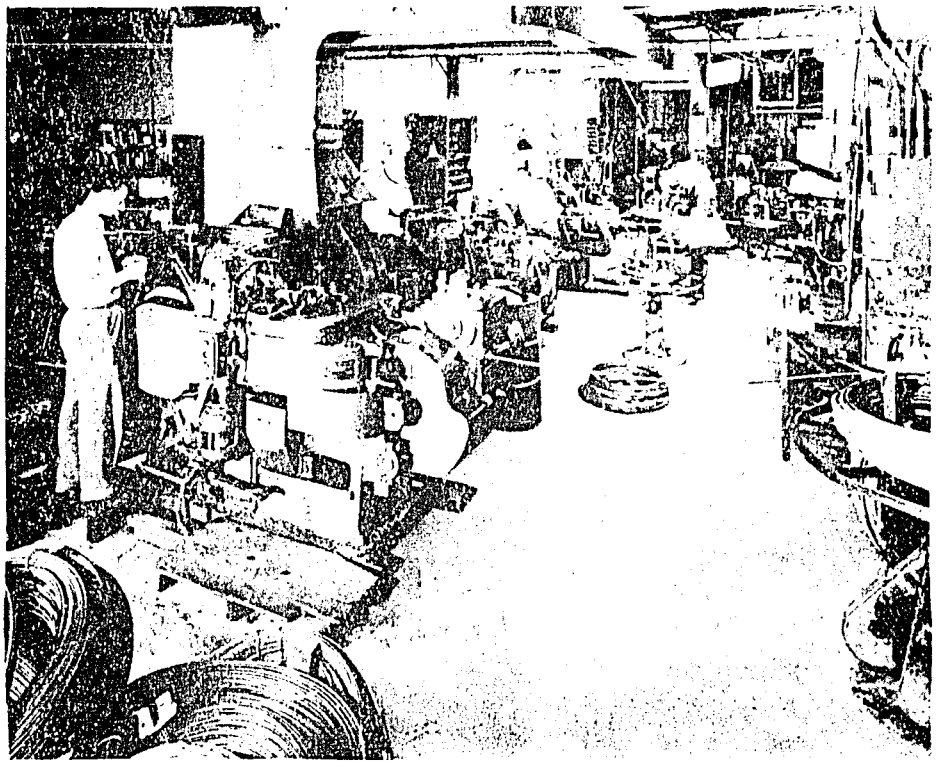

Figure 3 The Boltmaker

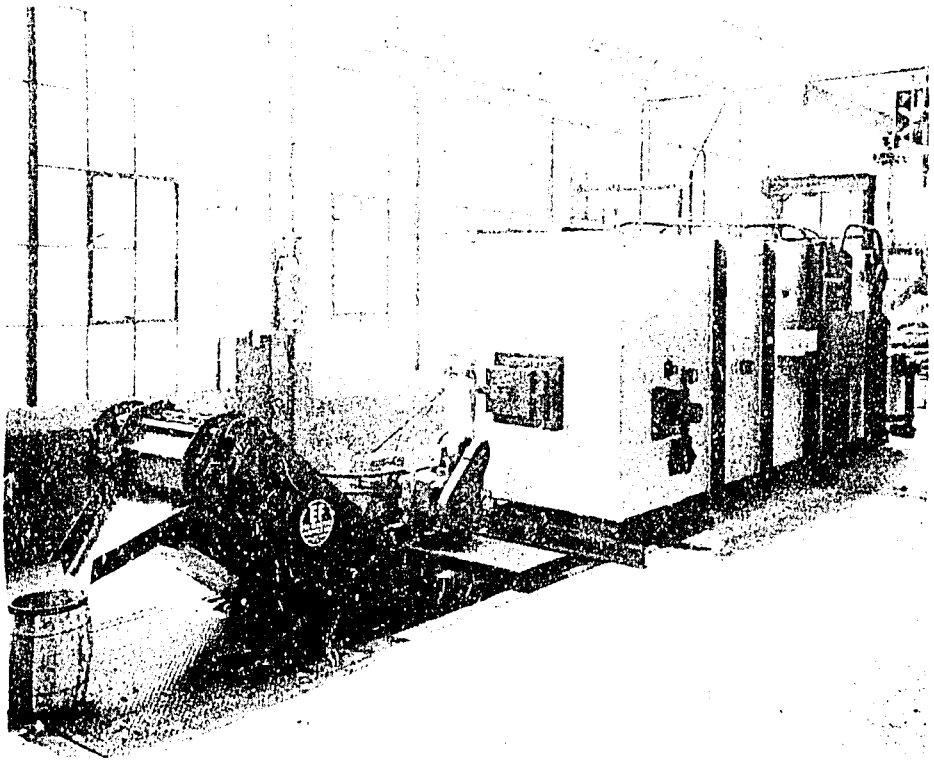

Figure 4 Heat-treating electric furnace

trimmer, pointer, and threader. In general, the Boltmaker is economical for long runs, it does not occupy much space, and it eliminates considerable materials handling. The main objection to the Boltmaker is that if one station "breaks down," the entire machine must be stopped, thus making all stations unproductive.

Cold-Formed Hexagon Nuts

Punching. There are two generally accepted methods in the United States for punching cold-forged nuts. In one of these methods, the rod is fed into a nut punching machine which cuts the rod into blanks of the required size (fig. B). On a stroke of a die the round head of the blank is stamped to a hexagon shape. The head may be chamfered in the same stroke through the use of an appropriate die. A hole is then punched in the center of the blank. Only nuts of a diameter of less than 1 inch across the flat surface are generally made by this cold-forging method.

The second method of cold punching nuts is by the use of a conventional punch press and coiled steel strip (fig. C). In this method, a punch press punches holes in the steel strip of suitable size for tapping and then blanks out the hexagon shape of the nuts. Several nut blanks are formed with each stroke of the die. If a beveled edge is desired, the nut blanks must go through a chamfer and reshear machine that can round off either one or both sides. Application of this method is restricted to nuts of 1/4-inch diameter and less.

Tapping. A thread is formed on the inside of the nut blanks by feeding spinning nut blanks against a hooked tap and forcing the blank up the shank. It is customary in plants in the United States to use separate machines for each size of nut, eliminating the need for machine changeover in making nuts of various dimensions. The length of runs for a particular dimension of a standard nut is large enough to justify this. Many plants produce a given dimension hexagon nut continuously on one machine.

Cleaning. Cleaning bolts and nuts is generally done after the completion of the metalforming operations, although quite often bolt blanks are also tumbled in a tumbling barrel to remove burrs, sharp edges, and grease prior to the threading operation. The cleaning medium may be either hot water, a soluble oil solution, or sawdust.

Annealing

Annealing, or heat treating, is generally done on bolts but not on nuts. This is done in either gas- or electric-fired furnaces (fig. 4). Bolts pass continuously through the furnace on a chain belt conveyor and remain in the furnace about an hour. On emerging from the furnace, the bolts fall through a controlled atmosphere into a quench tank. The purpose of this controlled atmosphere, which is a gas which does not support combustion, is to keep the surface of the bolts from sealing upon premature contact with air while hot. Quenching by submergence in an oil solution cools the bolts. The

solution is kept at about 100 degrees Fahrenheit, and pumps keep the quench solution in constant circulation to distribute its temperature evenly. After the heat treating operation, the bolts receive a fine water spray as they come out of the oil quench. This removes the water soluble quench oil and drawing compound.

Nutting and Packing

In the nutting operation, the nuts are screwed onto the bolts by an automatic machine. In some plants, the nutting operation takes place directly after the bolts are heat-treated. In other plants, those in which nuts and bolts are stored separately, nutting is done immediately before shipment. Nutting by hand is still practiced, but is primarily on nonstandard items where setup time for an automatic machine is not warranted for the size of the run. Hand nutting is done by placing a nut in a spinning holder and then inserting a bolt into the tapped hole of the spinning nut. It is an industry practice for cut-thread bolts to be nutted when packaged in boxes of 50 or 100 pieces, whereas roll-thread bolts and nuts are packed separately.

Bolts and nuts are commonly packaged in kegs, cartons, or wooden boxes for large industrial sales, and in cardboard containers for general consumer use. Bulk orders are generally shipped direct from the factory without the bolts being nutted whereas packaged bolts usually are nutted. Quite often the larger containers are packed directly from the machines and in some cases the bolts fall into kegs after the heat treating operation. At other times, bolts are taken to worktables where they are packaged in small containers.

The contents of filled containers are usually determined by weight, but a physical count is often used in the case of small packages. One system of packaging consists of a team in which one man fills a keg, another man weighs the keg and marks the factory order, and a third man seals and stencils the keg for identification. The kegs move between these operations on a roller conveyor and the filled kegs need never be lifted by hand. Small plants generally use one man to set up the carton, fill it with bolts, seal, mark, and place the carton on a conveying device.

DIES

Solid dies for Boltmaker or other machines are used to make bolts of sizes which include both of the reported bolts. As a general practice, firms in the bolt and nut industry make their own dies. Two types of solid dies are used. The first type is of a carbon steel composition and is hardened uniformly to about 60 Rockwell for the working surface and to about 40 Rockwell for the main body of the die. The second type of solid die has a carbide composition which is more costly to produce. Carbide dies are used by all 5 of the plants studied, but only on those products where the die impressions are very large in number. Two of the 5 firms reported that a properly constructed carbide die will give 10 times as many impressions as a carbon die. Carbon dies are also used for wire drawing, heading, and trimming in the firms studied. The firms studied generally rework carbon dies to the next larger size as they become worn.

Table 1. Machine bolt, 1/4-inch x 1-inch: Output and machine time required in manufacturing, by operation and by method, in 5 selected plants, U. S. A., 1952

Plant	Conventional Method					Boltmaker
	Total machine-minutes	Head	Trim	Point	Thread	
Plant A:						
Output 1/ . . .	---	7,566	5,040	1,344	4,267	4,468
Machine-minutes 2/ . . .	78.50	7.93	11.90	44.64	14.03	13.43
Plant B:						
Output	---	4,320	4,551	2,039	4,752	(3/)
Machine-minutes	69.13	13.89	13.18	29.43	12.63	---
Plant C:						
Output	---	6,120	3,585	3,100	3,500	3,825
Machine-minutes	63.03	9.80	16.74	19.35	17.14	15.69
Plant D:						
Output	---	5,850	3,234	(4/)	5,265	2,490
Machine-minutes	40.21	10.26	18.55	---	11.40	24.10
Plant E 5/:						
Output	---	6,300	3,726	(4/)	1,920	3.267
Machine-minutes	56.87	9.52	16.10	---	31.25	18.37

1/ Units per hour.
2/ Machine-minutes per 1,000 pieces.
3/ Boltmaker not used.
4/ Pointing done in the header machines.
5/ Cap screw.

