BLS Report No. 39

Case study data on productivity and factory performance . . .

HAND TOOLS

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By the
UNITED STATES DEPARTMENT OF LABOR
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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.

Case Study Data on
Productivity and Factory Performance

HAND TOOLS
(Machinist's Flat File,
Monkey Wrench, and
Expansive Bit)

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FOREWORD

This report is intended to be of primary use to 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 in this study. In addition, the general discussion of productivity and the presentation of man-hours per unit in the manufacture of three hand tools (flat file, monkey wrench, and expansive bit), 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 transmitted to the Bureau of Labor Statistics by the Foreign Operations Administration. The plants selected for the 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. The criteria used in selecting plants for study are that the product made by the plant be as nearly similar as possible 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

Each of the three tools covered in this report is considered in a separate section. Section A, on machinist's flat files, is in two chapters. Chapter I is directed primarily to the reader who is interested in the less detailed aspects of productivity in the manufacture of files. Chapter II contains detailed case studies of each plant and will be of value to the plant superintendent or the production engineer. Sections B and C, dealing with wrenches and expansive bits, respectively, are organized like Section A.

Section D is a brief discussion of workers earnings, and the benefits to the worker due to increased productivity and unionization where applicable. The appendixes contain case studies of labor adjustments to technological change, 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 from plant to plant because some information is not obtainable from all plants, and some information is not usable in the form in which it is provided. Supplementary information was obtained from other government agencies and 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 the first chapter and the case studies in the second chapter of Sections A, B, and C to identify the United States plants in this study whose employment, production volume, and integration most nearly approach the situation in his plant.

2. Appendix II 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 performance in the plants discussed in this report and to isolate areas in which his plant's performance is relatively good or relatively poor.

3. The European plant official may then compare the machinery and methods described in the report with those in his own plant, for those problem areas he has isolated. At this point the report does not give him the precise engineering information he may need but it does suggest the approximate requirements in terms of volume, methods, machinery, and manpower for approaching 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 his plant or outside consultants, will be needed. Intensive study must generally be made to correct the conditions found by comparison because these reports do not replace on-the-spot engineers or other specialists in the analysis of specific situations.

Case Study Data on
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HAND TOOLS
(Machinist's Flat File,
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SECTION A - MACHINIST'S FLAT FILE

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SECTION A - MACHINIST'S FLAT FILE

CHAPTER I: GENERAL REPORT

HIGHLIGHTS

Highly specialized cutting machinery, comprehensive schemes of production planning, and incentive wage payments enabled manufacturers in the plants surveyed to produce a machinist's flat file in less than 3 man-minutes. Quality control checks, applied at virtually every stage of production, led to the rejection of 5 percent or less of the completed files due to failure to pass inspection.

The ability to mass-produce files rests upon the use of highly specialized machinery, especially in the operation for cutting the teeth of the file. Cutting operation details are kept a closely guarded secret by individual manufacturers.

VOLUME OF PRODUCTION

The production of files and rasps for use in metalworking amounted to 112,483,000 units, having a value of $22,766,000, during 1947. 2/ Included in this total production were rotary files and burrs, which accounted for 6 percent of the total. These production levels for 1947 represent a 50.7-percent increase in quantity and a 112.7-percent increase in dollar value over the 1937 levels.

There were 37 establishments in the United States engaged in the manufacture of files in 1947, the last year for which complete information is available. 3/ The majority of these establishments had 10 or fewer employees and manufactured only special purpose files. Five file manufacturing establishments produced 90.1 percent of the total value of files manufactured in the United States in 1947.

Files and rasps are produced not only for metalworking but also for woodworking. Accessories for files are also manufactured. In 1947, output of woodworking files and file accessories amounted to approximately 1.8 million dollars, an increase of 97.1 percent over the corresponding figures for 1937.

1/ Prepared by Arthur S. Pearson and Arthur J. Nolan, Bureau of Labor Statistics, U. S. Department of Labor.

2/ Census of Manufactures: 1947, Vol. II., U. S. Department of Commerce.

3/ Ibid.

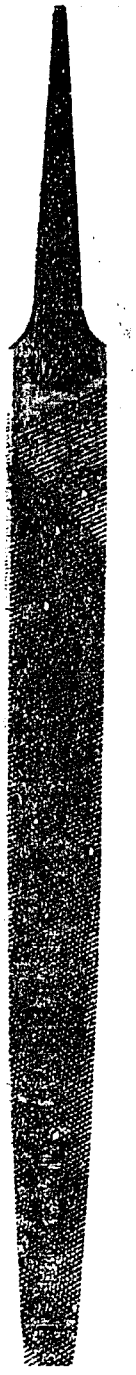

Fig. 1. Machinist's flat bastard file.

PRODUCT DESCRIPTION

Three major types of files are made - machinist's files, Swiss pattern files, and special purpose files. Machinist's flat files are the type studied in this report (fig. 1). This file is most commonly found in machine shops, but has innumerable applications in all kinds of manufacturing plants, garages, and repair shops. It is a fast-working file which removes metal rapidly, and is generally used when a very smooth finish is not necessary. The specifications and features of this file are as follows:

Feature	Specifications
Shape	Flat
Coarseness	Bastard-cut
Sets of teeth	Double-cut
Face	Tapered to point
Length - from heel to point	10 inches
Width	1 inch (approx.)
Thickness	1/4 inch (approx.)
Edges	Cut on both edges

File types are distinguished by a series of descriptive features. The first of these marks of identification is the cross-sectional shape. The cross-sectional shapes of files include flat, square, circular, triangular, and trapezoidal (fig. 3). The flat file, which is the subject of this study, has a long, narrow, rectangular cross section.

The degree of coarseness, or the frequency with which the teeth are spaced in the face of the file, is another method of identifying files by type. There are three common types: the bastard-cut, which has coarsely spaced teeth for heavy stock removal, the second-cut which has medium spacing, and the smooth-cut which is closely spaced for fine finishing. In addition, there are a few files coarser than bastard, and a few smoother than smooth-cut, but these have only a limited use.

The number of sets of parallel teeth extending across the face of a file is a third factor used in describing a file. A single-cut file has a single set of parallel teeth, diagonal to the longitudinal axis of the file. A double-cut file has two sets of diagonal rows. The first set is called the overcut; the second-cut is made at a different angle to the file axis and is known as the upcut. These rows are finer and deeper than the overcut (fig. 2).

Standard cuts in a file are either single-cut, or double-cut, although some special and patented cuts such as wavy-cut and curved-cut are available, and have the advantage of increased life, faster cutting, and improved finishing without scratching or serrating.

"Wood" means the width of the face of the file. The flat file, for example, would normally be tapered in width along the length of its face,

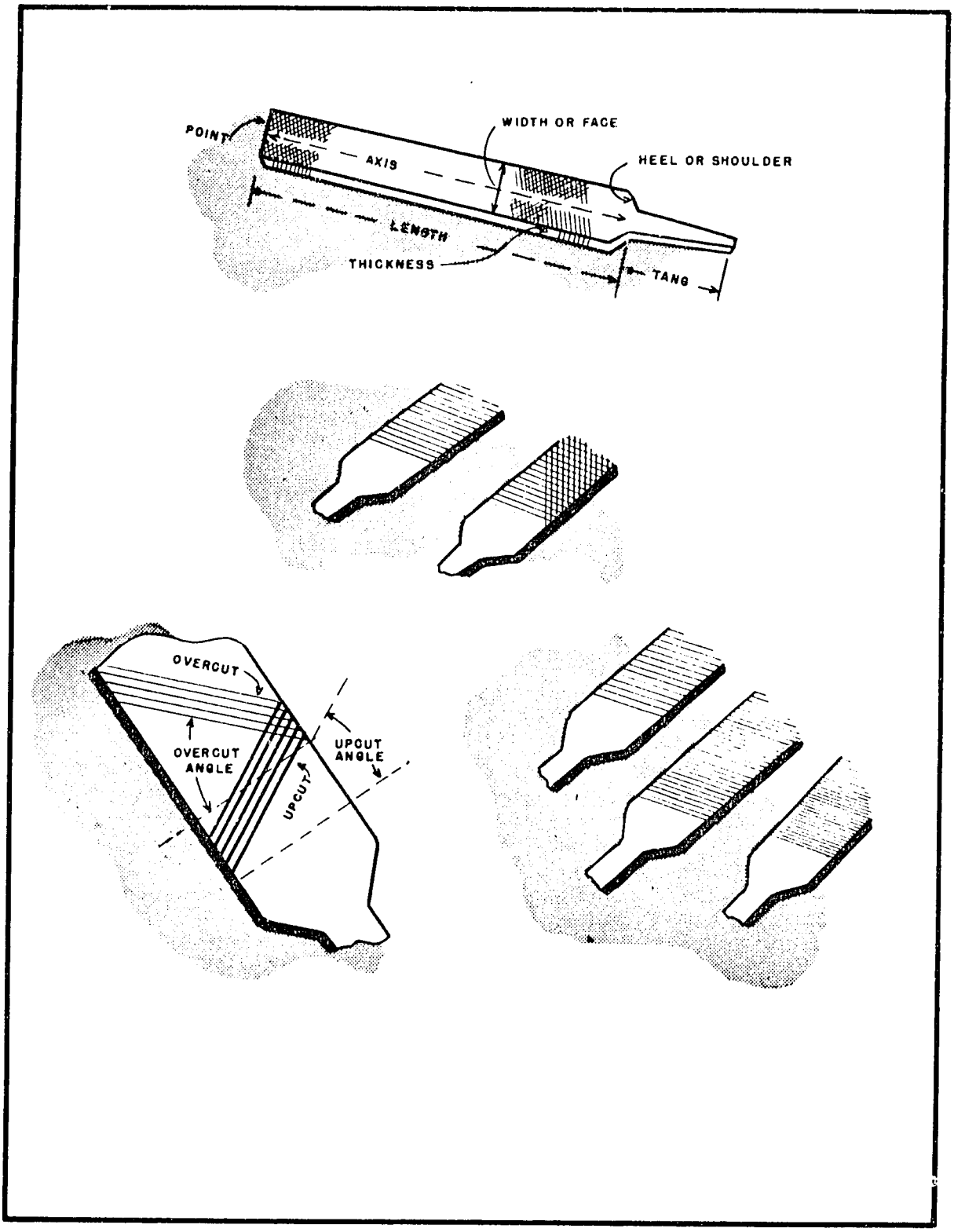

Figure 2 Standard names for the various parts of a file (top); number of cuts (center); types of cuts (lower left); and degrees of coarseness (lower right).

FILE FINDER FOR MACHINIST'S FILES

CROSS SECTION	NAME	SHAPE
	FLAT	RECTANGULAR
	HAND	THICK RECTANGULAR
	PILLAR	ALMOST SQUARE
	WARDING	THIN
	SQUARE	SQUARE

CROSS SECTION	NAME	SHAPE
	THREE-SQUARE	TRIANGULAR
	ROUND	CIRCULAR
	HALF - ROUND	THIRD - CIRCULAR
	KNIFE	KNIFE SHAPED

FILE FINDER FOR SWISS PATTERN FILES

CROSS SECTION	NAME	SHAPE
	HAND	RECTANGULAR
	PILLAR	WIDTH NARROWER THAN HAND FILE
	WARDING	THIN RECTANGULAR
	SQUARE	SQUARE
	THREE - SQUARE	TRIANGULAR (EQUILATERAL)
	ROUND	CIRCULAR
	HALF - ROUND	THIRD - CIRCULAR
	KNIFE	KNIFE SHAPED

CROSS SECTION	NAME	SHAPE
	CROSSING	OVAL, WITH UNEQUAL RADII
	EQUALLING	RECTANGULAR
	BARRETTE	TRAPEZOIDAL
	CROCHET	FLAT, WITH ROUND EDGES
	CANT	TRIANGULAR, (ISOSCELES)
	SLITTING	FLAT DIAMOND
	PIPPIN	APPLE SEED

Figure 3 Identification of files by cross-sectional shapes.

becoming narrower at its "point," which is the end opposite the "tang." Generally, the flat files are of rectangular cross-section, tapering both in width and in thickness. The length of a file is the distance from the "heel," which is the shoulder adjacent to the "tang," and the "point."