Table 2. Machine bolt, 3/8-inch x 1-1/2-inch: Output and machine time required in manufacturing, by operation and by method, in 5 selected plants, U. S. A., 1952

Plant	Conventional Method					Boltmaker
	Total machine-minutes	Head	Trim	Point	Thread	
Plant A:						
Output 1/ . . .	---	3,420	3,870	1,248	3,480	3,843
Machine-minutes 2/ . . .	98.21	17.39	15.50	48.08	17.24	15.61
Plant B:						
Output	---	2,670	4,551	(3/)	3,764	(4/)
Machine-minutes	51.18	22.47	13.18	---	15.53	---
Plant C:						
Output	---	4,600	3,585	2,100	3,500	3,525
Machine-minutes	75.49	13.04	16.74	28.57	17.14	17.02
Plant D:						
Output	---	2,904	3,410	(5/)	2,808	2,490
Machine-minutes	59.63	20.66	17.60	---	21.37	24.10
Plant E 6/:						
Output	---	1,920	2,739	(5/)	1,940	3,024
Machine-minutes	84.09	31.25	21.91	---	30.93	19.84

1/ Units per hour.
2/ Machine-minutes per 1,000 pieces.
3/ Pointing done in threadrolling machines.
4/ Boltmaker not used.
5/ Pointing done in header machines.
6/ Cap screw.

Table 3. Hexagon nut, 1/4-inch: Output and machine time required in manufacturing, by operation, in 3 selected plants, U. S. A., 1952

Plant 1/	Manufacturing operation			
	Total	Punch	Chamfer	Tap
Plant A:				
Output 2/	---	3,210	(3/)	3,200
Machine-minutes 4/.	37.44	18.69	---	18.75
Plant B:				
Output	---	5,215	(3/)	2,035
Machine-minutes	40.99	11.51	---	29.48
Plant D:				
Output	---	3,478	7,392	3,128
Machine-minutes	44.55	17.25	8.12	19.18

1/ Plant C does not make 1/4-inch nuts; plant E does not make nuts.
2/ Units per hour.
3/ Chamfer done in punching machines.
4/ Machine-minutes per 1,000 pieces.

Table 4. Hexagon nut, 3/8-inch: Output and machine time required in manufacturing, by operation, in 2 selected plants, U. S. A., 1952

Plant 1/	Manufacturing operation			
	Total	Punch	Chamfer	Tap
Plant A:				
Output 2/.	---	2,658	(3/)	2,748
Machine-minutes 4/	44.40	22.57	--	21.83
Plant B:				
Output	---	3,690	(3/)	2,400
Machine-minutes	41.28	16.26	--	25.00

1/ Plants C and D do not make 3/8-inch nuts; plant E does not make nuts.
2/ Units per hour.
3/ Chamfer done in punching machines.
4/ Machine-minutes per 1,000 pieces.

CHARACTERISTICS OF PLANTS STUDIED

The following case studies describe the size of the plants in terms of number of employees; the engineering and research facilities; materials moving and handling equipment used; and the factors responsible for bringing any of the plants in this survey to their present productivity level.

The case study method is considered more applicable than the tabular method of presentation for these data because most of these plants use both the conventional and the Boltmaker methods, whereas others use only the conventional method. Still others have developed machines and techniques which are unique to these plants, the significance of which might be lost if data were presented in tabular form.

Plant A

Employment. Plant A employs more than 1,800 production workers with about half direct workers and half indirect workers. The engineering staff consists of:

Activity	Number of workers
Production engineering	20
Methods and time study engineering . . .	7
Research engineering	6
Engineering drafting	9

Volume of Production. The manufacture of standard machine bolts and nuts comprised only 10 percent of this plant's total production in 1951. The majority of its output consisted of special products on which a great amount of developmental work is done. The management claims that production of special products is more profitable for this plant than the production of standard items insofar as special products allow for more opportunity in obtaining greater profits.

The following is an example of a special screw and the way it is used. An automobile manufacturing plant employed a girl on the assembly line to put washers on machine screws which were handed next to a man who turned the screws by hand a few times and then completed the tightening with a power tool. Plant A engineers produced a machine screw with a washer attached which could not fall off. As a result, the girl was no longer needed to put the washer on the screw, but could be employed on more productive work. In addition, the screw could be inserted in the power tool and driven into the frame whereupon the operator no longer needed to turn the machine screw manually prior to using the power tool. This resulted in more than a 100-percent increase in productivity for this operation.

Production of the reported products for the year 1951 is presented below:

Product	Quantity	Size of runs
1/4" x 1" machine bolts	400,000	30,000
3/8" x 1-1/2" machine bolts	500,000	40,000
1/4" hexagon nuts	35,000,000	200,000
3/8" hexagon nuts	5,000,000	200,000

Conventional Machine Bolt Method. In this plant, the rod is moved from the wire department to the header department by lift truck and left at the respective work stations. Rod is not butt welded. A hoist is used to lift the rod from the floor to the header machine. Headed blanks fall into tote boxes in batches of 65 pounds, which a helper stacks on skids. The skids are hauled by lift truck to be weighed, from which they are moved to the trimming department and deposited at the respective work stations. A helper empties the box into the trimming machine hopper. After trimming, the blanks are ejected into tote boxes on skids which a lift truck moves to the scales to be weighed and then to the pointing department. After pointing, the same method is used to transport the tote boxes to the thread rolling and heat treating departments. Each of the foregoing operations is preceded by a weighing operation.

Boltmaker Machine Method. In the Boltmaker system, the rod is moved by lift truck from the wire department to the respective work stations in the heading department. A helper uses a hoist to place the rod on the machine. Production, which on the Boltmaker is finished product, runs into tote boxes which a helper stacks on skids. A lift truck takes the skids to the scales where the tote boxes are weighed, and then to a conveyor station in the heat treating department. The furnace tender dumps the contents of the tote boxes onto the furnace conveyor. From the furnace the bolts again are ejected into tote boxes, placed on skids and moved by lift truck to the packing department.

Nut Manufacturing Method. In hexagon nut manufacture, coil stock is moved from the wire department to the nut punch department by lift truck. Operators take coil stock from the work station and place it in a reel box by hand. The stamped blanks drop into tote boxes which rest on skids. Lift trucks move the skids to the washing operation. The blanks in the tote boxes are manually dumped into washing hoppers. The blanks come out of the washing hoppers into tote boxes which are manually placed on skids. The skids are moved by lift truck to a scale for weighing, then to the tapping operations. The tote-box lift truck operation is repeated through the tapping, washing, and weighing operations. The finished nuts are moved by lift truck to the packaging department or to storage.

Productivity. Productivity has been increased by the use of improved machine and plant layout, the increasing use of tungsten carbide dies, the use of specially designed hoppers, and the company's own designed nut-tapper.

Plant B

Employment. Plant B has an average of 85 production workers, consisting of 52 direct workers and 33 indirect workers. The engineering staff consists of 3 persons - 1 production engineer, 1 methods engineer, and 1 drafting engineer.

Volume of Production. Production for the year 1951 for the reported products:

Product	Quantity
1/4" x 1" machine bolts	470,000
3/8" x 1-1/2" machine bolts	345,000
1/4" hexagon nuts	750,000
3/8" hexagon nuts	1,500,000

Machine bolts and nuts constitute about 20 percent of the plant's total production, all of which is made for stock. Runs are intermittent batches. Size of runs for bolts range from 10,000 to 100,000 pieces and for nuts from 100,000 to 1,000,000 pieces. A negligible amount of carton packaging is done as the majority of production is shipped in bulk.

Production Methods. This firm purchases 15/64-inch diameter rod for the 1/4-inch diameter bolt. This is drawn to .204-inch diameter. For the 3/8-inch diameter bolt, 23/64-inch diameter rod is purchased which is drawn to .304-inch diameter. The drawing is done by a Hogue wire drawing machine and is considered part of the heading operation. Coil for the bolts is butt-welded.

For nut-punching, the firm purchases 25/64-inch diameter rod for 1/4-inch hexagon nuts (coil weighs 330 pounds - approximately 90 feet in length) and 11/16-inch x 21/64-inch rod for 3/8-inch hexagon nuts (coils weigh approximately 450 pounds - 120 feet in length). In this plant each batch of bolts, 1,500 pounds, is subjected to a continuous tumbling operation for 10 or 15 minutes. In that operation, bolts are tumbled in a rotating drum containing a cleaning agent which removes burrs, sharp edges, and grease prior to the threading operation.

Materials Handling. In making machine bolts, coils of rod weighing 350 pounds are moved by overhead monorail from the picklers to the headers. The header helper uses a hoist to place the rod which is being fed into the header and butt welds the ends so that a continuous rod is fed to the header. Headed blanks fall from the header into tubs which are moved by electric lift truck to the trimming department. Each tub weighs 1,500 pounds when loaded. A trimmer helper shovels the bolt blanks into the trimming machine hopper from which the blanks again run into tubs which are moved to the continuous tumbling barrel. The tumbler tender lifts the tub with a hoist and dumps

the blanks into the tumbler. The blanks run into tubs which are moved to pointers, then the threading department, and the heat treating departments by the same method. The tubs of blanks are taken from heat-treating to stock by monorail. Nowhere in the plant does labor have to handle more than 10 pounds manually as the plant is equipped with electric hoists and industrial trucks.

In making nuts, the nut punch helper uses the overhead monorail to move a 500-pound coil from the stock pile onto a reel from which it is fed into the machine. Production runs into tote boxes which a helper places on skids and moves to the tapping department where they are dumped into bins near the tapping machines. The tapping machine operator shovels the blanks from the bins into the machine hopper. The finished nuts run into kegs which are hand trucked to stock.

Productivity. The firm redesigned a 3/8-inch header so that it included a trimmer station as well as a header station. The benefits are twofold. First, this eliminated the usual subsequent trimming operation and decreased man-hour requirements. Both operations occur on the same stroke. While the heading operation is being performed on the rod, the trimming operation is performed simultaneously on the blank which was headed on the previous stroke. Second and most important, it resulted in a savings of 8.2 pounds per 1,000 pieces of steel. The savings amounted to 40 tons of steel per year on this one special machine.

On the 1/4-inch hexagon nut punch machine, the firm designed an attachment which makes possible the use of round rod which is cheaper than flat stock. This attachment flattens the round rod prior to the punching operation. This has resulted in a saving of 12 percent of the cost of material.

Plant C

Employment. Plant C employs 821 production workers which includes 704 direct workers and 117 indirect workers. In the engineering department, there are 5 production engineers and 4 persons employed in product research.

Production Methods. This plant uses both the conventional and the Boltmaker methods of production. All runs are intermittent. Coils are not butt-welded. The rod is not drawn on regular Hogue wire drawers as part of the heading operation but is drawn through dies as a separate operation.

Materials Handling. Material comes in on a railroad siding to a general outside storage area. Overhead cranes are used to convey the material to and from the storage area. Coils are power-hoisted from the storage area to the pickling vats. After pickling, the coils are conveyed by lift truck to the wire-drawing department. In the drawing department, the rod is pulled through carbide dies and wound on a drum. The drum has a circumference of 93.9 inches and rotates at 20.5 r.p.m. The rod is moved from the drawing to the heading department by lift truck. Before each header is a hoist which is used to load rod onto the reels. Production from the headers flows into steel cans which are below the floor level. An overhead crane lifts the cans, which weigh 1,500 pounds when full, onto the scales. Cans are then lifted by crane and

contents dumped into overhead hoppers which feed the production machines. Hopper feed release is controlled by hand lever. The crane and scales are centrally located in the plant so that one crane operator can handle the entire production for all machines.

A monorail power hoist with a combination tote and dump container is used for transporting production from the nutting department to the packaging operation. Packaging is performed by hand in paperboard boxes of 50 per box and in wooden kegs of 2,400 nuts and bolts per keg. Packaged bolts are transported by gravity chute from second floor packaging to the main floor where they are palletized and moved to storage by a lift truck. Kegs are stored 9 to a skid and skids are stacked as many as 5 high.