The edges are the surfaces perpendicular to the faces. "Cut on both edges" means that parallel rows of teeth are cut into both the edge surfaces.

MANUFACTURING PROCESS

The principal raw material consists of steel bars, which are ordered in various widths and thicknesses, and various cross-sections, such as rectangular, square, triangular, and half round. In the case of the flat machinist's file, the shape is rectangular. Each batch of steel received from the steel mill is analyzed and tested for quality.

The actual making of the file begins with the cutting of a bar of steel to the proper length of the size contemplated. The first operation is called shearing. In shearing, trip hammers, rollers, and punches shape the bar of steel into a "blank." The first stage of the operation shapes the point and body; the second stage, the "tang." Following the shearing operation, the annealing, smoothing, hardening, finishing, and inspection take place. During annealing, the blank is heated to 815° C., and then left in the furnace for 24 hours to cool slowly. Slight distortion resulting from annealing is straightened by hand smithing. Heat treatment occasionally leaves slight surface oxidation of the steel, resulting in the formation of a skin or scale. In the succeeding operation the scale is ground off and the blank is prepared for the cutting machine.

The actual cutting of the file is done on special file machines which use a chisel-like cutter to incise the steel, thereby displacing the metal. The file is then cleaned, covered with a thick charcoal and flour paste (to prevent the adherence of lead), and placed in a lead bath for heat treatment to achieve proper cutting hardness. After heating, the file is quenched in brine, "freezing" the cutting surfaces of the tool. The file is then cleaned to remove paste and sandblasted to clean and sharpen teeth. The tang is softened and tempered, so that the addition of the handle will not fracture the file at this point. In addition to being inspected at virtually every state of its manufacture, the file is inspected when it is finished. This final inspection includes tests for proper sound, and a Brinell hardness test. It is then packaged for final shipment.

Operations are illustrated in figures 4, 5, 6, 7, and 8.

A sketch of a plant layout, not drawn to scale, appears in figure 9. The plant is located adjacent to a railroad siding.

MAN-HOURS PER 100 FILES

The 2 plants in this report which reported on machinist's flat files have been designated as plants A and B. Detailed case studies of these plants

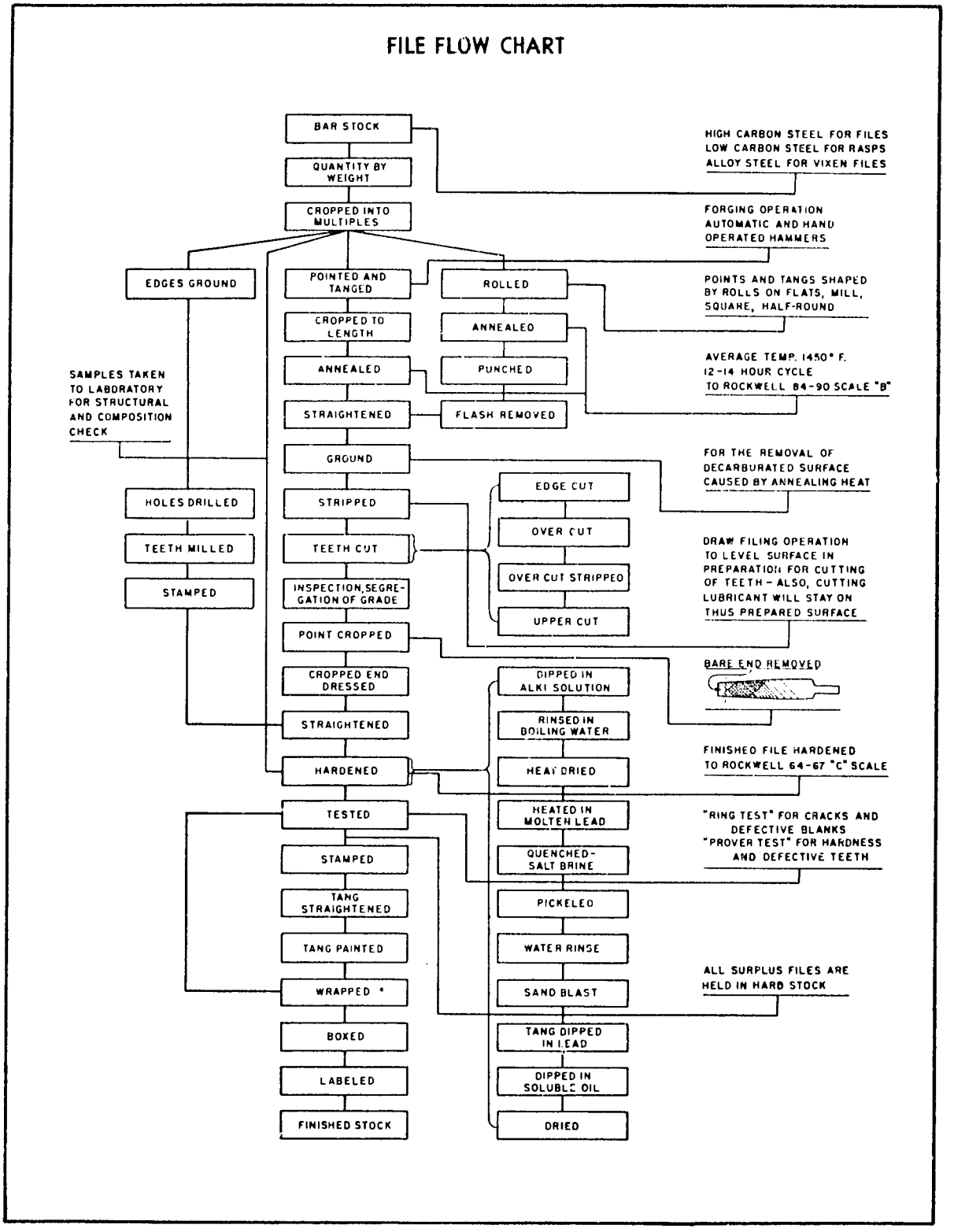

Fig. 4. File flow chart.

Fig. 5. Hardening of a file.

Fig. 6. Forging tang of a file.

Fig. 7. Cutting the teeth on the edge surfaces of a file.

Fig. 8. Inspection of a file.

Table 1. Man-hours required per hundred machinist's flat files, manufacturing costs, and production characteristics in 2 plants, U. S. A., 1951

Item	Unit	Plants	
		A	B
Unit Man-hours:			
Total	Man-hours per 100	4.255	4.807
Direct	Man-hours per 100	1/ 3.245	2/ 3.078
Indirect	Man-hours per 100	1.010	1.729
Manufacturing Costs:			
Total	Percent	100	100
Direct and indirect labor	Percent	39	39
Material	Percent	16	22
Manufacturing overhead	Percent	45	39
Production Characteristics: 3/			
Production of reported file as percent of all files produced	Percent	.84	(4/)
Production of reported file as percent of total production of all products	Percent	.77	1.3

1/ Difference between this figure and corresponding figure in table 2 is less than 1 percent due to rounding.

2/ This figure includes 0.1350 man-hours for the annealing operation and the 0.1175 man-hours for the packing operations. By contrast, these 2 operations are included under indirect total for plant A. After subtracting these 2 figures from above total of direct labor hours for plant B, there remains total direct labor of 2.8255 hours. This differs from corresponding figure for table 3 by amount less than 1 percent due to rounding.

3/ All production percentages are calculated on the basis of the dollar value of shipments during the reported period.

4/ Information not available.

Table 2. Direct man-hours expended at various stages in the production of 100 machinist's flat files, plant A, U. S. A., 1951

Operation	Direct man-hours per 100 units
Total: All operations	3.2582
Shear and flatten tangs	.1380
Punch tang and point	.1635
Annealing	(1/)
Straighten	.0795
Gang cut edges	.3540
Grind flat side	.1800
Inspection	(1/)
Set edges	.2250
Oil flat side	.0653
Overcut flat side	.4500
Strip over cut	.2400
Oil flat side	.0653
Upcut flat side	.5100
Crop points	.0533
Inspection	(1/)
Straighten	.0570
Paste	.0975
Hardening	.2775
Sharpening	.0473
Test	.2550

1/ All man-hours in annealing and inspection operations for plant A are included under indirect man-hours total (table 1).

Table 3. Direct man-hours expended at various stages in the production of 100 machinist's flat files, plant B, U. S. A., 1951

Operation	Direct man-hours per 100 units
Total: All operation	2.8267
Shearing to length	.0317
Forming shape	.4367
Annealing	(1/)
Grinding	.2717
Cutting	1.1650
Hardening	.6300
Finishing	.2917

1/ In this table, the 0.1350 direct man-hours for the annealing operation and 0.1175 direct man-hours for the packing operation are excluded from the total of 2.8267 direct man-hours per 100 files. This is done to make the data for plant B comparable with the data for plant A. Man-hours for inspection are included under the total for indirect labor (table 1).

will be found in chapter II.

In computing the total of 2.8267 direct man-hours per 100 files for plant B (table 3), the 0.1350 man-hours for the annealing operation were excluded because there is no direct labor data for the corresponding operation in plant A. Packing, the final operation, which for plant B requires 0.1175 direct man-hours per 100 units, was not reported for plant A. For plant A, the packing and annealing operations data are included under indirect man-hour data (table 1). The term "indirect labor," as used in table 1, includes specifically for plant A, the following: move men, janitors, watchmen, guards, shipping, receiving, and supervisory personnel. For plant B, indirect labor includes specifically: supervisory and clerical personnel, inspectors, janitors, trucking and material handling, setup, maintenance, and shipping personnel. In both plants, the indirect labor data exclude sales and administrative personnel.

The sources of direct man-hours for plant A are standard man-hour figures, adjusted for variance. Indirect man-hours per file were estimated by applying the ratio of indirect labor to direct labor throughout the plant to the standard direct man-hour figure.

INCENTIVE SYSTEMS

In both plants A and B extensive use is made of incentive systems for payment for manufacturing operations. All the operations in plant A are on an incentive pay basis except annealing, oil flat sides, crop points, and straighten. In plant B, all operations are entirely on an incentive basis, except annealing, hardening, and finishing on which some workers are paid on incentive, others on time rate systems. In neither plant is inspection paid on an incentive basis. In plant A, each incentive operation has been time-studied, and a rate per 100 units has been established. In plant B, the piecework pay system is based on individual piece rates per 12,000 blanks.

MANUFACTURING COSTS

For every dollar spent by plant A to manufacture machinist's flat files in 1951, 39 cents went to the wages of direct and indirect labor, 16 cents went to direct materials, which includes all material used in producing the flat files, and 45 cents went to all other manufacturing costs. Plant B required an identical relative expenditure for labor during the last quarter of 1951, but direct materials costs were relatively higher (table 1).

The indirect and direct labor costs shown above include wages paid production and related workers, but exclude administrative, sales, and office personnel. The occupations included as direct and indirect labor for the foregoing costs computations are identical with those used in calculating output per man-hour figures in table 2, and are listed in the paragraph under "Man-hours per 100 Files" (page 6).

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SECTION A - MACHINIST'S FLAT FILE

CHAPTER II: DETAILED REPORT

CASE STUDY - PLANT A

Buildings

The firm has 2 contiguous plant buildings, 1 of which is used for the production of files. The plant buildings are made of brick, partly 1-story, partly 2-story, with the total floor area of the 2 plants averaging 190 square feet per employee.

Kinds of Products Made

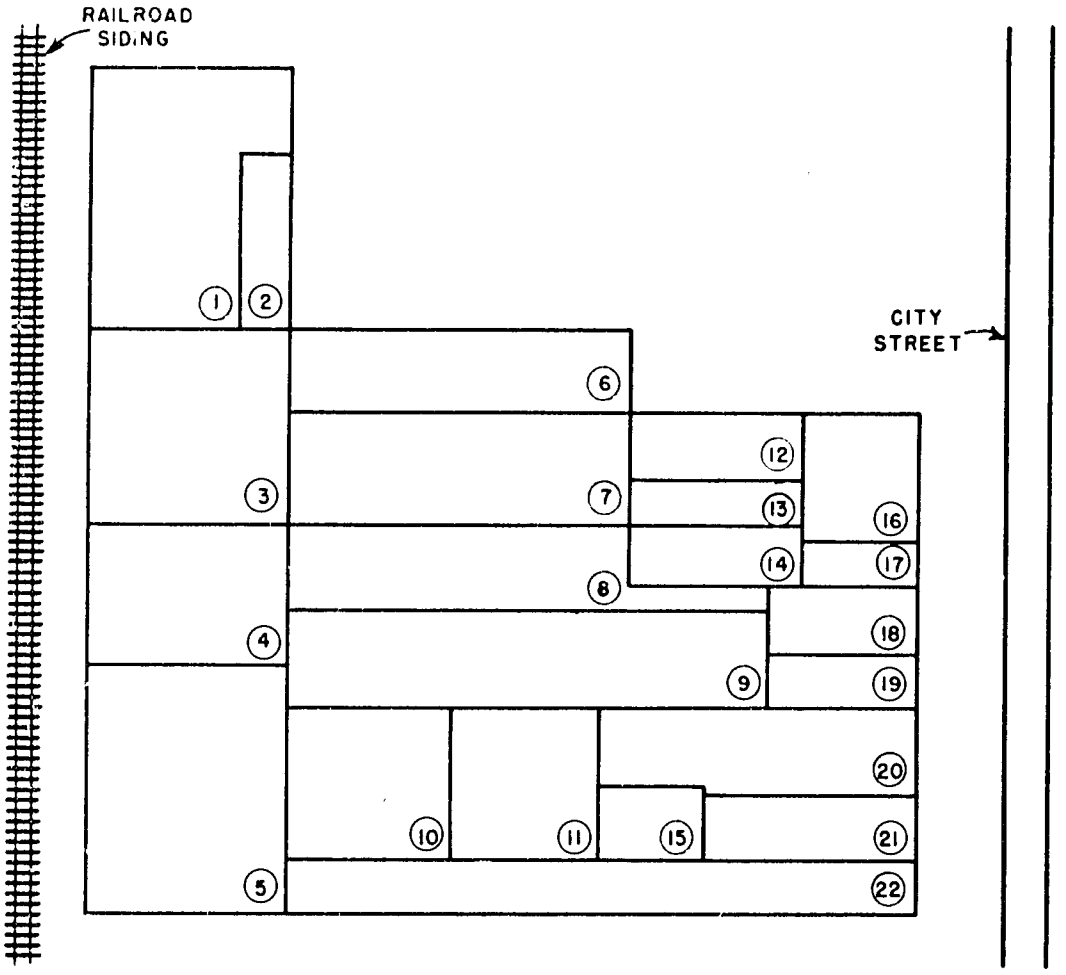
The production of 14,000 dozen files accounts for 91 percent of the total output of this plant, measured in terms of the dollar value of shipments during the reporting period (January 1 to December 31, 1951). Of the total dollar value of the shipments, 0.8 percent consisted of the flat 10-inch bastard file described in this study. Nine percent of the firm's production was in other miscellaneous machinist's hand tools.

Raw Materials Purchased

The basic raw material consists of flat steel bar stock 1 inch in width and 0.250-inch thick. The bar is obtained either in a 13 foot 1-5/8-inch length or in a multiple of a 12 foot 1/8-inch length. The approximate composition of the steel bar is: 1.1 percent carbon, 30 percent magnesium, .04 percent phosphorous, .05 percent sulphur, and .1 percent silicon. Fifty-ton lots are usually received at one time.

Production Planning and Control

The problem of determining the most economical lot sizes to be produced arises characteristically in those plants producing a variety of types and sizes of products, no one of which has sufficient demand to warrant continuous production throughout the year. Enough pieces must be run in each lot to offset the cost of planning, ordering, tooling, moving, and making ready the machines; but not so many as to incur avoidable carrying charges on a large inventory of finished parts. There is obviously a point at which these two influences on cost will balance each other. This point is



This is a sketch of the plant, and is not drawn to any scale. Departments are given their approximate shape and location. This sketch can only be used to see how material flows through the plant.

DEPARTMENT KEY:

1. Steel Storage
2. Carpenter Shop
3. Grinding Department
4. Round and Half-round Cutting Department
5. Shipping Department
6. Forge Department
7. Punch Press and Annealing Department
8. Stripping Department
9. Cutting Department
10. Hardening and Sharpening Department
11. Swiss File Department
12. Rasp Department
13. Electrician and Maintenance Department
14. Milling Department
15. Stock Room
16. Machine Shop
17. First Aid Room
18. Saw File Cutting
19. Hess Cutting
20. Vixen Milling
21. Production Office
22. Main Office

Fig. 9. File plant layout (not drawn to scale).

known as the economic lot size. The economic lot size in the plant is 2,400 units. The smallest production, or lot size, is 60 units.

The first step in the production scheduling program is to establish minimum and maximum reorder points for each item. The reorder point is reached when the inventory of raw materials or the inventory of the product to be produced drops to certain prescribed levels, below which there may be insufficient inventory to meet orders from outside the plant for the product, or from within the plant for raw materials. At this point, parts or raw materials must be ordered to meet minimum inventory needs or new products must be manufactured to fill anticipated demand. These reorder points are determined by past sales experience. Consideration is also given to the approximate time factor necessary to produce an economic lot size. Production orders are issued on the basis of these reorder points or of unfilled orders on hand. Orders are scheduled through the plant on a machine-loading basis. A followup procedure is carried on to make for full utilization of factors such as machine time and labor force. This firm tries to maintain a maximum 120-day inventory on all raw materials; it places orders when this reorder point is reached.

When the finished stock or product reaches its reorder point, an order card (fig. 10), is filled out by hand by the inventory clerk. The reorder point is decided by the same inventory clerk upon reading still another card that he keeps--the perpetual inventory record card (fig.11). After the reorder card is filled out, it is sent to the route sheet clerk who prepares a routing of operations from a master schedule and mimeographs this on the production order routing card, (fig. 12). This card is sent to the tabulating section, where time cards and move tickets are pulled and punched for each operation.

The plant is set up with three "control centers," which are divided into the following groups: first--forging, annealing, punch press, and grinding; second--cutting; and third--hardening, sharpening, and packing. These centers maintain a steady flow of production, serve as timekeepers, schedule production dates, and record the completion dates. This group actually schedules the dates on which production is to begin and to end. Then the control centers post the actual production to the routing sheet from time tickets.

After the production level called for on the routing sheet is reached, the sheets are sent to the cost department, where the cost is computed. For each item that goes through the plant, a record is maintained on the completion record card (fig. 13), and the following information is given on this form: the release date (the date on which the order is sent to the factory), order number, quantity, and the promised and actual completion date of the order in each group. This firm tries to maintain a stock of all products and only manufactures to customers' orders under special conditions or when no stock is available.

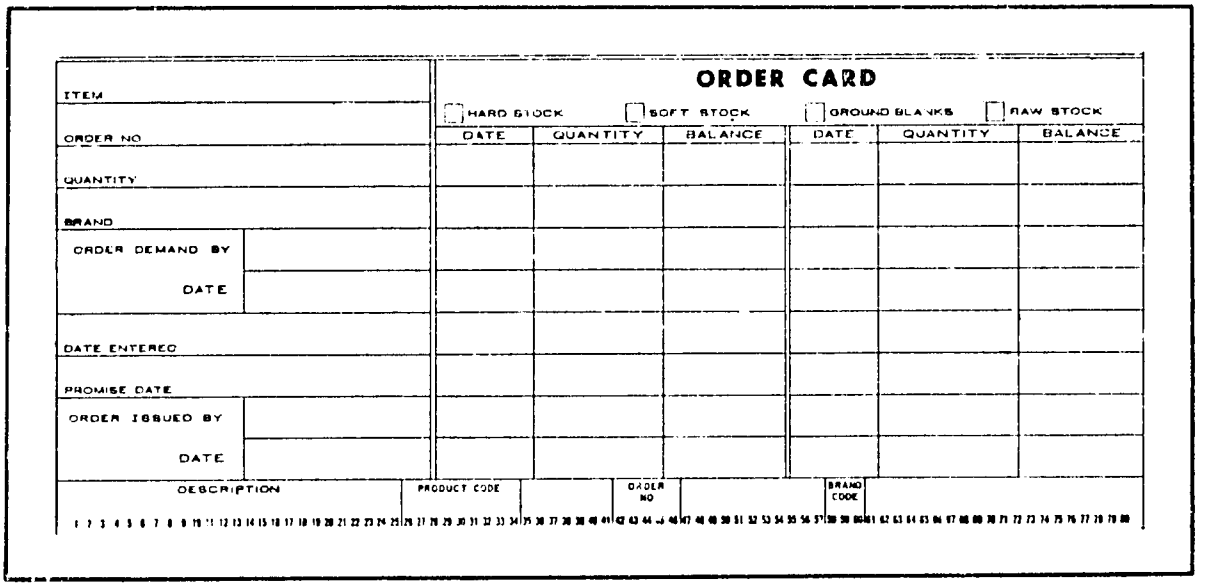


Fig. 10. Order card.