Productivity. Carbide dies have been used in the trimming department for 5 years. Their life is estimated at 10 times that of carbon steel dies. When the dies used in the drawing machines wear out they are reworked to draw wire of larger diameter.

Plant D

Employment. Plant D employs 200 production workers with 150 direct and 50 indirect workers. Since 80 percent of this plant's production is on special or nonstandard items, it employs a comparatively large staff of production engineers. The engineering staff consists of 8 production engineers, 1 methods engineer, and 1 product research engineer.

At the present time, wire-drawing and heat-treating are done by plants owned by this firm but located in different areas of the city.

Production Methods. This company uses both the conventional method and the Boltmaker method of production but it favors the Boltmaker method. Popular items are made for stock but the less popular items are run only when the firm has a sizable customer's order. Then, in addition to what is needed for that order, an additional supply (usually, 1 year) is made for stock. This makes for longer production runs and a minimum of downtime owing to machine setup. In this plant, the pointing operation is done in the header, the shape of the die being made to do both heading and pointing simultaneously.

Materials Handling. Materials-handling practices in this plant are relatively simple. The production of each machine flows into small tote boxes, 2 feet x 1 foot x 8 inches. These are pulled manually by the use of a hooked rod from one operation to the next and then to the scale. The scaleman weighs the boxes and places them on a skid with the use of a hoist on an overhead rail. Skidded tote pans are moved by lift truck to the packaging department.

Productivity. Productivity gains in this plant have been credited by management to the following factors: the installation of improved and automatic machinery, faster operating speeds, the increased use of carbide dies, reduced scrap, improved plant layout to conform with the work flow, centrally located weighing stations, and an increased use of power hoists and lift trucks

for materials handling. This company at present does not butt-weld its coil stock, but it expects to do so in the near future and, in addition, to install Hogue wire-drawing machines. This is expected to cut down waste and to speed up the operation.

Plant E

Employment. Plant E employs 2,607 production workers, of whom 1,357 are direct workers and 1,250 are indirect workers. The engineering staff consists of 41 production engineers and 12 methods engineers.

Production Method. This plant butt-welds its coils and thereby estimates a saving of 1 yard of material per coil. The wire and rod are purchased clean by the company and the rod is drawn directly at the heading station.

Materials Handling. Coils of rod are brought from the storeroom to the header department by electric lift trucks. An electrically operated hoist on a monorail lifts the coils into place on the reels. Production flows from the machines into tote pans. Manually drawn lift trucks are used to transport the pans to the scales. At the scales, the pans are loaded by hand onto skids and an electric lift truck transports them to each succeeding department.

Productivity. Some of the most significant increases in output in this plant have been due to the installation of Waterbury-Farrel high production automatic headers and counters. These machines have not only a very high cycle speed but perform both heading and pointing in the same operation. Other gains have been attributed to the increased use of automatic machines such as the Boltmakers, and the increased use of carbide dies. Welding the coil stock is also claimed to save materials.

COMPOSITION OF MATERIAL

There is a trend toward using steel of a higher carbon content in the cold forming of nuts and bolts. For any given size bolt, the cost of the material and the cost of forming is less with the use of lower carbon steel, but the tensile strength of this type of steel is also less. As the carbon content increases the holding power increases, permitting the use of smaller bolts. This conserves material and reduces costs. The following tabulation gives the chemical composition of metal used for making bolts and nuts in the plants in this study.

Plant	AISI Code	Used In
A	C1010 C1108	Bolts Nuts
B	C1018 C1108-9-10	Bolts Nuts
C	C1017	Bolts
D	C1020 C1112	Bolts Nuts
E	(1/)	(1/)

AISI Code 3/	Chemical Composition 2/			
	Carbon	Manganese	Phosphorous	Sulfur
C1010	0.08-0.13	0.30-0.60	0.040	0.050
C1017	0.15-0.20	0.30-0.60	0.040	0.050
C1018	0.15-0.20	0.60-0.90	0.040	0.050
C1020	0.18-0.23	0.30-0.60	0.040	0.050
C1109	0.08-0.13	0.60-0.90	0.040	0.08-0.13

1/ Information not available.

2/ Compositions as reported in the Society of Automotive Engineers Handbook, 1951.

3/ American Iron and Steel Institute classification for metals is standard throughout the United States.

PRODUCTION AND INVENTORY CONTROL

Both production and inventory control are practiced in all the reporting plants.

Production Control

In one production control method, perpetual inventory cards are kept. When these cards indicate that the quantity of an item has dropped to a specified level, the production control department submits the specification of this item, along with those of other standard items to be manufactured, to the assistant production manager. At the same time, the production control department releases a regular production order to the header department and copies of this order to the trimming, pointing, and thread rolling departments. This procedure notifies the various departments that the items will soon be coming through the plant. The assistant production manager notifies the header department what to schedule in view of special items that may have priority, available machinery, and the opportunity to schedule similar orders in such a way as to reduce setup time. The header department notifies the rod department of the sizes and the quantities of rods that will be required. Because there is some supply of the item in the stock bin at the time the factory order is placed, there is no particular hurry for the production of stock items and the header department may choose to hold an order for several days in order to group similar orders.

Full time material handlers move the material to the next operation as indicated on the routing slip. Subsequent departments are not notified when the preceding operation is completed but watch incoming material. They, in turn, schedule items when machinery is available, using the opportunity to group orders to reduce setup time.

Each machine operator submits a production summary which indicates the operation performed and quantity by weight to the production control department which keeps a status record of all goods in process. Expediters are employed to investigate long delays and to help maintain proper work flow.

In another method, when perpetual inventory records indicate that the stock of a standard item needs replenishing the plant superintendent's office determines the quantity to be produced, taking into account, the quantity of unfilled orders and the normal replenishing amount necessary to bring the stock up to a predetermined level. A factory order is released to the production manager who determines when the order will be scheduled with a minimum of downtime due to setups. The production manager submits a copy of the factory order to each respective machine group for which he has scheduled production 1 week in advance. The header group leader notifies the rod department what rod will be needed 1 day in advance. The rod department delivers the material to the header department where the group leader prepares routing cards which are placed in each container. By indicating the content weight of each container the group leader fills out routing cards for the proper number of containers to obtain the weight of the product desired, the control of quantity of material in process being made by weight.

Subsequent department helpers watch for work completed on the preceding operation and haul it to their machine group. On the route card each subsequent department fills in the date that its particular operation was completed and again places one route card in each container. The group leaders use their factory order copy to indicate their daily production in terms of pounds. Upon completion of each operation, the factory order copy is returned to the factory office where it is filed to indicate status of work-in-process.

Control in another plant is basically vested in the header department. As orders are designated for production, the production control department determines the size of run and schedules the work in the header department. A production order, in duplicate, is sent to the header department; this order contains the operational sequence. The header department requisitions the raw material. After the work is headed, one copy of the production order is returned to the production control department; the other copy accompanies the job-lot through the plant and is returned to the production control department by the department performing the final operation. At the header department, small cards are placed in each material container to identify the job.

Inventory Control

Firms in the industry generally keep perpetual inventory records of their products. To these records are posted completed units in stock, as well as units taken from stock for the purpose of filling customers' orders. In addition, on initiating a factory order, the quantity of the order is entered on the perpetual inventory card so anyone examining the card has knowledge of the existence of the order. Some plants also enter the stage of production of each item, based upon reports received from the various production departments. Perpetual inventory records also are kept for raw materials. One of the benefits of a perpetual inventory system is that it permits the establishment of a reorder point. When the inventory falls below this point a production order is issued to replenish the stock.

Three of the 5 firms studied report that they maintain a 90- to 100-day inventory at all times. The sales experience of the company generally determines what quantity constitutes a 90- to 100-day supply. One firm whose sales consist mostly of nonstandard items, makes no attempt to maintain a minimum inventory. The firm accepts orders of standard items in large quantities only. When a large order is received for a standard item, this firm fills it from inventory if possible. If the quantity desired is not in stock, the firm will manufacture enough of the product to fill the order as well as to replenish its stock. The quantity produced is determined by forecasts and is large enough to fill the needs of the firm for a considerable period of time.

One way that stock can be counted rapidly and a reorder point maintained without the use of a perpetual inventory system, is to store the items in bins which vary in volume based on an established rate of shipment of the particular item. The depth and length of all such bins are equal but the width varies according to the rate of shipment. As a result, the less popular items are stored in bins of narrow width whereas the more popular items are stored

in bins of greater width. At predetermined intervals, a man rakes all bins level. Those products that lie below a given level in their bin are designated for reorder. This given level is the same for all bins and is designated as the stock reorder level. With the use of tables giving the weight of the product at a given bin level, physical inventory is taken by measuring the height of the leveled bins. In this manner, one firm reports that the taking of physical inventory of all stock items requires but a few hours.

Some items are packaged only as orders are received. For the more popular items, some of the inventory is kept packaged ready for shipment. Machine bolts, 1/4-inch x 1-inch, are packaged and stocked in boxes of 100, whereas machine bolts, 3/8-inch x 1-1/2-inches are packaged and stocked in boxes of 50. These bolts are nutted before packaging. Some firms stock nutted bolts in kegs, in quantities of 3,200 for 1/4-inch x 1-inch bolts, and 2,400 for 3/8-inch x 1-1/2-inch bolts. For some large industrial orders the bolts are packed in kegs and shipped unnutted. These kegs are stacked on wooden platform skids, 6 to 9 kegs on a skid. In storage the skids are stacked about 5 high. Fork-lift trucks are used to move and stack the skids.

INSPECTION

Common machine bolts and hexagon nuts are made with a class 2 fit which is a relatively loose fit; i.e., the tolerances between the dimension of the bolt and the nut allow ready interchangeability. (See appendix III for description of class fits.) Because of this spot checks are used rather than 100 percent inspection. Tables 5 and 6 show typical inspection standards for bolts and nuts. The following are inspection procedures in use in three of the plants in the survey.

In method 1, setup operators perform inspection on the first few pieces and spot check the work at various intervals during production. This firm does not employ roving floor inspectors. Less than 1 percent of the nuts and bolts are rejected. Approximately two-thirds of the rejected bolts are reworked; the remainder are sold as scrap.

In method 2, the setup man spot checks the first few pieces and calls a roving floor inspector who carefully inspects the pieces. The floor inspector must give his approval for the lot to be produced. Spot inspections at the work station follow. Rejects which are due to manufacture amount to less than 1 percent. Rejected pieces are sold as scrap metal.

In method 3, the original inspection is made at each work station at the time the job is set up. After thread rolling, in a separate inspection department, women inspectors draw several bolts from each container and inspect further. If the sample passes inspection, the container is emptied on a belt conveyor and the bolts are carried past a second group of inspectors who visually check for poor work. If the units withdrawn by the first inspection team do not pass inspection, the pan is placed on a belt conveyor and when it reaches the second inspection team it is removed and given to a third inspection team for a 100-percent inspection. Rejects are sold for scrap.