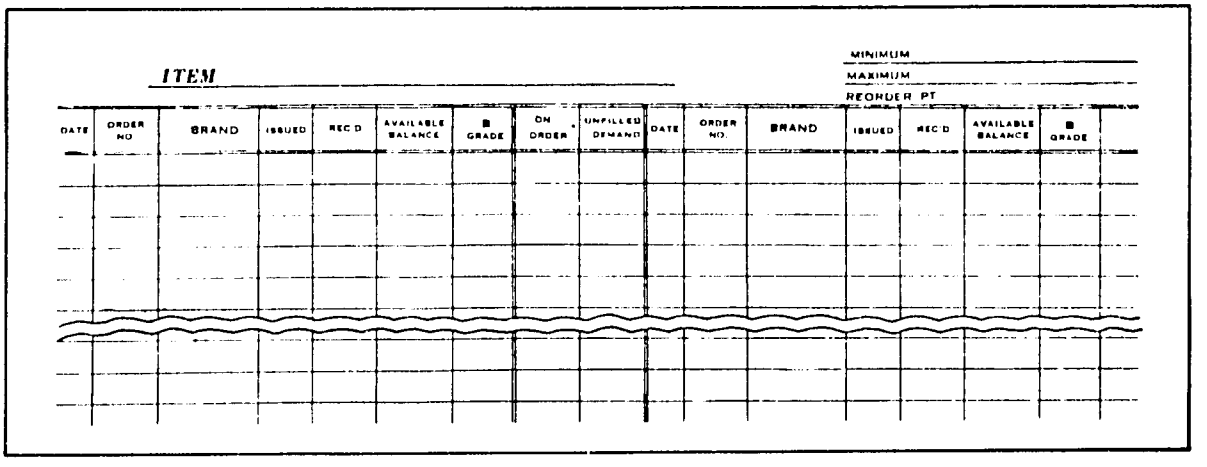
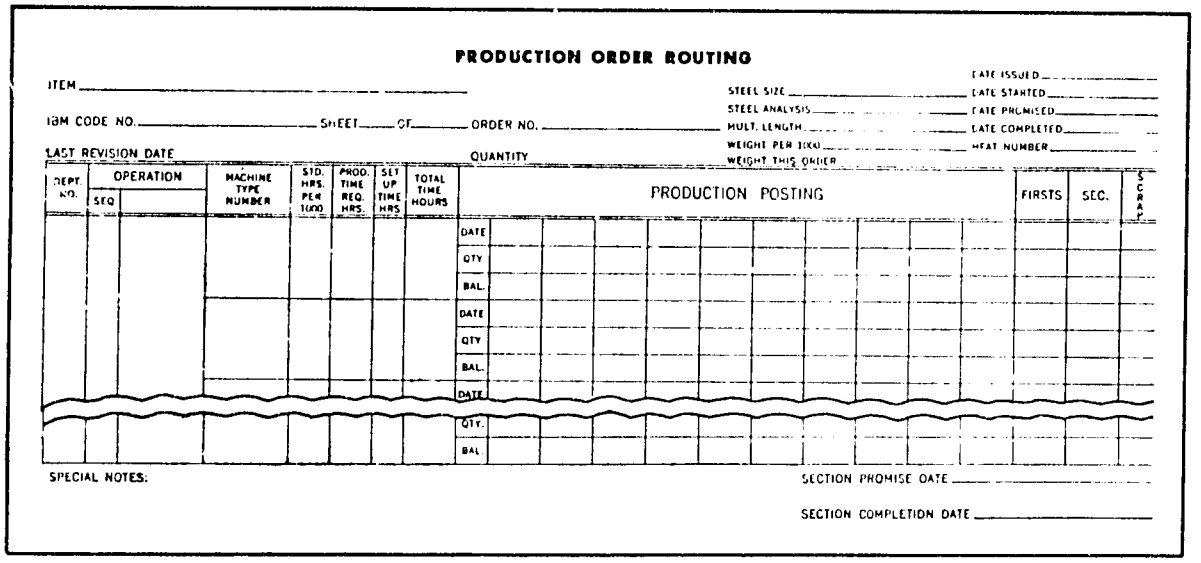


Fig. 11. Inventory record card.



PRODUCTION ORDER ROUTING

ITEM _____

IBM CODE NO. _____ SHEET ____ OF ____ ORDER NO. _____

LAST REVISION DATE _____ QUANTITY _____

STEEL SIZE _____ DATE ISSUED _____

STEEL ANALYSIS _____ DATE STARTED _____

MULT. LENGTH _____ DATE PROMISED _____

WEIGHT PER 1000 _____ DATE COMPLETED _____

WEIGHT THIS ORDER _____ HEAT NUMBER _____

DEPT. NO.	OPERATION SEQ		MACHINE TYPE NUMBER	STD. HRS. PER 1000	PROD. TIME REQ. HRS.	SET UP TIME HRS	TOTAL TIME HOURS	PRODUCTION POSTING	FIRSTS	SEC.	SCRAP
								DATE / QTY / BAL.			

SPECIAL NOTES:

SECTION PROMISE DATE _____

SECTION COMPLETION DATE _____

Fig. 12. Production order routing card.

ITEM _____

RELEASED	ORDER NO.	QUANTITY	1ST CONTROL		2ND CONTROL		3RD CONTROL	
			P	C	P	C	P	C
			P	C	P	C	P	C
			P	C	P	C	P	C
			P	C	P	C	P	C
			P	C	P	C	P	C
			P	C	P	C	P	C
			P	C	P	C	P	C
			P	C	P	C	P	C
			P	C	P	C	P	C
			P	C	P	C	P	C

Fig. 13. Completion record card.

Materials Movement

In this plant, the files are moved from one operation to another by 4-wheel, hand push-carts which usually transport 6,000 file blanks at one time, or manually operated fork lift trucks which can carry 5 racks of the type used in the annealing operation, each rack holding 560 of the 10-inch file blanks. These 2 types of equipment are operated by "move men" and "fork lift operators," respectively.

Pronged hand hooks are used by pasters and dippers to move the files from the paste to the hardening and then to the sharpening operations. Two hooks are used at a time, each carrying 15 files.

Inspection

After each operation, every file is given a visual inspection by the operator. The Brinell hardness is spot checked after the annealing and hardening operations. All sides of the file are tested for cutting ability by use of a "prover." A prover is a piece of metal of such hardness that it can be cut by a properly manufactured file. The file is then visually checked for straightness and shape of teeth. This is the final inspection.

Five percent of the total files produced are rejected as unsuitable for sale. The major reasons for rejection are poor cutting, poor grinding, improper hardening, and warping. One percent of the "rejects" are reworked until they meet quality standards; the rest are broken and sold as scrap metal. This firm does not sell any of its files as "seconds."

Employment

In this plant, the total employment exceeds 250 persons. Eighty-six percent of the total number of employees in this plant are engaged in production or jobs related to production.

CASE STUDY, PLANT B

Buildings

The main factory structure consists of several interconnected 1- and 2-story brick buildings, situated within a square land area, which house the manufacturing and service departments. A 1-story, modern brick powerhouse is in the rear of the main factory buildings.

Sales and administrative offices are housed in adjoining 2- and 3-story brick buildings, which are erected across one end of the area occupied by the factory buildings, and are connected to them.

The production area measures 212,500 square feet.

Kinds of Products Made

The major products produced in this plant are files and rasps. The product under study, a machinist's flat bastard 10-inch file, accounts for 1.3 percent of the total production of this plant, in terms of the dollar value of shipments during the reporting period.

Raw Materials Purchased

Plant B purchases bars of hot rolled carbon file steel. The bars are 8 feet in length and have a rectangular section 1.000-inch wide and 0.250-inch thick. Shipments usually received at one time ranged in weight from 50,000 to 80,000 pounds.

Production Planning and Control

Production planning in this plant is based on a predetermined normal stock for each item. A perpetual inventory record of finished files and blanks allows scheduling of a continuous flow of goods by means of regular monthly orders to the factory at the "control points." The control points are the points at which forging and the cutting operations are reached.

Materials Movement

The files are moved from one operation to another by means of equipment similar to that used in plant A, namely, the fork lift truck and the hand truck, both of which are operated by "truckers." By means of an automatic power conveyor, the files are transported from the cutting to the hardening, and then to the finishing operation in a continuous manner.

Inspection

Inspection is continuous during almost every step of manufacture, in that operators and supervisors watch for deviations from quality standards. Uniform quality standards are assured by a group of roving inspectors, headed by a quality control foreman. A complete inspection, just after the cutting operation and as a final step before packing, is included in the normal sequence of operations for all files.

Of the total file production 4.5 percent are rejects. The chief reason for rejection is improper tooth formation in the cutting operation, which results in various imperfections called chops, one sidedness, poor overcut, and lightness. Rejects are transferred for use within the plant or sold for scrap.

Employment

In this plant, employment totals more than 250 persons. Seventy-six percent of the total number of employees in this plant are engaged in production or jobs related to production.

Reported Period

The reported period in this plant extended from October 1, 1951, through December 31, 1951, and the output amounted to 13,000 dozen files.

Table 4. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant A, U. S. A., 1951

Operation	Job title and description	Number of men required	Machinery and equipment	Number of machine units	Standard man-hours per 100 units
Shear and flatten tang: Long flat bars of stock are cut to the required length (12-1/8 inches) and these are taken through a furnace by a wire screen conveyor. (This heats the file blank to a workable state.) After heating, blank is run through rollers which flatten the tang.	Shear operator	4	Shears, 4-inch blade made in plant, foot control which starts and stops operation, runs on cycle.	4	0.1380
			Furnace, gas-fired, 3 feet long.	4	
			Conveyor belt. Files are mounted on a wire screen which is placed on a conveyor belt that carries file blanks through the furnace.	4	
Shear and flatten tang: Long flat bars of stock are cut to the required length (12-1/8 inches) and these are taken through a	Tang flattener	4	Rollers, firm's design, automatic, continuous running.	4	

1/ Information not available.

Table 4. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant A, U. S. A., 1951--Continued

Operation	Job title and description	Number of men required	Machinery and equipment	Number of machine units	Standard man-hours per 100 units
Shear and flatten tang:--Continued furnace by a wire screen conveyor. (This heats the file blank to a workable state.) After heating, blank is run through rollers which flatten the tang.					
Annealing: Blanks go through annealing furnace on annealing racks.	Loader, places racks of file blanks on conveyor and feeds into furnace. Unloader, removes racks from conveyor after annealing.	2 per shift 2 per shift	Specially designed furnace which raises file blanks to required temperature and also has controlled cooling, 80 feet long and 10 feet wide. Has continuous conveyor to carry racks through furnace.	2	(1/)
Punch tang and point: Flattened file blank is placed in die in	Punch press operator, tang.	8 man	40-to 60-ton presses which have been designed to	13	0.1635

1/ Information not available.

Table 4. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant A, U. S. A., 1951--Continued

Operation	Job title and description	Number of men required	Machinery and equipment	Number of machine units	Standard man-hours per 100 units
Punch tang and point:--Continued					
punch press, and tang is punched out; then placed on turntable and rotated to another punch press where the point is cut square; then placed in rack for transportation to next operation.	Punch press operator, point.	5 women	meet company specifications. Press has adjustable stroke of 8 inches to 10 inches.		
Straighten: File blanks are fed by hand through a series of rollers to straighten them. (Warping is caused by annealing and punch press operations.)	Straighten roller feeder.	4	Small roller of own design, has a series of 12 to 15 rollers (3 inches diameter) per machine.	4	0.0795
Gang cut edges	(1/)	(1/)	(1/)	(1/)	.3540
Grind flat sides . . .	(1/)	(1/)	(1/)	(1/)	.1800

1/ Information not available.

Table 4. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant A, U. S. A., 1951--Continued

Operation	Job title and description	Number of men required	Machinery and equipment	Number of machine unit	Standard man-hours per 100 units
Inspection: File blanks are checked for size (width and thickness) with micrometers. This is a spot check but all files are given visual inspection for shape (taper).	Inspector	4	None	--	--
Set edges: A man passes the edges of the file blank over an emery wheel so that when the file is cut there will not be a "build-up" on the edge of the file; this operation removes the sharp edge of the file blank.	Grinder	4	Stand type emery wheel grinder.	4	0.2250
Oil flat side: A film of oil is applied to the blank to aid in cutting. Blanks are fed by hand through 2 rollers coated with oil.	Oilers	2	Specially designed rollers which apply oil to blanks.	2	.0653

Table 4. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant A, U. S. A., 1951--Continued

Operation	Job title and description	Number of men required	Machinery and equipment	Number of machine units	Standard man-hours per 100 units
Overcut flat sides . . (First cut of teeth)	(1/)	(1/)	(1/)	(1/)	0.4500
Strip overcut: After files have received their first cut, they are placed in a machine which oscillates a file over them and knocks off the sharp edge of the tooth and also roughs the file. This operation is followed by an oiling operation.	Stripper machine operator	8	Specially-built machine which has 12 arms (6 per side). Files are held below the arms which oscillate a file over the file being processed.	8	.2400
Oil flat side: (Supra)	Supra	--	Supra	Supra	.0653
Upcut flat side.. . . . . (finish cut)	(1/)	(1/)	(1/)	(1/)	.5100
Crop points: The end of the file (point) is cut off square to improve the looks of the file.	Point cropper	3	Cropper, large shears which are operated by foot controls.	3	.0533

1/ Information not available.