Table 5. Typical inspection and tolerance standards for machine bolts manufactured in the United States

(All figures based on 1 inch)

Operation	Machine bolt 1/4" x 1"	Machine bolt 3/8" x 1-1/2"	Inspection instrument used
Heading:			
Blank diameter . . .	.212 to .215	.330 to .333	Micrometer
Head diameter . . .	± 1/64	± 1/64	Steel scale
Head height	± .010	± .010	Micrometer
Bolt length	± 1/64	± 1/64	Steel scale
Trimming:			
Cross flat of head	.363 to .375	.544 to .562	Micrometer
Blank diameter . . .	.212 to .215	.330 to .333	Micrometer
Pointing:			
Chamfer angle . . .	Check angle		Visual
Threading:			
Thread outer diameter	.2428 to .2500	.3660 to .3750	Ring-go-no-go-gage
Thread pitch diameter	.2139 to .2175	.3299 to .3344	Ring-go-no-go-gage
Thread length . . .	3/4 ± 1/32	1 ± 1/32	Steel scale

Table 6. Typical inspection and tolerance standards for hexagon nuts manufactured in the United States

(All figures based on 1 inch)

Operation	Hexagon nut 1/4"	Hexagon nut 3/8"	Inspection instrument used
Nut punch:			
Cross flats of nuts . .	7/16 ± .015	5/8 ± .015	Micrometer
Nut thickness	7/32 ± .010	21/64 ± .010	Micrometer
Hole size	.208 to .211	.324 to .327	Micrometer
Tapping:			
Internal thread	(1/)	(1/)	Thread-go-no-go-gage

1/ Information not available.

WEIGHTS AFTER HEADING AND THREADING

A common practice in the industry is to count bolts and nuts, particularly the smaller sizes, by weight. This is done by weighing a container or tote pan of bolts or nuts, subtracting the known weight of the pan, and dividing the resultant by the known weight per 1,000 pieces. In some plants this is done after each operation to determine output for incentive pay and as a means of determining production for inventory control. Table 7 shows the weights per 1,000 pieces of the reported bolts after the heading operation and after the threading operation.

Table 7. Weights after heading and threading of machine bolts in 4 selected plants, U. S. A., 1952

(Weights in pounds per 1,000 bolts)

Bolt	Plant 1/			
	A	B	C	E
1/4 inch x 1 inch:				
Weight after heading	25.4	19.0	21.8	21.7
Weight after threading	17.7	16.0	17.6	19.6
3/8 inch x 1-1/2 inch:				
Weight after heading	83.9	68.0	73.3	66.7
Weight after threading	61.8	56.8	61.3	60.9

1/Information not available for plant D.

COMPARATIVE PLANT PERFORMANCE

Data on output, staffing by operation, and machinery by operation are presented for each plant in this study (tables 8 through 13).

Machine Cycles Per Hour

The term "machine cycles per hour" as used here means the number of operations the machine should perform per hour as determined by the plant engineers, taking into account the age and condition of the machine and any other factors which will cause the machine to operate at an efficiency output other than the manufacturers rated output. This does not include allowances for setup time, downtime, or time when the machine is not operating because of lack of work or shortage of raw materials.

The output per hour in the case of machines is the actual number of units upon which a specific operation is performed by an individual machine. Where more than one machine is used for an operation, an average is taken. In some cases, the actual number of units produced per machine per unit of time may exceed the cycle capacity of the machine. An example of this is the punching operation in plant D, in which 7 nut blanks are punched with each stroke of the machine. However, the output of the machine, in terms of cycles per hour, is less than its rated output per hour.

Output Per Hour

Output per hour in this report means the number of standard units produced an hour per machine based upon normal operating experience. The difference between this output figure and the machine cycles per hour described above are losses which are due to setups, and downtime which is due to repairs and adjustments to the machine. The average loss due to repairs and maintenance is 20 percent of rated capacity. The remaining loss is due to setup and other operating interruptions.

When an operation is performed by a worker rather than by a machine, the output per hour is in pounds; and in packaging the output is in boxes or kegs.

Duties of Workers

Setup man. Determines the tools and dies necessary for a job, obtains, installs, and adjusts tools and dies. Adjusts machines. Inspects the first few pieces of a production run to insure proper setup.

Setup operator. Same duties as setup man and in addition he has the responsibility of operating a machine. He may direct the activities of a helper. A combination of a setup man and an operator.

Operator. Feeds in stock, makes minor adjustments, checks and removes finished parts, and may clean and oil machine. May direct the activities of a helper.

Helper. Works under the direction of an operator or setup operator. Loads and unloads material, cleans and oils machines, cleans work area, performs the more routine aspects of machine operation. Often is in training for the position of operator.

Table 8. Output and related information, bolt and nut manufacture, by operation, in plant A, U. S. A., 1952

Operation	Machine	Staffing	Machines cycles per hour	Output per hour (pieces)
	1/4" x 1" Machine bolt			
Heading	National 1/4"	1 operator to 3 machines 1 helper to 6 machines	9,100	7,566
Trimming	Waterbury Farrel, 5/16"	1 operator to 4 machines 1 helper to 4 machines	8,100	5,040
Pointing	Cook pointer	3 operators to 18 machines	2,000	1,344
Threading	Waterbury Farrel, 1/4"	1 operator to 10 machines 1 helper to 10 machines	6,300	4,276
Boltmaker	National, 1/4" Boltmaker	1 operator to 2 machines 1 helper to 4 machines	6,060	4,468
Annealing and . . . . washing	Salem electric furnace	1 man per furnace	--	650 lb.
Packaging				
Box of 100	Scale	1 man	--	206 boxes
Keg of 5770 . . . . (nutted)	Scale	1 man	--	8 kegs
	3/8" x 1-1/2" Machine bolt			
Heading	National, 3/8" Waterbury Farrel, 3/8"	1 operator to 3 machines 1 helper to 6 machines	3,500 4,400	3,450 average for both machines
Trimming	Waterbury Farrel, 3/8"	2 operators to 5 machines	6,720	3,870
Pointing	Cook pointer	3 operators to 18 machines	2,000	1,248

Table 8. Output and related information, bolt and nut manufacture, by operation, in plant A, U. S. A., 1952--Continued

Operation	Machine	Staffing	Machines cycles per hour	Output per hour (pieces)
	3/8" x 1-1/2" Machine bolt--Continued			
Threading	Waterbury Farrel, 3/8"	1 operator to 7 machines 1 helper to 7 machines	4,680	3,480
Boltmaking	National, 3/8" Boltmaker	1 operator to 2 machines 1 helper to 4 machines	5,100	3,843
Annealing and . . . . washing	Salem electric furnace	1 man per furnace	--	650 lb.
Packaging				
Box of 50	Scale	1 man	--	192 boxes
Keg of 1,795 . . . (nutted)	Scale	1 man	--	8 kegs
	1/4" Hexagon nut			
Punching	Waterbury Farrel, 1/4"	6 operators to 20 machines	5,700	3,210
Tapping	Company's own design	2 setup men to 56 machines 7 operators to 56 machines	6,600	3,200
Tumbling	Tumbler	1 man to 4 tumblers	--	3,250 lb.
Nutting	Detroit, No. 2	(1/)	2,343	1,615

1/ Information not available.

Table 8. Output and related information, bolt and nut manufacture, by operation, in plant A, U. S. A., 1952--Continued

Operation	Machine	Staffing	Machines cycles per hour	Output per hour (pieces)
	3/8" Hexagon nut			
Punching	Waterbury Farrel, 3/8"	3 operators to 11 machines	3,700	2,658
Tapping	Company's own design	2 setup men to 28 machines 4 operators to 28 machines	4,560	2,748
Tumbling	Tumbler	1 man to 4 tumblers	--	3,250 lb.
Nutting	Detroit, No. 2	(1/)	2,243	1,615

1/ Information not available.

Table 9. Output and related information, bolt and nut manufacture, by operation, in plant B, U. S. A., 1952

Operation	Machine	Staffing	Machine cycles per hour	Output per hour (pieces)
		1/4" x 1" Machine bolt		
Heading	Waterbury Farrel, 5/16"	1 operator to 4 machines 1 helper to 4 machines	6,000	4,320
Trimming	Waterbury Farrel, 3/8"	1 operator to 4 machines 1 helper to 4 machines	5,550	4,551
Tumbling	1,500-lb. capacity drum	1 operator to 1 tumbler	--	(1/)
Pointing	Economy, 1/2"	1 operator to 11 machines 1 helper to 11 machines	2,832	2,039
Threading	Waterbury Farrel, 1/4"	1 operator to 11 machines 1 helper to 11 machines	5,940	4,752
Annealing	Continuous conveyor gas furnace	1 operator to 1 furnace	--	1,245 lb.
		3/8" x 1-1/2" Machine bolt		
Heading	Waterbury Farrel, 3/8"	1 operator to 4 machines 1 helper to 4 machines	3,708	2,670
Trimming	Waterbury Farrel, 1/2"	1 operator to 4 machines 1 helper to 4 machines	5,550	4,551
Tumbling	1,500-lb. capacity drum	1 operator to 1 tumbler	--	(1/)
Pointing and threading	Waterbury Farrel, 3/8"	1 operator to 11 machines 1 helper to 11 machines	4,830	3,864
Annealing	Continuous conveyor gas furnace	1 operator to 1 furnace	--	1,245 lb.

1/ Information not available.

Table 9. Output and related information, bolt and nut manufacture, by operation, in plant B, U. S. A., 1952--Continued

Operation	Machine	Staffing	Machine cycles per hour	Output per hour (pieces)
	1/4" Hexagon nut			
Punching	Waterbury Farrel, 5/16"	2 operators to 6 machines 1 helper to 6 machines	6,360	5,215
Tapping	National, 5/16" automatic	1 operator to 9 machines	2,544	2,035
	3/8" Hexagon nut			
Punching	Waterbury Farrel, 3/8"	2 operators to 6 machines 1 helper to 6 machines	4,500	3,690
Tapping	National, 3/8" automatic	1 operator to 9 machines	3,000	2,400

Table 10. Output and related information, bolt manufacture, by operation, in plant C, U. S. A., 1952

Operation	Machine	Staffing	Machine cycles per hour	Output per hour (pieces)
	1/4" x 1" Machine bolt			
Heading	National, 5/16"	1 operator to 4 machines 1 helper to 4 machines	7,680	6,120
Trimming	Waterbury Farrel, 1/2"	1 operator to 2 machines 2 helpers to 2 machines	5,040	3,585
Pointing	Economy, 3/8"	1 operator to 7 machines 1 helper to 7 machines	4,440	3,100
Threading	Waterbury Farrel, 3/8"	1 operator to 7 machines 1 helper to 7 machines	5,280	3,500
Boltmaking	National, 5/16" Boltmaker	1 operator to 2 machines 1 helper to 2 machines	5,520	3,825
Washing	Drum with revolving screw	1 loader 1 unloader	--	3,460 lb.
Annealing	Gas-fired furnace	3 men to 7 or 8 furnaces	--	734 lb.
Nutting	Company's own design	1 operator to 8 machines 1 helper to 8 machines	3,660	2,360
Packaging				
Box of 100	Scale	2-man crew	--	200 boxes
Keg of 3,200 . . .	Scale	6-man crew	--	120 kegs

Table 10. Output and related information, bolt manufacture, by operation, in plant C, U. S. A., 1952--Continued