Table 4. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant A, U. S. A., 1951--Continued

Operation	Job title and description	Number of men required	Machinery and equipment	Number of machine units	Standard man-hours per 100 units
Inspection: Each file is given a visual inspection to see if the tooth structure is correct, and spot checked with micrometer for proper thickness.	Inspector	4	None	--	(1/)
Straighten: Operator uses a small lead hammer to tap the files to make them straight. This has to be done before hardening.	Hand Straightener	5	Small lead hammer and flat iron block.	--	0.0570
Paste: File is covered with a paste which is used in heat treating so the lead won't fill the file cut. Files are placed in racks which have holes for the tangs and lowered into	Pasters	4	Paste vats. Drying furnaces, gas-fired. Overhead chain hoist, hand operated on rail.	4 4 4	.0975

1/ Information not available.

Table 4. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant A, U. S. A., 1951--Continued

Operation	Job title and description	Number of men required	Machinery and equipment	Number of machine units	Standard man-hours per 100 units
Paste--Continued a paste solution by hand crane. Then they are placed in a drying oven for about an hour.					
Hardening: Files are placed in lead baths in a vertical position with tangs above the molten lead (tangs are not submerged in the lead). After heating to proper temperature, they are quick-quenched in salt brine. Files are handled with tongs.	Heat treater	12	Large lead baths, gas-fired, thermostatically controlled.	12	0.2775
Sharpening: Files are dipped in acid to remove paste and then through a sharpening machine (combination of steam and sand under pressure), which cleans and sharpens file.	Sharpeners Dippers, men who move files in department and dip them in acid.	10 5	Steam and sand blast machine.	10	.0473

Table 4. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant A, U. S. A., 1951--Continued

Operation	Job title and description	Number of men required	Machinery and equipment	Number of machine units	Standard man-hours per 100 units
Sharpening--Continued					
Files are then dipped in oil to prevent rust.					
Test: Files are tested with a piece of steel of proper hardness (the files should cut this metal), and checked to see if they are straight. Testers can tell much about the file by the way it cuts the prover. All sides are checked.	Tester	6 women	None	--	0.2550
Total man-hours (all operations)					3.2582

Table 5. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant B, U. S. A., 1951

Operation	Job title and description	Number of men required	Machinery and equipment	Standard man-hours per 100 units
Shearing to length: Steel bars fed into power shear by operator and cut into proper lengths.	Shear operator	1	Variable power shear	0.0317
Forming shape: Sheared blank is processed through forging rolls and punches to form point, body, and tang.	Roll forge operator Press operator Hopper tender.	1 1 1	Forging rolls Punch press	.4367
Annealing: File blank is clipped to length and put into a furnace to be annealed, then removed for inspection and test.	Chief furnace man Furnace man and trucker. Clipper and tray packer. Tray unpacker Anneal inspector and pyro checker.	1 1 1 1 1	Oil-fired annealing Alligator shear	.1350
Grinding: The formed blank is ground after annealing to remove the scale and prepare the surface for cutting.	Grinding machine operator.	1	Edge grinding machine Side grinding machine	.2717
Cutting: A file cutting machine	Edge cutting machine operator.	1	Edge cutting machine	1.1650

Table 5. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant B, U. S. A., 1951--Continued

Operation	Job title and description	Number of men required	Machinery and equipment	Standard man-hours per 100 units
Cutting--Continued operating a sharp chisel, raises a series of teeth on the file blank. Finished cut blanks are then clipped and buffed on the points.	Side cutting machine operator.	1	Side cutting machine	
	Emery wheel operator	1	Emery wheel	
	Clipping machine operator.	1	Alligator shear Vertical belt grinder	
Hardening: The blank is branded, given a special coating to prevent oxidation of the tooth points during hardening, then hardened and straightened.	Stamper	1	Stamping press	0.6300
	Crater and decrater	1	Pasting machine	
	Paste elevator operator.	1	Hardening furnace	
	Hardener	1		
	File carrier	1		
Finishing: The file is cleaned, then sharpened by sandblasting and the tang is blued. It is then oiled to prevent rust and given a final close inspection.	File carrier	1	Automatic finishing machine	.2917
	Setup man and ringer	1		
	Straightness inspector.	1		
	Loader	1		
	Spacer	1		
	Bluer	1		
	File inspector	1		
	Tester	1		

Table 5. Operations, equipment, and standard man-hours in the manufacture of machinist's flat files, plant B, U. S. A., 1951--Continued

Operation	Job title and description	Number of men required	Machinery and equipment	Standard man-hours per 100 units
Packing: Finished files are wrapped in protective paper, boxed and sealed.	Wrapper and boxer Sealer, light work	1 woman 1 woman	Wrapping bench Sealing tape dispenser	0.1170
Total man-hours (All operations, exclusive of packing and annealing)				2.8267

Case Study Data on
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HAND TOOLS
(Machinist's Flat File,
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CHAPTER I: GENERAL REPORT

HIGHLIGHTS

The most important features of productivity in the manufacture of monkey wrenches in the plants surveyed are the subdivision of production steps into a series of small repetitive tasks, and incentive wage payments to employees. One plant included in this report produces 100 wrenches in less than 7 man-hours total labor by minimizing machining and grinding in finishing operations.

During 1947, the year of the most recent United States Census of Manufactures, 91 million wrenches of all types were produced in the United States. 4/ Monkey wrench production represented only a small percentage of this total output which also included open end wrenches, pipe wrenches, socket wrenches, adjustable wrenches, and special purpose wrenches.

Companies which manufacture monkey wrenches generally produce a wide variety of mechanics' hand tools. In the average plant, total annual monkey wrench manufacture usually requires 20 or fewer workers for a production period of less than a month.

In recent years the monkey wrench producer has been experiencing declining domestic markets. Other wrenches, particularly the crescent or adjustable wrench, have been replacing the monkey wrench among users.

PRODUCT DESCRIPTION

The product reported is a 9-inch steel monkey wrench. The actual wrench for which data are presented was variously referred to by manufacturers as auto wrench, adjustable wrench, and monkey wrench.

The specifications are: length 9 inches; jaw opening 2-5/8 inches; jaw thickness 3/8 inches; jaw depth 1-1/4 inches. Data are shown in this report for 3 monkey wrenches manufactured by 3 different companies. The wrenches

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4/ Census of Manufactures, 1947 - Bureau of Census, U. S. Department of Commerce, Washington, D. C.

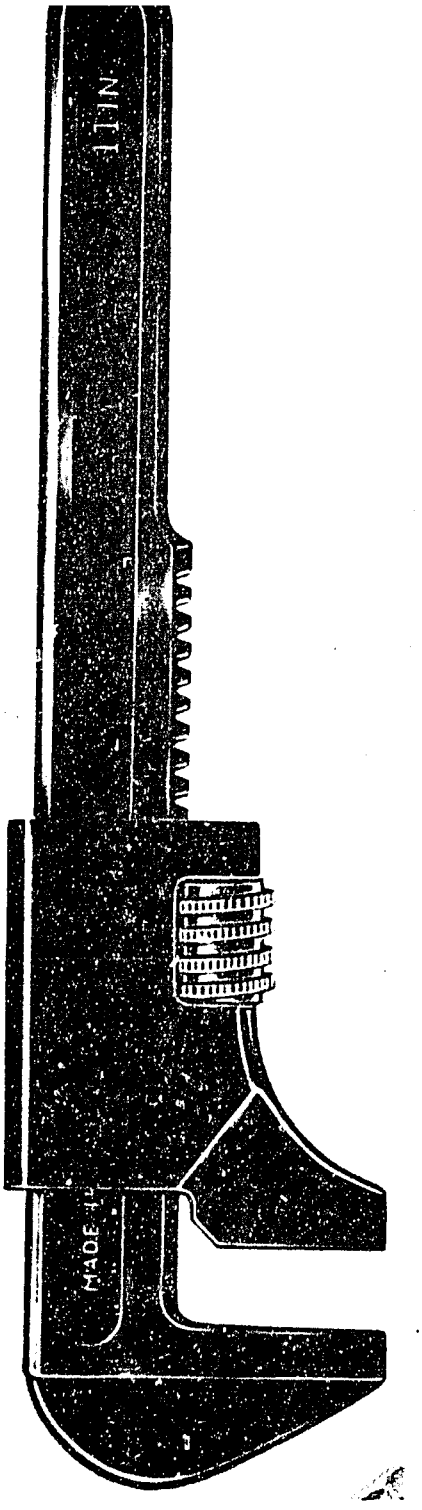

Fig. 14. Nine-inch steel monkey wrench.

reported by plants C and E generally follow the design and specifications of the wrench illustrated in fig. 14. The wrench reported by plant D, however, is not comparable to either of the other wrenches.

The manufacture of monkey wrenches involves the fabrication of the two basic parts, the bar (handle) and the jaw, and the assembly of these two parts with a knurl and screw (these two parts are frequently purchased). The knurl which is held against the teeth on the bar holds the wrench together and enables the user to adjust the jaw to the desired opening. The bar and the jaw of the monkey wrench are either forged or cast. In this report, only plant E reports on a completely forged wrench. Plant C forges the bar but purchases a rough casting for the jaw. Plant D, on the other hand, forges the jaw and purchases a casting for the bar. These differences in product integration lead to difference in manufacturing operations and labor required per monkey wrench (table 8).

MANUFACTURING PROCESS

The manufacture of monkey wrenches represent a relatively small part of the manufacturing operations of each plant in the report. In each plant the monkey wrench is only one of a variety of products manufactured. In plants C and E total production of monkey wrenches is less than 1 percent of total plant production.

In each plant the principal problem is to schedule the production of a wide variety of products so that plant machinery and equipment are used throughout the year. The variety of products or parts produced by plant E in a given year numbers in the hundreds. Plant layout and production machinery must be sufficiently flexible to produce such a large variety of tools and to shift frequently to the production of special orders.

In plants C and E, forging is the most important phase of the overall manufacturing picture. In each plant, forgings are produced in production lots of maximum efficient size. Generally, production lots in the forging department are much larger than production lots in other departments. Frequently, rough forgings are stored until needed or until plant machinery and equipment are available for machining and finishing.

From the forging department or from storage, as the case may be, the parts of the wrench proceed through machining and finishing operations. The machining and finishing steps are subdivided into many small tasks. Each worker in the production sequence performs a small part of the total operation. Frequently the same worker will perform several steps in the production process. (Plant C reported that only 15 workers contributed to the production of its monkey wrench.) In plant D the same operator can mill the backs, flats, and teeth of 2,500 bars (the average production lot in the machine shop) on the same machine in less than a 40-hour week. It is necessary only to set up the machine to effect transfer to the next step in the production process.

Table 6. Man-hours required per 100 monkey wrenches, manufacturing costs, and production characteristics by selected plants, U. S. A., 1950-51

Item	Units	Plants 1/		
		C	D	E
Unit man-hours:				
Total	Man-hours per 100	6.645	27.842	33.030
Direct	Man-hours per 100	2.999	11.975	15.890
Indirect	Man-hours per 100	3.646	15.867	17.140
Manufacturing cost: 1/				
Total	Percent	100.0	100.0	100.0
Labor (direct and indirect).	Percent	46.0	16.0	53.0
Material	Percent	6.0	46.0	16.0
Overhead	Percent	48.0	38.0	31.0
Production characteristics:				
Annual production of all wrenches.	One wrench	More than 100,000	More than 100,000	More than 100,000
Annual production of monkey wrench to all wrenches.	Percent	5	15	4
Annual production of all wrenches to total production.	Percent	4	17	3-1/2

1/ Actual cost of the monkey wrench was less than standard cost in each plant: 3 percent less than standard in plant C; 2 percent less than standard in plant D; and 1 percent less than standard in plant E.

Table 7. Direct man-hours by operations in the manufacture of 100 steel monkey wrenches, by selected plants, U. S. A., 1950-51

Operation	Standard direct man-hours per 100 wrenches		
	Plant C	Plant D	Plant E
Forging	0.765 Forged bar only	1.202 Forged jaw only	1.670 Forged bar and jaw
Machining	.954 Little machining	4.000	10.320 (Extensive machining which is not done in plant C or D.)
Heat treating	.121 Bar only hardened	2.572 Bar and jaw hardened. Alloy steel must be annealed.	1.040 Bar and jaw hardened alloy steel must be annealed.
Tumblasting	.174	.480	.300
Inspection	Inspection done by indirect labor.	.809 Includes packing and inspection of purchased casting and final inspection.	.310 Includes packing.
Finishing	.308 (Parkco Lubrite finishing process.)	.954 Gray paint finish	.900 Black lacquer finish and hardened cyanide bath.
Handwork	.300 Hand straightening.	1.106 Hand straightening and filing.	None.
Assembly	.378	.852	1.040

The finished wrench is generally assembled and inspected by a bench-worker who uses a powered ratchet screw driver to turn screws during assembly.

Materials are generally moved within departments in metal tote boxes on platform trucks. Interdepartmental movement is generally done by electric- or gasoline-powered trucks.

MAN-HOURS PER MONKEY WRENCH

Direct man-hours given in this chapter are unadjusted standard man-hours based on time studies made by company or consulting engineers. At any given time actual man-hours may vary from these standards. In a footnote to table 6 a variance factor is given for each man-hour figure. Although this variance factor is based on the ratio of actual costs to standard costs, company management generally felt that this cost variance would most effectively reflect variance in man-hours.

Indirect man-hours in this report are estimated from standard direct hours. The ratio of plant-wide indirect labor to direct labor is applied to the standard direct man-hour figure. This estimate assumes the same ratio of indirect to direct labor throughout the plant for all products. This, of course, is not true in all plants in this study. In each plant making monkey wrenches in this study, indirect labor accounts were included in the overhead accounts which were generally charged as 150 percent of direct labor charges. It was never possible to extract the indirect labor which contributed specifically to the production of monkey wrenches.

Differences in direct labor per monkey wrench for the three plants in this report do not necessarily reflect differences in productivity or efficiency. Although plants C and E report on wrenches which are comparable in design, direct comparison of man-hours is not intended because of differences in manufacturing operations. Plant E manufactures a completely forged wrench and performs a number of machining and finishing operations not performed by either plant C or plant D. The design and manufacturing process for plant D's wrench are not comparable to those for either of the other two plants' wrenches.

Table 8. Direct man-hours in the manufacture of steel monkey wrenches, by 100 parts, by selected plants, U. S. A., 1950-51

Part	Standard direct man-hours per 100 parts		
	Plant C	Plant D	Plant E
Jaw	0.82	6.08	8.09
Bar (handle)	1.78	2.66	4.89
Other parts including knurl	.02	1.03	.34
Assembling, finishing, and packing	1/ .38	2.21	2.58

1/ For plant C, packing and finishing hours are not included in this figure. Packing is performed by indirect labor and finishing hours are included in figure for the individual parts.

Table 7 shows total direct man-hours for classes of operations. The comments within this table for the operations in each plant indicate relative comparability.

Indirect labor per unit, which is computed by applying the plant-wide ratio of indirect labor to direct labor to the standard direct man-hour figure, does not necessarily reflect the amount of indirect labor required to produce the 9-inch monkey wrench. Indirect labor per wrench for each plant in this survey was obtained from the plant-wide ratio of indirect to direct labor. In plants C and E where monkey wrench production is a small percentage of total output, this method of estimating may overstate the actual amount of indirect labor required per monkey wrench.

Some differences in direct and indirect unit man-hours are due also to the classification of accounts by the individual firm. For example, plant C charges packing and inspection to indirect labor accounts whereas plant D and E charge these functions to direct labor.

INCENTIVE SYSTEM

Each manufacturer of monkey wrenches noted herein pays most of his direct labor on an incentive system. Production standards are established for each operation; production in excess of these standards is paid to the workers. Group operations such as heat-treating and annealing are usually not included under these plans.

MANUFACTURING COSTS

A large proportion of the total manufacturing cost of monkey wrenches for plants C and E was attributable to direct and indirect labor (table 6). However, plant D exhibited a different pattern, in which the preponderance of the costs were absorbed in the price of materials, rather than in labor. This difference is due to the fact that plant D purchased a relatively large number of parts from subcontractors.

Case Study Data on
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HAND TOOLS
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SECTION B - MONKEY WRENCH

CHAPTER II: DETAILED REPORT

CASE STUDY PLANT C

Buildings

The plant buildings of this firm consist of 4 interconnected structures. The forge shop and stockroom are 1-story buildings. The maintenance building has 2 floors. The main building has 3 floors. The machine shop is on the first floor, the main assembly area is on the second floor, and the third floor is used for storage and light assembly.

Kinds of Products Made

This plant manufactures a wide line of mechanics' hand tools for distribution under its own name and produces industrial forgings on a job contract basis. Total monthly wrench production represents less than 1 percent of total plant output.

Forgings are usually produced in production runs of 5,000 units. Production runs for other operations are about half this size. This plant will generally process about eight different products at one time.

This plant reported on a 9-inch malleable steel monkey wrench of the same design as the sketch (fig. 16). The bar is drop-forged and the jaw is a purchased casting.

Specifications: 9-inch monkey wrench; jaw opening 2-3/8 inches, jaw thickness 3/8 inch, jaw depth 1-1/8 inches, weight 13 ounces.

Raw Materials Purchased

The following materials were purchased by plant C:

Raw materials or parts	Description or specifications	Quantities usually received at one time
Knurl	Screw stock.....	1/ 5,000
Pin.....	Screw stock.....	5,000
Jaw casting.....	Casting	5,000
Bar stock for handle...	SAE 1040 Steel.....	(2/)

1/ Depends on current price. Usually extra items are purchased and put into stock.

2/ Information not available.

Production Planning and Control

Operations in the forge shop control the entire production schedule. Forge shop operations take about 60 percent of all operating time in the plant. On the first of every month a preference order sheet is issued based on inventory, orders, and expected sales. The reported product is generally produced in lots of 2,500. Most production will be on a 2- to 3-week cycle. The firm usually makes and ships within the month.

Materials Movement

Parts are moved between operations manually in tubs or by motor-powered trucks in tote boxes.

Inspection

Torque tests are applied to insure that the assembly will withstand a practical amount of torque. The pin which holds the knurl is inspected to see that it is secure, and the jaw is inspected to insure that it works freely on the bar.

About one-half of 1 percent of production is rejected as inferior. The principal reasons are: teeth are not milled deep enough or drillings in jaw are not properly centered. Rejects may be reworked or scrapped depending on degree of inferiority. The firm generally finds it more economical to scrap rejects.

Employment

This plant employed an average of 125 persons during 1951, including 100 production or related workers. Most of the direct workers were paid on an incentive basis.

The following accounts were classified by plant C as indirect labor: inspection, shipping and receiving, materials handling, idle time, packing, supervision, overtime, timekeeping, repairs and maintenance, setup, and tool and die making.

Reported Period

The reported period in this plant extended from April to November 1951 and the output amounted to 1,000 dozen wrenches.

Table 9. Operations, equipment, and standard man-hours in the manufacture of steel monkey wrenches, plant C, U. S. A., 1950-51

Part and operation	Number of men required	Machine	Number of machine units	Standard man-hour per 100	Setup time per 100
9-inch bar:					
Heat and forge bar	2	1,600 lb. Chambers drop hammer.	2	0.532	0.050
Straighten bar	1	Hand-hammer work	-	.300	
Trim bar	1	Niagara trim press - 3-1/2 inches.	2	.155	.011
Tumble bar	1	Sly tumbling barrel 24 x 40 inches.	2	.064	
Coin bar	1	400-ton clearing press	1	.078	.025
Mill bar complete	1	Potter and Johnson milling machine.	1	.253	.017
Harden bar	1	Open top plier conveyor furnace.	1	.065	
Draw bar	1	Lindberg draw furnace	1	.056	
Wheelebrate bar	1	Wheelebrator - 27 x 36 inches	1	.069	
Parkco Lubrite bar	1	Parkco Lubrite tanks and equipment.	1	.208	
Total (Bar)				1.780	
Saws:					
Mill	1	Cincinnati hydromatic miller	1	.267	.017
Broach	1	West Steel broaching machine	1	.145	.004
Drill	1	Moline 4-spindle drill press	1	.114	.027
Grind burrs	1	Standard electric grinder	4	.174	
Wheelebrate jaws	1	Wheelebrator - 27 x 36 inches	1	.041	
Parkco lubrite jaws	1	Parkco Lubrite tanks and equipment.	1	.083	
Total (Jaw)				.824	

Table 9. Operations, equipment, and standard man-hours in the manufacture of steel monkey wrenches, plant C, U. S. A., 1950-51--Continued

Par and operation	Number of men required	Machine	Number of machine units	Standard man-hour per 100	Setup time per 100
Knurl:					
Parkco Lubrite Knurl	1	Parkco Lubrite tanks and equipment		0.017	
Total (Other parts, including knurl)				.017	
Assemble:					
Assemble complete with jaw and knurl	1	Assembled by hand on a bench		.378	
Total (Assembling, finishing, packing)				.378	

SECTION B - MONKEY WRENCH

CHAPTER II: DETAILED REPORT

CASE STUDY, PLANT D

Buildings

This plant operates in a 3-story brick veneer, wooden frame building, part of which was converted from its use under previous owner and part added by the company after purchase of the building.

All parts of the building are at least 25 years old. The plant manufacturing area has 137,000 square feet.

Kinds of Products Made

This plant manufactures monkey and pipe wrenches, pipe vises, and pipe cutters. Wrench production represents about one-sixth of total plant output. Monkey wrench production is about one-seventh of this total.

The reported product is generally produced in lots of 2,500 in 5 different sizes. At the same time the plant usually produces 3 other products.

Specifications of the product reported upon are: 10-inch steel monkey wrench, forged jaw, cast handle, jaw opening of 1-15/16 inches, and weight of 30 ounces. As already noted, this wrench is not comparable in design and manufacturing process with the other wrenches.

Raw Materials Purchased

The following materials were purchased by plant D:

Raw materials or parts	Description or specification	Quantities usually received at one time
Handle	Malleable casting	100
Jaw steel	Bar stock 11/16 x 1-1/4 inches	5-10 tons
Nut steel	Cold rolled 1-3/8 inches round	1-2 tons
Stripped flat stock for washer	Carbon steel	1/4 ton

Production Planning and Control

Production is scheduled by the plant superintendent on the basis of inventory and expected orders. The wrenches are generally produced for order rather than for stock.

Materials Movement

Pieces are handled, generally, from operation to operation in tote boxes on hand trucks.

Inspection

The purchased, cast handle is inspected before processing. The inspection for cracks and blowholes is done both visually and by the magnaflux technique, which is a kind of metal fluoroscope. An average of 1.5 percent of production is rejected for improper milling, hardening, and poor match of parts.

Rejected output is generally disassembled, parts accumulated, and repaired. Most parts are generally salvaged.

Employment

In plant D the following accounts are classed as indirect labor: shipping and receiving, materials movement, packing, supervision, repairs and maintenance, setup, tool and die making, watchmen, and floormen.

This plant employed an average of 140 workers during 1951, including 123 production workers. Most of the direct workers were paid on a wage incentive plan.

Reported Period

The reported period in this plant extended from January 1 through December 31, 1951, and the output amounted to 2,000 dozen wrenches.