Operation	Machine	Staffing	Machine cycles per hour	Output per hour (pieces)
	3/8" x 1-1/2" Machine bolt			
Heading	National, 3/8"	1 operator to 4 machines 1 helper to 4 machines	5,760	4,600
Trimming	Waterbury Farrel, 1/2"	1 operator to 2 machines 2 helpers to 2 machines	5,040	3,585
Pointing	Economy, 3/4"	1 operator to 7 machines 1 helper to 7 machines	3,000	2,100
Threading	Waterbury Farrel, 3/8"	1 operator to 7 machines 1 helper to 7 machines	5,280	3,500
Boltmaking	National, 3/8" Boltmaker	1 operator to 2 machines 1 helper to 2 machines	5,040	3,525
Washing	Drum with revolving screw	1 loader 1 unloader	--	3,460 lb.
Annealing	Gas-fired furnace	3 men to 7 or 8 furnaces	--	735 lb.
Nutting	Company's own design	1 operator to 8 machines 1 helper to 8 machines	3,660	2,360
Packaging				
Box of 50	Scale	2-man crew	--	200 boxes
Keg of 2,400	Scale	6-man crew	--	120 kegs

Table 11. Output and related information, bolt and nut manufacture, by operation, in plant D, U. S. A., 1952

Operation	Machine	Staffing	Machine cycles per hour	Output per hour (pieces)
	1/4" x 1" Cap screw			
Heading and pointing	Waterbury Farrel, 5/16" Hi-pro.	(1/)	9,000	5,850
Trimming	Waterbury Farrel, 3/8"	(1/)	5,880	3,234
Tumbling	100 lb. Roto barrels	1 operator to 4 barrels	--	(1/)
Threading	Waterbury Farrel, 1/4"	1 operator to 10 machines 1 helper to 10 machines	8,100	5,265
Boltmaking	National, 3/8" Boltmaker	(1/)	4,980	2,490
Heat treating	Lindberg gas-fired furnace-1,000 lbs. capacity	(1/)	--	(1/)
Packing Kegs-220 lb.	Scale	1 man	--	15 kegs
	3/8" x 1-1/2" Cap screw			
Heading and pointing	Waterbury Farrel, 3/8"	(1/)	5,280	2,904
Trimming	Waterbury Farrel, 3/8"	(1/)	5,880	3,410
Tumbling	100 lb. Roto barrels	1 operator to 4 barrels	--	(1/)

1/ Information not available.

Table 11. Output and related information, bolt and nut manufacture, by operation, in plant D, U. S. A., 1952--Continued

Operation	Machine	Staffing	Machine cycles per hour	Output per hour (pieces)
	3/8" x 1-1/2" Cap screw--Continued			
Threading	Waterbury Farrel, 3/8"	1 operator to 10 machines 1 helper to 10 machines	4,680	2,808
Boltmaking	National, 3/8" Boltmaker	(1/)	4,980	2,490
Heat treating	Lindberg gas-fired furnace-1,000 lb. capacity	(1/)	--	(1/)
Packing Kegs-220 lb.	Scale	1 man	--	15 kegs
	1/4" Hexagon nut			
Punching	71-ton, Minster, punch press	1 operator to 3 machines	6,240	3,478
Chamfering	Waterbury Farrel, 5/16"	1 operator to 3 machines	12,000	7,392
Tumbling	100-lb. Roto barrels	1 operator to 4 barrels	--	(1/)
Tapping	National, 1/4"	1 operator to 17 machines 1 helper to 17 machines	4,740	3,128

1/ Information not available.

Table 12. Output and related information, bolt manufacture, by operation, in plant E, U. S. A., 1952

Operation	Machine	Staffing	Machine cycles per hour	Output per hour (pieces)
	1/4" x 1" Cap screw			
Heading and pointing	Waterbury Farrel, 5/16", Hi-pro.	1 operator to 2 machines	10,500	6,300
Trimming	Waterbury Farrel, 1/4"	5 operators to 14 machines	7,740	3,726
Tumbling	Drum	2-man crew	--	1,500 lb.
Threading	Waterbury Farrel, 1/4"	4 operators to 13 machines	4,800	1,920
Boltmaking	National, 5/16" Boltmaker	1 operator to 1 machine	5,400	3,267
Heat treating	General Electric furnace	2 operators	--	(1/)
Inspection	Visual and instrumental	Inspection crew	--	(1/)
	3/8" x 1-1/2" Cap screw			
Heading and pointing	Manville, 3/8"	3 operators to 4 machines	3,840	1,920
Trimming	Waterbury Farrel, 3/8"	5 operators to 14 machines	4,980	2,739
Tumbling	Drum	2-man crew	--	1,500 lb.
Threading	Waterbury Farrel, 3/8"	2 operators to 13 machines	4,840	1,940

1/ Information not available.

Table 12. Output and related information, bolt manufacture, by operation, in plant E, U. S. A., 1952--Continued

Operation	Machine	Staffing	Machine cycles per hour	Output per hour (pieces)
	3/8" x 1-1/2" Cap screw--Continued			
Boltmaking	National, 3/8" Boltmaker	1 operator to 1 machine	4,800	3,024
Heat treating	General Electric furnace	2 operators	--	(1/)
Inspection	Visual and instrumental	Inspection crew	--	(1/)

1/ Information not available.

Table 13. Standard man-minute requirements and related information, bolt and nut manufacture, by operation, in plant B, U. S. A., 1952

Operation	Machine	Staffing	Standard man-minutes per 1,000 pieces 1/
	1/4" x 1" Bolt		
Head	Waterbury Farrel, 5/16" Solid die, double stroke, cold header	1 setup operator 1 helper	5.60
Trim	Waterbury Farrel, 3/8" Automatic bolt trimmer	1 setup operator 1 helper	5.10
Tumble	Continuous type tumbler	1 tender	3.70
Point	Economy Engineering, pointing machine	1 setup operator 1 helper	3.64
Thread	Roll-threader	1 setup operator 1 helper	3.57
Heat treat	Continuous gas-fired furnace	1 tender	.77
	3/8" x 1-1/2" Bolt		
Head	Waterbury Farrel, 3/8" Solid die, double stroke header	1 setup operator 1 helper	9.17
Trim	Waterbury Farrel, 3/8" Automatic bolt trimmer	1 setup operator 1 helper	5.10
Tumble	Continuous type tumbler	1 tender	13.10
Point	Economy, pointing machine	1 setup operator 1 helper	3.64

1/ Adjusted to include 25 percent allowance for machine downtime.

Table 13. Standard man-minute requirements and related information, bolt and nut manufacture, by operation, in plant B, U. S. A., 1952--Continued

Operation	Machine	Staffing	Standard man-minutes per 1,000 pieces 1/
	3/8" x 1-1/2" Bolt--Continued		
Thread	Waterbury Farrel, No. 20	1 setup operator 1 helper	4.40
Heat treat	Continuous conveyor gas furnace	1 furnace	2.74
	1/4" Hexagon nut		
Punch nut	Waterbury Farrel, 5/16"	2 setup operators 1 helper	5.70
Tap nut	National, bent shank, automatic tapper	1 setup operator	3.14
	3/8" Hexagon nut		
Punch nut	Waterbury Farrel, 3/8"	2 setup operators 1 helper	7.25
Tap nut	National, bent shank tapper, 3/8"	1 setup operator	2.52

1/ Adjusted to include 25 percent allowance for machine downtime.

Case Study Data on
Productivity and Factory Performance

COLD-FORMED MACHINE BOLTS AND HEXAGON NUTS

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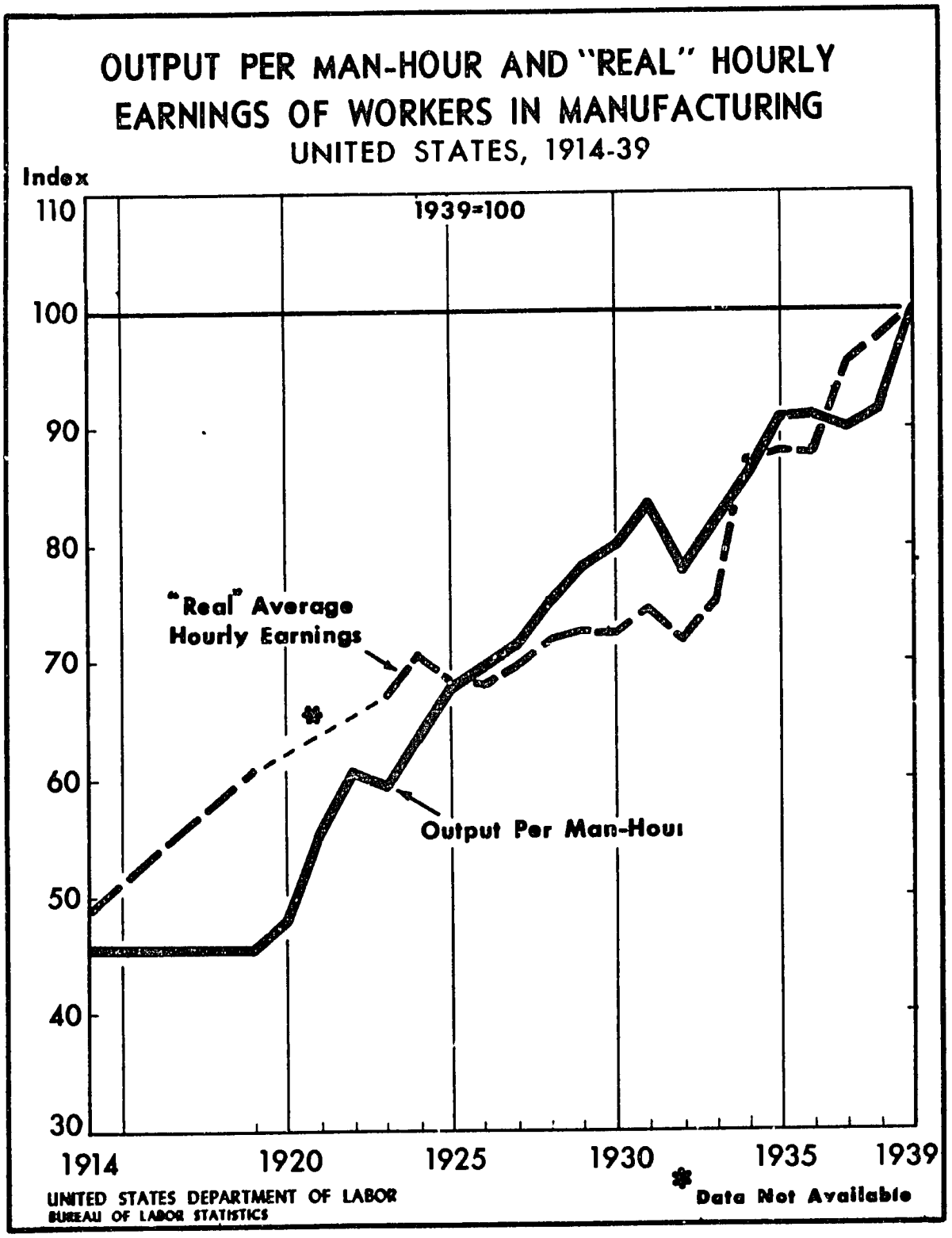

Figure 5 Output per man-hour and "real" hourly earnings, manufacturing, U. S. A., 1914-39

CHAPTER III: LABOR IN THE FASTENERS INDUSTRY

(NOTE: THIS CHAPTER IS NOT INTENDED TO BE A COMPLETE STUDY OF LABOR OR LABOR CONDITIONS IN THIS INDUSTRY. IT IS PRESENTED PRIMARILY TO ILLUSTRATE THAT THE UNITED STATES FACTORY WORKER HAS ACHIEVED A HIGH STANDARD OF LIVING IN HIS HIGHLY PRODUCTIVE ECONOMY.)