Table 10. Operations, equipment, and standard man-hours in the manufacture of steel monkey wrenches, plant D, U. S. A., 1950-51

Part and operation 1/	Machine or equipment 2/	Standard man-hours per 100 units
Jaw:		
Forge and cutoff - Heat steel in . . . furnace, helper carries to forger who inserts hot steel on bottom open-face die, presses treadle on hammer to form jaw (last blow performs cut-off). Helper carries from furnace to forge and then returns the cold bar to furnace.	1,600-pound board drop hammer.	0.800
Annealing - heat to 1100° F - . . . . cool slowly to take out hardness preparatory to machining.	Oil-fired furnace	.844
Sand blast - tumbles part with . . . . steel shot power - sprayed onto jaws to remove scale.	Pangborn Sandblast machine.	.113
Hammer ends - straighten bent . . . . flash preparatory to trimming.	Hammer and anvil.	.546
Cold trim - place forging in press . . on a trimming die and release upper part of press to cut off flash.	Standard number 5 geared press, shaft drive.	.182
Snagging - grind off edge left . . . . after trimmer cuts off flash.	Norton grinder, standard wheel.	.390
Cold drop - jaw cold struck in . . . . die to get proper, uniform size.	1,600-pound drop hammer.	.150
Mill face - surface inside jaw, . . . i.e., part of jaw that comes in contact with nut being turned, is smoothed off.	3 milling machines	.367
Thread - thread jaw neck	Double spindle threading machine.	.225
Straighten - hand benchwork with . . hammer and anvil. To take bend out of the jaw.	Hammer and anvil	.220

See footnotes at end of table.

Table 10. Operations, equipment, and standard man-hours in the manufacture of steel monkey wrenches, plant D, U. S. A., 1950-51--continued

Part and operation 1/	Machine or equipment 2/	Standard man-hours per 100 units
Jaw--cont.		
Grind neck - rough grinding operation.	Snag wheel - Norton grinder.	0.590
Heat treat	Electric furnace	.158
Temper (a draw operation to eliminate brittleness in the whole jaw).	Electric furnace	.250
Harden - to harden teeth in neck	Electric furnace	.500
Test - for hardness with a Brinell machine which makes a pinch prick in jaw and reads force it takes to penetrate.	Brinell testing machine.	.220
Tablast - a sandblasting operation performed on a rotating table.	Sandblasting machine	.100
Spray paint	Spray gun and spray booth.	.175
Total (Jaw)		6.080
Nut:		
Cutoff	Gridley, 4-spindle automatic cutoff.	.320
Burr - remove rough edges left in cutting.	Burring machine	.090
Tap - thread in nut	6-spindle tapping machine.	.200
Heat treat	Electric hardening furnace.	.270

See footnotes at end of table.

Table 10. Operations, equipment, and standard man-hours in the manufacture of steel monkey wrenches, plant D, U. S. A., 1950-51--continued

Part and operation 1/	Machine or equipment 2/	Standard man-hours per 100 units
Washer:		
Punch - punch hole	Punch press	0.070
Tumble	Tumbling barrel	.077
Plating - done outside the plant	-	-
Total (other parts, including knurl)		1.027
Handle (purchased casting):		
Visual inspection by stock laborers who remove castings from jute bags when they arrive from foundry.	-	.250
Inspect - special machine to magnify and take penetrating glance at the metal.	Magnaflux machine	.125
Rough grind sides - double grinding machine with parallel grinding wheels to remove burrs.	Double grinding machine.	.214
Mill face and nut slot - Mill corresponding edge on handle previously milled on jaw and mill slot where jaw is inserted in handle.	3 milling machines	.855
File burr - hand-file burrs on handle.	Hand file work	.340
Harden head	Electric furnace	.300
Sandblast or tablast	Sandblasting on rotating table.	.190
Dip and hang handle on racks - (a painting operation).	-	.295
Unload racks	-	.090
Total (Bar (handle))		2.659

See footnotes at end of table.

Table 10. Operations, equipment, and standard man-hours in the manufacture of steel monkey wrenches, plant D, U. S. A., 1950-51--continued

Part and operation 1/	Machine or equipment 2/	Standard man-hours per 100 units
Assemble handle, jaw nut, and washer:		
Double grind shanks of jaw and assemble.	Double grinding machine, 2 wheels, 1 polisher.	0.378
Rough grinding job to even up nose of jaw.	Double grinder.	.371
Assemble nut guard (washer) to handle and jaw.	Hand assembly.	.652
Dip end of handle in red paint	-	.144
Spin nut to close wrench	-	.200
Wash in oil. Placed on carrier in oil bath.	-	.250
Pack and bag - individually wrapped	-	.214
Total (assembling, finishing, and packing)		2.209

1/ 2 men on first operation; all the rest, 1 man for each operation.
2/ 1 machine unit unless otherwise stated.

CASE STUDY, PLANT E

Buildings

Plant E carries on its operations in a 4-story brick building about 50 years old. The building has been improved over the years and is in excellent condition. The forging, trimming, and heat treating of monkey wrenches take place on the first floor which covers about 200,000 square feet. The machining, finishing, and assembly of the wrench are done on the second floor. Upper floors are used for machining, light assembly work, and storage.

Kinds of Products Made

This plant produces a varied line of mechanics' tools distributed under its own brand name. The plant also manufactures drop forging equipment and produces industrial forgings on a job contract basis.

The monkey wrench is usually forged in lots of 1,000 units. Machining and finishing production lots are usually 500 units. There are usually 3 different size monkey wrenches in the average production lot. Hundreds of different products are processed in the plant at the same time.

Specifications of the monkey wrench reported upon are: 9-inch completely drop-forged monkey wrench with jaw opening of 2-5/8 inches, jaw thickness of 3/8 inch, and jaw depth of 1-1/4 inches.

Raw Materials Purchased

The following materials were purchased in plant E:

Raw materials or parts	Description or specifications	Quantities usually received at one time
1 inch jaw steel	1040 round steel	Carload lots
1-11/16 inch bar steel	1040 round steel	Carload lots
Knurl	Screw stock	5,000 units
Screw	Standard screw	5,000 units

Production Planning and Control

The assistant production manager is in charge of production planning. On the basis of past sales, he estimates production needs and draws up schedules. Standard control forms are used to insure availability of machines, workers, and equipment.

Materials Movement

Materials in the forge shop are moved on steel racks on 2-wheel hand trucks. Throughout other operations, parts are moved in tote boxes on electric fork trucks.

Inspection

Visual inspection is done by direct workers throughout all operations. During final inspection when the wrench is checked for performance and appearance, approximately 2 percent of production is rejected. The most frequent defects are poor machining, defective forgings, and poor trimmings. Rejects are sometimes reworked but must be sold as scrap. Among the rejects, "seconds" with minor imperfections are sold to employees at reduced prices.

Employment

This plant employs 390 workers including 340 production or related workers. Most of the direct workers are paid on a wage incentive basis.

In plant E the following accounts are classed as indirect: shipping and receiving, materials handling, supervision, timekeeping, repairs and maintenance, salvage labor, setup, tool-and-die making, watchmen, and yard labor.

Reported Period

No particular production period was selected. In this plant, standard man-hours for monkey wrench production were used.

Table 11. Operations, equipment, and standard man-hours in the manufacture of steel monkey wrenches, plant E, U. S. A., 1950-51

Part and operation	Number of men required	Machine or equipment (1 unit for each operation)	Standard man-hours per 100 units
Bar:			
Forge	2	1,600-pound drop Billings and Spencer hammer. Oil type furnace.	0.47
Anneal	2	Gas type furnace, 20-foot long conveyor.	.18
Tumblast	1	"Wheelebrator" barrel-type tumbler. Small shot for 20 minutes.	.11
Trim	1	Punch press 40-50 ton P and G Ferracute punch and dies.	.24
Remove flash	1	Snagging wheel-Norton wheels on a Gardner base or will mud tumble about half the time, if trimming machine is in good condition.	.61

Table 11. Operations, equipment, and standard man-hours in the manufacture of steel monkey wrenches, plant E, U. S. A., 1950-51—continued

Part and operation	Number of men required	Machine or equipment (1 unit for each operation)	Standard man-hours per 100 units
Straighten	1	400-ton Toledo coining press	.20
Mill back	1	Brown and Sharpe milling machine 2 fixtures, each holds 4 bars.	.77
Mill flats	1	Brown and Sharpe milling machine 2 fixtures, each holds 4 bars.	.61
Mill teeth	1	Brown and Sharpe milling machine 2 fixtures, each holds 4 bars.	.45
Disc flats (polish) .	1	Gardner double discer.	.43
Heat treat	3 or 4	Normalize 1 hour plus draw 2 hours gas type furnace for normalizing gas or electric furnace for drawing.	.74
Tumblast - remove . . scale after heat treat.	-	"Wheelebrator" barrel type with shot.	.075
Total (bar)			4.885
Jaw:			
Forge	2	1,200 Billings and Spencer hammer (2 per hammer blow).	0.34
Anneal	2	Gas type furnace, conveyor type.	.12
Tumblast	1	"Wheelebrator" barrel-type tumbler with metal shot. Cleaning operation.	.075
Trim	1	P and G Ferracute punch and dies; punch press.	.23
Cold drop; . . . . . similar to straightening operation.	1		.19

Table 11. Operations, equipment, and standard man-hours in the manufacture of steel monkey wrenches, plant E, U. S. A., 1950-51--continued

Part and operation	Number of men required	Machine or equipment (1 unit for each operation)	Standard man-hours per 100 units
Jaw--cont.			
Drill and butt mill.	2	Allen drill press, 4-spindle setup 2 drill and 2 butt mill.	2.44
Punch	1	Brown and Sharpe broaching machine, vertical broach - broach surface after drilling.	.38
Burr one end	1	Burring abrasive wheel	.15
Mill one end	1	Van Norman hand miller	.58
Broaching	1	La Pointe vertical broaching machine.	.58
Mill top slot and end.	1	Brown and Sharpe milling machine 2 fixtures, each holds 4 jaws.	.83
Re-broach (a finishing operation).	1	La Pointe broach.	.38
Drill screw hole	1	Allen drill press - 1 spindle	.85
Tap screw hole.	1	Allen tapping machine	.34
Burr lip and knurl hole.	1	Abrasive burring wheel	0.25
Heat treat	1	Normalize 1 hour, draw 2 hours. Gas or electric type furnace for drawing. Gas furnace for normalizing.	.32
Tumblast		Wheelebrate - barrel type with steel shot.	.033
Total (Jaw)			8.088

Table 11. Operations, equipment, and standard man-hours in the manufacture of steel monkey wrenches, plant E, U. S. A., 1950-51--continued

Part and operation	Number of men required	Machine or equipment (1 unit for each operation)	Standard man-hours per 100 units
Knurl:			
Mill both ends . . .	1	Pratt and Whitney bench lathe.	.27
Cyanide harden . . .	-	Chemical bath. Case hardened	.067
Total, (Knurl)			.337
Assemble, Finish and Pack:			
Assemble new . . . . (if large order 2 men - 1 for bar and jaw and 1 for knurl and screw).	1	Ratchet screw driver or power screw driver.	1.04
Tip if necessary . . to get ends of jaws even. Done on a single disc grinding machine.	1	Gardner single disc	.40
Spray black . . . . lacquer - lay wrenches on trays, 25 to 30 per tray.	1	Hand spray in spray booth	.83
Finish inspection . . and pack 3 to a box. Look for finish and proper performance. See that jaw moves freely.	1 (Female)	---	0.31
Total (Assembling, finishing, packing)			2.58

Case Study Data on
Productivity and Factory Performance

HAND TOOLS
(Machinist's Flat File,
Monkey Wrench, and
Expansive Bit)

SECTION C - EXPANSIVE BIT

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SECTION C - EXPANSIVE BIT

CHAPTER I: GENERAL REPORT

HIGHLIGHTS

Effective subdivision of machining and finishing operations, incentive wage payments to employees, and concentration of most production operations in 1 small shop enable 1 company in this report to produce an expansive bit in less than 18 man-minutes.