Labor Background

Factory workers' earnings, along with the earnings of other groups in the United States, have increased in real as well as in monetary terms along with an almost continuous productivity improvement. Their average real weekly earnings doubled, whereas the workweek declined one-fifth between 1909 and 1947 according to Bureau of Labor Statistics estimates. These substantial improvements in income could not have been achieved except for increased output per man-hour of work made possible by a constantly improving technology of production. Although all workers have benefited from greater productivity, workers in industries with strong unions have generally been in the forefront in obtaining gains from increased productivity. In additior to increased pay and shorter hours, workers have also chosen to take some of the returns from greater productivity in the form of so-called "fringe benefits," such as paid holidays, vacations, pensions, and rest periods.

Despite the advantages arising from technological change, both organized and unorganized labor have on many occasions resisted the introduction of new methods or machinery because of the threat of short run unemployment and the natural resentment to changes. Examples of how management and labor working together have successfully coped with the problem are given in appendix I.

Hours and Earnings of Industrial Workers

Average hourly earnings of production workers in the fabricated metal products industry (Standard Industrial Classification 3494--Bolts, nuts, washers, and rivets), of which the manufacture of bolts and nuts is a constituent part, averaged between 3 and 5 percent higher for the 5-year period 1947-51, than the average hourly earnings of production in all manufacturing industries in the United States for the same period (table 14).

Table 14. Average hours and earnings of production workers in all manufacturing industries and in the fabricated metal products industry, U. S. A., 1947-51

Year	Consumers' 1/ Price Index (1935-39=100)	All manufacturing industries			Fabricated metal products (except ordnance, machinery, and transportation equipment)		
		Average weekly earnings	Average weekly hours	Average hourly earnings	Average weekly earnings	Average weekly hours	Average hourly earnings
1947 . .	159.6	$49.97	40.4	$1.237	$52.06	40.8	$1.276
1948 . .	171.9	54.14	40.1	1.350	56.68	40.6	1.396
1949 . .	170.2	54.92	39.2	1.401	57.82	39.6	1.460
1950 . .	171.9	59.33	40.5	1.465	63.42	41.4	1.532
1951 . .	185.6	64.88	40.7	1.594	69.35	41.7	1.663

1/ Consumers' Price Index for moderate income families in large cities - Handbook of Labor Statistics.

The amount of worktime required of an average factory worker, and an average production worker in the fabricated metal products industry in the United States to buy selected food and clothing items in 1947 are shown in table 15. The percentage difference between average hourly earnings for workers in all manufacturing industries and in the fabricated metal products industry in 1947 was only slightly different in 1951 (slightly over 1 percent).

Table 15. Amount of worktime required of average factory worker and of average production worker in the fabricated metal products industry in the U. S. A. to buy selected food and clothing items, 1947

Item	Unit of measure	Average factory worker		Average worker in fabricated metal products industry 1/	
		Hours	Minutes	Hours	Minutes
Food					
Milk	1 liter	--	9	--	9
Eggs	1 dozen	--	34	--	33
Oranges	1 dozen	--	21	--	20
White flour	1 kilogram	--	11	--	11
White wheat bread. .	1 kilogram	--	13	--	13
Butter	1 kilogram	1	28	1	25
Salt pork	1 kilogram	--	49	--	48
Potatoes	1 kilogram	--	7	--	7
Coffee	1 kilogram	--	51	--	49
Clothing					
Men:					
Heavy wool suit. .	1	36	43	35	37
Work shirt	1	1	19	1	17
Socks	1 pair	--	16	--	16
Street shoes . . .	1 pair	6	32	6	20
Work shoes	1 pair	5	56	5	45
Women:					
Wool coat	1	17	53	17	20
Street dress . . .	1	8	20	8	5
House dress . . .	1	2	31	2	26
Rayon and nylon stockings . . .	1 pair	--	53	--	51
Street shoes . . .	1 pair	5	26	5	16

1/ Derived by multiplying the time in hours and minutes of average factory workers by ratio of average hourly earnings in all manufacturing to average hourly earnings in fabricated metal products industry, 1947.

Fringe Benefits

Just as the output per man-hour of the United States worker has more than doubled in the period for which comparable data are available, 1914 to 1939, so the "real" average hourly earnings for the same period have more than doubled (table 14).

In addition to higher pay and a shorter workweek, workers in the United States have obtained certain nonwage benefits commonly called "fringe benefits." The "fringe benefits" include paid holidays, paid vacations, rest periods, shift differentials, overtime pay, insurance, retirement funds, and many others depending upon company policy and labor-management contract provisions. The following examples of fringe benefits as reflected in contracts covering two of the plants in the survey are indicative of benefits enjoyed by many of the production workers in the industy.

The United Steel Workers of America, CIO, and the United Auto Workers, CIO, negotiated these two contracts with plants C and E of this study.

Fringe Benefits	Plant C	Plant E
SHIFT DIFFERENTIALS		
Evening (second shift)	4 cents per hour over first shift	5 cents per hour over first shift
Night (third shift)	6 cents per hour over first shift	10 cents per hour over first shift
OVERTIME RATES		
Rate of pay after 40 hours per week	1.5	1.5
Rate of pay after 8 hours per day	1.5	1.5
Rate of pay for seventh consecutive day	2.0	2.0
HOLIDAYS		
Number of holidays	6	6
	Paid at straight time if not worked	Paid at straight time if not worked
Holiday pay (if worked)	1.5	2.0
INCENTIVE PAY	Straight piece rates	Straight piece rates
PAID ANNUAL VACATIONS		
Length and eligibility	1 week 1-5 years 2 weeks 5-25 years 3 weeks over 25 years	1 week 1-5 years 2 weeks after 5 years

Fringe Benefits--continued

	Plant C	Plant E
Vacation pay	Average rate of earnings per hour for first two complete pay periods in May	2 percent of straight time annual earnings
INSURANCE	Group health and hospitalization and pension plan	Group health accident and hospitalization plan

Source: Union contracts (United Steel Workers of America - CIO and United Auto Workers - CIO.)

Adjustments to Technological Change

Labor and management in the United States have always been faced with problems arising from changes in processes and the introduction of new machinery. The problems generally include determination of earnings, workloads, work schedules, displacement of special skills by new machinery and methods, and, in some cases, actual displacement of workers. Over the past 25 years, with the more rapid growth of labor unions, adjustments and solutions to these problems have been reached in many instances on a case-by-case basis as a result of negotiations between the two parties. The success of the solutions and adjustments has depended almost entirely on the attitudes and procedures with which labor and management approached each case and only incidentally on the technical details of the change itself.

Moreover, negotiations over technological change in many fields of manufacturing indicate that the experience gained from a case in one industry is applicable to problems of change in other industries. Consequently, the methods and ideas developed in negotiations over technological change are used in many industries in addition to the one in which a problem first appeared. Technical details concerning machines, processes, and conditions of employment still require agreement on a case basis within the framework of ideas and methods handed down from past experience.

The examples of adjustments to technological change in appendix I have been selected because of the techniques and procedures they illustrate, without regard to the industry in which they occurred.

APPENDIX I: CASE STUDIES OF ADJUSTMENTS TO TECHNOLOGICAL CHANGE

(NOTE: THE CASE STUDIES USED TO ILLUSTRATE ADJUSTMENTS TO TECHNOLOGICAL CHANGE WERE NOT MADE IN THE FASTENERS INDUSTRY. THESE EXAMPLES WERE SELECTED BECAUSE OF THE TECHNIQUES AND PROCEDURES THEY DEMONSTRATE, WITHOUT REGARD TO THE INDUSTRY IN WHICH THEY OCCURRED.)

Case Study No. 1: 4/

"The importance of good communications in the development of a healthy collective bargaining relationship has been recognized by Sharon management. It accepts the view that the employees have a right to expect adequate information regarding policies and plans which affect them. Especially is management obligated if it expects a high degree of responsibility on the part of the union and its members.

"To take a specific example, management held a series of conferences with union representatives well in advance of the contemplated purchase of the Farrell plant in 1945. The purpose of these conferences was to inform the union and employees of the proposed expansion and to gain their cooperation in solving the issues and maladjustments which might grow out of the Farrell acquisition. Similarly, conferences have recently been held regarding a proposal to increase the blast furnace facilities at Farrell by 20 to 25 percent. The implications of such decisions are very serious for some of Sharon's employees, and management consequently wished to inform them of the plans and to receive their cooperation in making necessary adjustments.

"Furthermore, Sharon management recognizes that employees are often suspicious of - and therefore antagonistic toward - policies and practices which they do not understand. An industrial relations official once spent the better part of three days explaining a specific phase of the incentive system to a local union representative. That union representative, once

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4/ Sharon Steel Corp. and United Steelworkers of America. Causes of Industrial Peace Under Collective Bargaining, Case Study No. 5, National Planning Association, Washington, D. C., 1949.

he had grasped the problem, was of great assistance to management in helping to explain the problem to other employees. This instance was only one of many which served to substantiate management's belief that effective communications can be of great value in achieving acceptance for policies which otherwise might be rendered ineffective by employee opposition.

"Highly formalized procedures generally have not been used at Sharon for the purposes of communication. There have been occasional memoranda addressed to the employees as a whole, and a few such extraordinary procedures as the banquet which followed the National Labor Relations Board (NLRB) election at Sharon in 1937. But even procedures such as these have not been used regularly by management. On the whole, the function of maintaining a satisfactory flow of information from management to union, as well as in the reverse direction, has been accomplished largely by informal and personalized methods. 5/ Conferences between one or more management and union officials, a letter or telephone call, or some other direct and essentially informal channel has kept each party informed of the other's plans and problems. Needless to say, the effectiveness of such a system depends almost entirely upon individual relationships between management and union officials.

"Communications within management also have been marked by a high degree of informality. For example, Sharon has never operated a full-fledged foreman training program. In one way or another, however, top management has succeeded in communicating its policies to lower levels promptly and effectively. Communication up the line is another question. Apparently nothing approaching consultative supervision or "multiple management" has been given any serious consideration at Sharon.

"Communications within the union have been only slightly more formal than within management. Informal contacts and relationships have been relied upon to a great extent. One very effective stimulant to downward communication within the union has been the fairly recent emphasis upon increasing the activities and responsibilities of the local union officials. That effort has required the communication of much information from the district office to the local officials, and then from those officials to the membership. In addition, union publications of various types have played a part in keeping members generally informed regarding the union's problems and policies.

"Finally, the attempts to maintain a free flow of information between management and union at Sharon do not indicate a desire on the part of management for joint consultation or participation by the union in the actual decisions of company officials. When management conferred with the union on the contemplated purchase of the Farrell plant, it was not asking the union to participate in the decision to make the purchase. The intention was merely

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5/ Interestingly enough, past issues of the company magazine, Sharonsteel Record, have contained extremely few references to the union, the collective bargaining agreement, or any other phase of the relationship.

to advise the employees and union of the impending expansion and to seek their cooperation in meeting whatever difficulties or disarrangements might result. There has been no attempt to undertake a formal union-management cooperation program similar to those which have been developed in various other companies in the steel industry. With the exception of joint safety committee, the only instance of true joint participation at Sharon was the job evaluation program designed to eliminate wage inequities during the recent war. That program, however, as well as the joint participation which it involved, was specifically ordered by the War Labor Board.

"Even so, it would not be fair to say that Sharon management has clung tenaciously to its decision-making prerogatives and resisted every attempt by the union to give advice and counsel. One of the things which has distinguished management policy at Sharon from that of most of its large competitors is the pronounced lack of emphasis which has been placed upon the "management prerogatives" clause of the contract. Management has at all times expected and encouraged assistance from the union, and has not hesitated to provide the information necessary to facilitate such assistance. The company has stood ready to assist the union in any way possible, and reciprocity in this respect has always been encouraged. In the course of developing and maintaining such mutual assistance, both management and the union have learned and acknowledged that effective communications within and between the parties are mandatory if the union and its members are to play their proper roles in strengthening the company and helping to assure its future progress and development.

"On balance, it is by no means easy to decide the extent to which communications and consultation between and within management and union may have contributed to industrial peace at Sharon. The flow of information between the parties apparently has been adequate, and it is difficult to see how that fact could have failed to make a positive contribution to industrial peace. Communications within the respective organizations have perhaps been less notable, but not so much so that they should be termed unsatisfactory. Whether the contribution made by these factors might have been greater had more formal procedures been followed is a matter of conjecture. The question is very significant in terms of the applicability of Sharon's methods to other situations. It should not, however, be allowed to obscure the definite contribution to industrial peace which communications and consultation as practiced at Sharon have in fact made."

Case Study No. 2: 6/

"Steelworkers, in common with all other Americans, naturally welcome increasing labor productivity, if only because they realize that augments the fund from which higher living standards may be realized. Yet increasing labor

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6/ Minnequa Plant of Colorado Fuel and Iron Corp. and Two Locals of United Steelworkers of America. Causes of Industrial Peace Under Collective Bargaining, Case Study No. 9, National Planning Association, Washington, D.C., 1951.

productivity, whether reflecting technological improvements or more effective human teamwork, also arouses the worker's natural fear of demotion or displacement. The steel industry has not yet solved this long-standing human problem or even approached it as broadly as has the automobile industry - exemplified in the latter case by the General Motors contract of 1950.

"Nevertheless, both management and union leaders at Minnequa are making a sincere effort to minimize the adverse effects on workers of introducing modernized and improved mechanical and human teamwork processes. This is reflected in the care with which incentives arrangements and seniority problems were handled when a new rod mill was installed at the Minnequa Plant in 1949. The same case illustrates the painstaking attention which is given to the classification of jobs involving the new processes. Technological displacement was handled by the parties in conformance with a subsection of the contract's seniority clause, which outlines a procedure of mutuality in the instance of interplant transfers required by additions of new plants and discontinuance of other plants.

"After the new mill was put into operation, following the voluntary shift of workers from the old rod mill, unpredictable kinks had to be resolved, and these were still being straightened out eight months after installations had been completed. The mill not only ran at partial capacity for some time, but also job classifications had to be tentative, and incentive standards were temporarily held in abeyance, with retroactive pay to be based on production records from the time the mill started.

"The union accepted the company's tentative job classifications with the understanding that time would be allowed for jobs to "jell." This involved no demotions, but take-home pay was diminished in these instances where incentive earnings, temporarily held in abeyance, would have exceeded hourly rates. This was offset to some extent by the fact that 10-hour shifts were adopted, with the contract providing for overtime premium for work in excess of eight hours.

"In approaching the comprehensive task of establishing job classifications for the new mill, the initial step of management and the union was to reach agreement on job descriptions. Then followed a re-examination of the company's tentative classifications in the light of the agreed upon job description. Based on the 30 labor grades established by the national committee studying wage inequities, a method of polled judgment was applied in an attempt to slot the jobs, as mutually defined, into corresponding labor grades. Although the contract provides that in cases of disagreement the company may proceed unilaterally, subject to later appeals through the grievance procedure, every effort was made to reach agreement by this method of pooled judgment which drew on practices in comparable situations in other plants and in the industry generally. Of 23 job classifications discussed in April 1950, 10 were accepted by the union without dispute, the company made concessions on seven, and the union provisionally withdrew objections on the remaining six. The outcome was that many workers were upgraded, owing to the fact that

some jobs which were reclassified affected relatively large concentrations of workers. An example was the flying shear job, which was raised from labor grade 9 to labor grade 10 in a mutual attempt to harmonize the new rod-mill rates with rates generally paid for like or similar work. In all of this processing the union did not waive its contractual right for reconsideration in the light of further information or living experience.

"Essentially the same mutuality exists at Minnequa in the classification of new jobs as in the reclassification of old jobs affected by technological change or organizational flow changes. In all such proceedings the company's position is based on data prepared by the industrial engineering staff. The union in turn acts directly through its committee on wage inequities rather than indirectly through the grievance procedure. Sometimes the advice of the United Steelworker's wage experts is also sought. Thus it may be seen that both union and management handle the difficult job of dealing with ever-changing job content on a high factual level.

"This is a long step forward from the old days in the steel mills, with their lush growths of scattered wage rates. Today the industry has a simplified, understandable, and comprehensive wage structure based on mutual agreement. This wage structure is by no means a straitjacket for it serves only as a guide to the classification of particular local jobs. Nor is it a static wage structure, for the parties in their joint wage inequity committees have the means of keeping abreast of changes as they occur. The existence of a guiding wage structure and of arrangements for applying it to changing conditions is a major contribution to industrial peace."

APPENDIX II: INDUSTRY BACKGROUND

Prior to the middle of the 19th century, bolts were made by blacksmiths with the use of a hammer, anvil, and vise. In 1845 the cold header machine was developed. This machine permitted mass production of cold headed bolts. The growth of the industry continued; today the fastener industry uses 2 percent of the Nation's steel output.

In 1947 the industry consisted of 364 establishments with a total employment of 40,908. Over half the workers in the industry were employed in 26 establishments employing over 500 people each. Concentration of employment has been centered around the large industrial centers of Cleveland, Chicago, and Pittsburgh; and in the general industrial area of New England.

The firms in the fastener industry manufacture many types of bolts, nuts, screws, washers, and rivets, both hot and cold formed, in standard sizes made for stock and in special sizes made to customers' specifications. A number of the smaller firms prefer to manufacture special products to customers' specifications, finding this more profitable than trying to compete with the larger firms on standard items.

Manufacturers of nuts and bolts distribute their products either directly to the consumer, as in the case of large industrial users; or to wholesalers or hardware retailers in such cases where the consumer purchases the items in small quantities. Wholesale distributors of bolts and nuts usually handle other hardware items and distribute their products over a wide area. The present tendency is for many distributors to maintain a large variety of sizes in stock so that orders may be filled quickly with greater expediency.

Table IIa. Statistics for the fasteners industry, by region, U. S. A., 1947

Region	Number of establishments	All employees		Production and related workers		Expenditures for new plant and equipment (in thousands)
		Number (average for the year)	Salaries (in thousands)	Number (average for the year)	Total man-hours (in thousands)	
Total	364	49,235	$151,514	40,908	85,895	$18,263
New England . .	63	11,157	32,512	9,308	20,006	3,811
Middle Atlantic. .	66	11,105	33,435	8,865	17,960	2,635
East North Central . .	182	24,368	78,500	20,560	43,591	10,937
West North Central . .	9	526	1,363	437	889	54
Southern. .	12	1,236	3,041	1,070	2,126	515
Pacific . .	32	843	2,663	668	1,323	311

Source: U. S. Bureau of the Census - Census of Manufactures, 1947.

Table IIb. Number of establishments and employees, by size of plant, fasteners industry, U.S.A., 1947

Item	Number of employees								
	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	1,000-2,499
Number of establishments	69	41	37	66	47	53	25	15	11
Total employees .	144	283	515	2,161	3,250	8,391	9,300	10,729	14,462
Value added by manufacture (in thousands) . . .	$817	1,622	2,239	12,636	19,458	52,538	60,622	60,385	75,344

Source: U. S. Bureau of the Census - Census of Manufactures, 1947

APPENDIX III: THREAD FIT STANDARDS

Threads are one of the prime determinants of the difficulty or ease of their manufacture. Accuracy of three diameters--pitch, major, and minor--is necessary; angle of thread sides must be correct; spacing of threads must be right, not only overall, but progressively from point to point along the spiraling hills and valleys, so that leading segments of threads being assembled will not be impeded by mismating of sections to follow. The most usual way is to check them with gages which are made to allow a prescribed tolerance in product manufacture.

Over-tightness of threads is avoided by fitting them to standard go-gages. Go-plug-gages for nuts represent the largest bolt on which the nut is expected to go. Likewise, go-ring-gages for bolts represent the smallest nut into which the bolt is expected to go. Obviously, bolts and nuts that assemble with these standard go-gages will go together without interference. Go-gages are common inspection tools, since the most important requirement of bolts and nuts in rapid assembly is that they go together easily.

Standard not-go plug and ring gages are similar to go-gages, but are larger in pitch diameter in the case of plugs and smaller in the case of rings than corresponding go-gages. Not-go gages have a short length of thread, and it is recognized practice to permit them to assemble with the product a distance equal to the thread length of the gage without perceptible shake or play.

Thus, for inspecting bolts and nuts, go-gages and not-go gages differ in pitch diameter by a small amount. Product thread may vary slightly between these limits in diameter, thread angle, or spacing, so long as it assembles with the go-gage and does not assemble with the not-go gage by more than the standard amount. This difference in pitch diameter between go-gages and not-go gages is the specified pitch diameter tolerance of the product.

Several standard tables of pitch diameter tolerances have been published by the American Standards Association. It is necessary to refer only to a class number, as class 1, 2, or 3, in the order of accuracy. In classes 2 and 3 the tolerances are figured from a common basic pitch diameter, oversize for nuts, and undersize for bolts. In class 1 the nut is figured from the basic pitch diameter, but the bolt runs undersize from a diameter slightly less than the basic pitch diameter in order to provide a definite clearance, even under the tightest conditions. In all three classes the amount of tolerance is extremely small compared with other dimensions of the thread.

In considering the different classes of thread tolerances, one class of tolerance is often considered to be of better "quality" than another simply because the tolerance permitted is smaller. This is not true, for quality of a product is that which fits it for a given use and is meaningless when considered apart from this use.

For extreme or specific assembly requirements, more or less latitude may be necessary. Closer tolerances may be needed where accumulated spacing error of long thread engagement must be compensated for, where materials of both parts are unusually hard, where oil seepage must be avoided, or provide a drive fit. A definite clearance between parts may be used for extreme ease of assembly, to give room for plating, or to prevent seizure under high temperature service. The only requirement of threads for general purpose bolts and nuts is that they assemble easily and that they be strong enough to break the bolts.

Fit

Screw thread fits are produced by the application of specific tolerances or tolerances together with allowances, the latter being applicable in the case of the screw only, to the basic pitch diameter of the thread which is the same for both internal and external threads of like size and pitch. The tolerances throughout are applied plus to the hole and minus to the screw.

Class 1 Fit. A screw and hole threaded to class 1 specifications will never produce a close fit because the maximum pitch diameter of the screw is always smaller than the basic value by a definite allowance while the minimum pitch diameter of the hole is the basic value. There will always be "play" or looseness, therefore, between mating parts made to class 1 fit.

The class 1 fit is recommended only for screw thread work where clearance between mating parts is essential for rapid assembly and where "shake" or play is not objectionable.

Class 2 Fit. A screw and hole threaded to class 2 specifications may vary from a fit with no play whatever, when the pitch diameters of both mating parts are at their common basic value, to a fit with some play, in the case of a minimum screw and a maximum hole, when the total class 2 pitch diameter tolerance has been applied to both parts.

Class 2 represents a high quality of commercial screw thread product and is recommended for the great bulk of interchangeable screw thread work.

Class 3 Fit. A screw and hole threaded to class 3 specifications may vary from a fit with no play whatever, when the pitch diameters of both mating parts are at their common basic value, the same as in the case of class 2. With a minimum screw and maximum hole, however, when the total class 3 pitch diameter tolerance has been applied to both parts, a fit with some play, approximately 70 percent of that allowed under class 2 specifications, is obtained. It is evident, therefore, that all class 3 product falls within the specifications for class 2.

Class 3 represents an exceptionally high grade of threaded product and is recommended only in cases where the high cost of precision tools and continual checking of tools and product is warranted.

APPENDIX IV: QUESTIONNAIRE

This appendix contains the form used in the collection of data for this report and a glossary of technical terms used in this industry.

Data for this report were collected by field agents of the Bureau from selected plants which cooperated voluntarily in supplying answers to the questionnaire applicable to this industry. The questionnaire used has been reproduced in abbreviated form--all the questions and instructions are included but the space allowed for answering has been drastically reduced to save space in this report. Field agents are requested to obtain as much information as they can for each question--particularly for the narrative type question--and to use additional paper to supplement the space allowed in the questionnaire. It was not possible to get usable answers for some of the questions asked, however, the major portion of the information requested was obtained.

UNITED STATES DEPARTMENT OF LABOR
Bureau of Labor Statistics
Washington 25, D. C.

CONFIDENTIAL

PRODUCTIVITY AND FACTORY PERFORMANCE

COLD FORMED MACHINE BOLTS AND HEXAGON NUTS

Name of Industry or Product Group _____

Plant Name _____ Address _____

Parent Company _____ Address _____

Officials Interviewed: (Cross out "Co." or "Plant")

Name _____ Title _____ (Co.) (Plant)

Name _____ Title _____ (Co.) (Plant)

The data submitted on this questionnaire will be seen only by sworn employees of the Bureau of Labor Statistics. The data will not be released in any form which permits identification with any specific company, without written permission.

Survey made by _____ Date _____

Part A. GENERAL QUESTIONNAIRE

PRODUCT INFORMATION

1. Product Specification:

2. Reported Product:

   a. Enter the model and description of reported product (attach catalog descriptions)

   _____

3. Composition of Production:

   What percentage of the value of total plant production or sales in 1951 was represented by the following:

   a. Reported product _____

   b. Reported product plus all related types or models of product _____.

4. Reported Period:

Select a recent period at least as long as the normal production cycle, but in no case shorter than one week, in which production operations were proceeding at an average level.

Period begins _____ and ends _____

PRODUCTION, MAN-HOURS, AND EMPLOYMENT

5. Production and Man-Hours:

a. For the product reported (A2) enter the total production for the entire year of 1951 and for the period reported (A4). Enter, also, the man-hours for production and related workers (Direct and Indirect labor) for the entire year, or if not available, and in any event, for the reported period, and indicate which method of reporting man-hours is used (unit) or (aggregate) by crossing out the word which does not apply.

Time Period	Total Production		Man-Hours	(Unit)	(Aggregate)
	Number	Unit of Measure	Total	Direct	Indirect
1951-Entire Yr.					
Reported period					

b. Describe the source and the procedure whereby the preceding man-hour figures were obtained (e.g., actual, standard adjusted for deviation from actual, labor cost ÷ by average wage.)

_____

c. List the labor classifications or accounts included in indirect man-hours shown above.

_____ _____

6. Costs of Production:

Enter below the proportion to total manufacturing cost of the following accounts during the reported period, for the reported product (estimate if necessary):

Percent

a. Labor cost (include wages paid production and related, workers, i.e., direct, plus indirect workers, but excluding payrolls for administrative, sales and office personnel) . . . . . _____

b. Direct materials cost (include cost of all materials which are used in producing the reported product) . . . _____

c. Other factory cost (include fuel, electric energy, wages and salaries of non-production workers, cost of office supplies, maintenance, depreciation, etc.) . . . _____

ANALYSIS OF MANUFACTURING PROCESS

7. Operations, machinery, and material flow for quantity of production reported (A5) during period reported (A4).

a. Enter below the sequence of the operations reported, and for each operation listed (including inspection) give a brief description of the operation, the machinery used, the number of machines used, the designed capacity of the machines, the number of production and related workers in each operation, and unit man-hours per operation. Include among operations the material movements: In describing them note equipment used, and who actually handles movement.

Op. Seq. No.	Operation Performed (or Department) and Nature of Work Done (Include Materials Movements)	Machines, Equipment, or Materials Moving Devices				No. of Workers	Unit Man-Hours Per Operation
		Name, Mfg., Model No. and Special Attachments	Drive*	No. of Units	Designed Capacity (Volume and Speed)		

* "L" if line, "U" if unit, "G" if group.

b. Indicate whether man-hours are standard, estimated, or actual by crossing out appropriately: (Standard) (Actual) (Foreman's Best Estimate)

INTEGRATION AND PARTS USED

8. Parts List -- For each part listed, check whether the part is manufactured in the plant, in other plants of this firm, or purchased during reported period, and enter the operation sequence number in which the part is used.

Part Name	Manufactured (Check)			Used in Op. Seq. No.	Other Products in which this part is used
	This Plant	Other Plant Same Firm	Other Firm (Purchased)		

9. Total Employment

   a. Average total employment in the plant during the reported period (Sum of b plus c below) . . . . . _____

   b. Production and related workers: (Total 1 & 2) . . . . . _____

      (1) Direct workers . . . . . _____

      (2) Indirect workers . . . . . _____

   c. Nonproduction workers (e.g., office, admin., sales, etc.) _____

10. Engineering and Research:

    Enter the number of workers employed during the reported period that spend the major part of their time in the following activities:

Activity	Number of Workers
Production engineering	
Methods or time study engineering	
Product research	

NARRATIVE QUESTIONS

11. Changes in Product or Operation:

    What major changes have been made since 1947 to effect operation simplification, and/or product simplification, or to save critical materials? Describe one or more examples.

12. Production Control:

    Is the plant's production control system significantly different from the usual practice in the industry? Yes___ No___ If yes, decribe.

13. Jigs and Fixtures

Describe one or more examples of special jigs, fixtures, or attachments, which have been developed since 1947, which have had a significant effect on man-hours, and estimate and effect.

14. Plant Layout and Materials Handling:

a. Describe the plant layout, using diagrams wherever possible.

b. If plant was not originally constructed for its present use, describe outstanding changes made since its construction or acquisition to adapt the building to the production of the reported product.

c. Describe generally the material handling methods used in this plant. (Supplementary to IC).

15. Productivity Factors:

Describe the key factors which contributed most to achievement of the present level of productivity in this plant.

16. Reconciliation of Man-Hour Figures (For Agent's Use)

Compute the number of unit man-hours for this product as obtained by adding the man-hours for each operation, in Question 9 or the "Detailed Analysis Sheet", and compare this total with the total obtained from Question 5. The unit time per operation can be entered in the blank column for Question 21, below.

EXHIBITS

Submit the following, if available:

17. General plant layout diagram.

18. Forms used in production control and scheduling.

19. Photographs of plant operations, equipment, and layout.

20. Catalog.

CHECK LIST FOR DETAILED ANALYSIS SHEETS (IF USED)

21. List below all sheets completed for analysis of manufacturing parts or processes showing part or sub-operation and sheet number:

Part, Sub-Operation or Process	Sheet No.	

22. Detailed Analysis of Manufacturing Parts or Processes

Plant Name _____

Part or Operation Sheet No. _____ of _____ Sheets.

a. Part, Department or Process Name _____

Briefly describe the process for this part or operation _____

_____

_____

b. Production and man-hours for a day or other short production cycle:

Length of period (hours): _____ Production: _____ (Quantity) _____ (Unit of Measure)

Total number of man-hours: _____

c. Staffing Pattern:

Occupation and Description	Number of Production and related workers	Total No. of Hours

d. Method of Wage Payment:

1. Check whether predominantly: Straight time _____ or incentive system _____

2. If incentive system, describe the method used _____

_____

e. Machinery and Output:

Name, Manufacturer, Model No., and Special Attachments	Drive*	No. of Units	Designed Capacity (volume and speed)	Average Actual Output Per Day

* "L" if line, "U" if unit, "G" if group

f. Material Movement:

Work Station		Amount Moved	Method and Description of Equipment Used
From	To		

GLOSSARY

Blank:	A stamped or molded piece of metal roughly approximating a predetermined size and shape.
Cap screws:	The cap screw is generally considered a high-quality fastener and is used in a tapped hole or whenever it is necessary to wrench-up by the head. It differs from a machine bolt in that a machine bolt is generally tightened by wrenching-up a nut while the cap screw is tightened by wrenching-up the head.
"D" (major diameter):	The largest diameter of the thread of a bolt or nut.
Fasteners:	A trade term signifying the industry which includes the manufacture of such items as bolts and nuts, screws, rivets, and washers.
Fit:	Screw thread fits are produced by the application of specific tolerances or tolerances together with allowances, the latter being applicable in the case of the screw only, to the basic pitch diameter of the thread which is the same for both internal and external threads of like size and pitch. The tolerances throughout are applied plus to the hole and minus to the screw.
Hopper:	A receptacle for holding blanks, or parts waiting to be fed to a machine or passed on to a subsequent operation. A hopper is usually placed above the machine so that the parts may be gravity-fed to the machine.
Lot:	A homogeneous group of parts or products having common characteristics such as size, type, use and plating. Most mass-produced goods are made in lots to facilitate longer and more economical production runs, handling and packaging.
Machine minutes:	The number of minutes required to turn out a specific quantity of product on a given machine.
Machine setup:	The changing of dies, jigs, fixtures, or any adjustments made to a machine for the purpose of adapting the machine to a particular production run.
Nonstandard or special nuts or bolts:	Those which are not made for stock but are made to a customer's specifications.

Nut stock:	Rod or wire which has been flattened to an elliptical shape to facilitate the stamping of nut blanks.
Pointing:	An operation in which the lead end of the bolt is pointed, chamfered, or beveled for thread protection and fast assembly.
Quenching:	A process of cooling steel rapidly by immersing it in oil or water. This hardens the steel and prevents brittleness.
Rod:	A term referring to a length or coil of hot-rolled drawn steel or other metal whose diameter is usually greater than 1/4 inch.
Shank:	That part of the bolt blank upon which the threads are made.
Skid or pallet:	A movable platform used in conjunction with a mechanical lift truck for the purpose of moving or storing materials and finished goods.
Standard bolts or nuts:	Bolts or nuts carried in stock rather than made to a customer's order. Generally the more popular sizes and classifications.
Tote boxes:	Small metal boxes or pans into which the blanks are fed from the machines. Tote boxes are purposely made small to facilitate ease in handling as they are usually moved manually with the use of a hooked pulling rod.
Wire:	A term referring to a piece or coil of cold-rolled or drawn steel or other metal whose diameter is usually less than 1/4 inch.
Wrench-up:	A term applied to the act of tightening bolts or cap screws with a wrench.