There are fewer than 10 plants in the United States today which manufacture expansive bits. Among these manufacturers are companies which make heavy metalworking equipment, companies which primarily make drills and wood boring bits, and companies which make a wide line of mechanics' hand tools. No one firm is a dominant producer; most plants produce about equal portions of the total expansive bit production. Although the expansive bit continues to be a popular and useful tool among woodworkers, several manufacturers indicated that in recent years sets of bits in graduated sizes for power tools have made inroads on the market for the expansive bit.

PRODUCT DESCRIPTION

The product reported in this section is a Clark pattern expansive bit with boring capacity from 1/2 to 1-1/2 inches. This type and size bit generally retails for under $2.50. The bit is equipped with 2 cutters: a number 1 cutter which will bore holes from 1/2 to 7/8 inch, and a number 2 cutter which will bore holes from 7/8 to 1-1/2 inches. The bit has a round, polished steel shank which is tapered and square at the end.

The strap, which sits in a dovetail on the body, overlaps and holds the cutter in place. By loosening the strap screw and releasing the strap, the cutter may be adjusted to the desired position. Graduations on the cutter indicate the size of hole which will be bored at a particular position.

Several different models of expansive bits are manufactured in the United States. A model that sells for slightly less than the Clark pattern bit has only 2 parts, the cutter being attached directly to the body by a screw. Adjustment to the desired size is made by loosening the screw and moving the cutter which is slotted. In another model, the bit has a solid head with the cutter racking back and forth through the head; adjustment to the desired size is accomplished by a turn of the screw which is geared against the cutter.

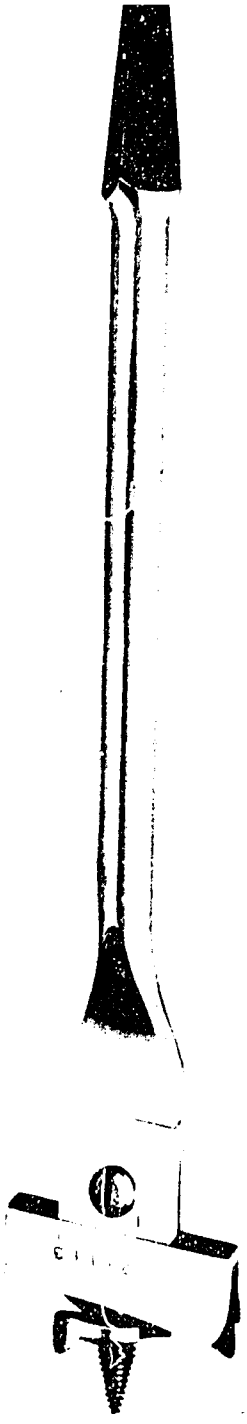

Fig. 15. Clark's pattern expansive bit.

Table 12. Man-hours required per 100 expansive bits, manufacturing costs, and production characteristics by selected plants, U. S. A., 1950-51

Item	Unit	Plant	
		F	G
Unit man-hours:			
Total	Man-hours per 100	29.7	59.0
Direct	Man-hours per 100	25.6	39.5
Indirect	Man-hours per 100	4.1	19.6
Manufacturing cost:			
Total	Percent	100.0	100.0
Labor (direct and indirect)	Percent	38.2	60.0
Material	Percent	7.1	5.0
Overhead	Percent	54.7	35.0
Production characteristics:			
Annual production of all models of expansive bits	One bit	200,000	30,000
Annual production of reported bit as percent of all expansive bits produced	Percent	32	33
Annual production of expansive bits as percent of total production	Percent	25	Less than 1

The bits reported on by plants F and G for the study are comparable. The bit is illustrated in figure 15. Small differences in finishing operations may be responsible for some differences in man-hours required per bit. Each plant begins manufacture with similar raw materials and generally reflects comparable levels of product integration, performing all manufacturing operations within the plant. The major difference between the 2 plants is in size of overall production operations. Plant F is a small plant which manufactures primarily wood boring bits. Plant G, on the other hand, is a large company which produces a wide line of mechanics' hand tools besides its major line of metalworking equipment. Plant F produces expansive bits continuously; plant G produces expansive bits for short periods at the same time that it produces a wide variety of other tools and equipment.

MANUFACTURING PROCESS

The manufacture of expansive bits is a forging, machining, and finishing process. The 2 major parts, the body and the cutters, are forged. After forging, these parts are machined, heat-treated, finished, and assembled. Machining and finishing operations in each plant have been subdivided into many small tasks; plants F and G report on more than 50 operations for the entire manufacturing process. The subdivision of jobs permits long production runs on one machine setup and develops maximum skill for the job in the individual worker.

The largest portion of direct labor in the manufacture of expansive bits is used to machine and finish the bit (table 12). These operations include milling, drilling, grinding, tapping, turning, and polishing; they are performed in a small machine shop in each plant. Although plant G is much larger than plant F, the machine shops in these plants are comparable in size, equipment, and layout. Each shop is equipped with standard machine tools which are grouped with similar machines located together. For most production steps, machines are located in the sequence of operations. The smallness of the shops and the length of production runs lessen problems of material movement. In any event the layout of plant G must be flexible enough to allow production of a variety of products not related to the expansive bit.

The machine shop in plant F is directly oriented toward the continuous, efficient production of expansive bits. For certain operations, 1 worker operates 2 or more adjacent machines performing the same operation at the same time. (The operations are indicated on the operation sheets, table 15.) Production runs are long and machine setup time is kept to a minimum. One operator performs the same task for long periods of time and becomes very adept.

In the other operations - forging, heat-treating, tumbling, finishing, and assembly - the differences of size and diversification of manufacturing activities between these 2 plants are more pronounced. Through the various departments in plant G pass the hundreds of different parts and products from all manufacturing divisions of the plant. The manufacture of this varied line of products requires the use of various facilities throughout the plant and the employment of a large number of persons in such functions as material and production control, scheduling, and material handling. In plant F, on the

Table 13. Direct man-hours by operation in the manufacture of 100 expansive bits, by selected plants, U. S. A., 1950-51

Operations	Standard direct man-hours per 100 expansive bits	
	Plant	
	F	G
Forging	1.56	2.10
Heat treating	1.25	.65
Machining	15.60	24.91
Handwork	3.65	4.10
Assembly	.95	1/ 4.96
Packing, finishing, and inspection	2.63	2.76

1/ Assembly man-hours for plant G include hand-finishing operations.

Table 14. Direct man-hours in the manufacture of expansive bits, by 100 parts, by selected plants, U. S. A., 1950-51

Part	Plant	
	F	G
Body	8.69	11.90
Number 1 cutter	3.51	6.07
Number 2 cutter	3.55	6.06
Strap	1.41	1.23
Assembling, finishing, inspecting, and packing	1/ 8.48	2/ 14.22

1/ Inspection is classified as indirect labor in plant F.
2/ Assembly man-hours in plant G include hand-finishing operation.

other hand, the control functions are performed by the plant superintendent and material handling is done by floormen or direct labor.

MAN-HOURS PER EXPANSIVE BIT

Direct man-hours are unadjusted standard hours which are based on time studies made by company or consulting engineers. Plant management in each plant indicated that actual hours may vary from standards, plus or minus 5 percent. Indirect labor per expansive bit is estimated by applying the ratio of plant-wide indirect to plant-wide direct to the standard direct man-hour figure.

Indirect labor includes such functions as shipping and receiving, setup, machine maintenance, inspection, floormen, supervision, janitorial, tool-and-die making, and timekeeping. In plant F, the estimating procedure probably gives a realistic allocation to the reported expansive bit. In plant G, however, where expansive bit production is a very small part of overall operations, this method may overstate indirect man-hours per expansive bit.

Lower man-hours per expansive bit in plant F may indicate higher productivity or efficiency in that plant, but it is important to point out several factors that may explain some differences in man-hours per unit. (Table 13 illustrates differences in labor time for major categories of operations. Table 14 shows man-hours difference per component parts.) Because of the varying size of its manufacturing operations and the diversity of its products, plant G employs many more indirect workers than plant F. Many of the functions performed by indirect labor in plant G are performed in plant F by direct labor, or are handled informally, or are carried out by the parent company.

It is more probable that lower direct labor per unit in plant F reflects higher productivity in that plant. (This statement does not refer to the relative efficiency of these plants. Differences in overhead or labor costs may offset costs of additional man-hours.) The largest differences in man-hours between the plants occur in the machining operations. In plant F continuous production of a single product in a small shop eliminates some of the extra labor time associated with multiproduct production and with frequent shifts in production. The smallness of the shop permits close supervision. All phases of management rest in one man, the plant superintendent. In each plant direct labor is paid at bonus rates for production that exceeds standard output. Management in each plant stated that this payment method was very important to high output per worker.

INCENTIVE SYSTEM

Each manufacturer of expansive bits noted in this report pays most of his direct labor on an incentive system. Production in excess of these standards is paid to the workers. Group operations such as heat-treating and annealing are usually not included under these plants.

Table 15. Breakdown of costs in the forging department of typical plant manufacturing expansive bits, U. S. A.

Item	Percentage of cost
Expansive bit body (shank):	
Direct labor:	
Forging	13.1
Trimming	8.1
Coining	.4
Material:	
Steel	29.6
Scrap	2.8
Die:	
Forging die	11.6
Trimming die	1.4
Coining die	2.3
Expansive bit cutters (2 cutters):	
Direct labor:	
Forging	8.1
Trimming	4.3
Material:	
Steel	6.4
Scrap	1.9
Die:	
Forging die	9.5
Trimming die	.5
Total cost	100.0

MANUFACTURING COST

The labor cost relative to the total manufacturing cost of an expansive bit was greater in plant G than in plant F (table 12). This difference may be traced to the same factors which tend to explain the differences in unit man-hours for the 2 plants. These factors are discussed in the paragraph entitled "Man-Hours per Expansive Bit" (supra).

BREAKDOWN OF COSTS IN FORGING DEPARTMENT

Table 15 shows the costs of direct labor, raw materials, and dies in the forging department of a typical plant manufacturing expansive bits. Total manufacturing cost in the typical plant usually includes the costs of direct labor, overhead, and materials costs. Overhead as used for such a purpose is computed as 150 percent of direct labor. However, in table 15 overhead is omitted and only direct labor, materials, and that part of the overhead account which includes the cost of dies are included.

Die costs are based on the average life of a pair of body dies of 20,000 forgings; on the average life of a pair of number 2 cutter dies of 30,000 forgings; and on the average life of a pair of number 1 cutter dies of 40,000 forgings.

SECTION C - EXPANSIVE BIT

CHAPTER II: DETAILED REPORT

CASE STUDY, PLANT F

Buildings

This company's manufacturing operations are housed in 3 buildings, 2 brick and 1 frame. The largest building, a 2-story brick structure, contains the finishing and packing departments, the heat-treating department, the forge shop, and storage space. A slightly smaller 2-story frame building handles machining and finishing for all production except expansive bits. In a small 1-story brick building all machining of expansive bits is performed. Except for small special contract work, expansive bit production is the sole function of this machine shop.

Kinds of Products Made

This plant manufactures a wide line of wood boring bits.

The reported product is Clark's pattern of the expansive bit with boring range of 1/2 inch to 1-1/2 inches, polished, bright round shank, tapered lacquered square end.

This plant manufactures expansive bits continuously. The plant manufactures 2 types of expansive bits and 2 sizes for each model. Average monthly production for the reported expansive bit during 1951 was about 5,000 units.

Raw Materials Purchased

The following materials were purchased from the parent company by plant F:

Raw materials and parts	Description
1050 Hot rolled steel	7/16-inch round, 20-foot length, body steel
1050 Hot rolled steel	3/8-inch round, 20-foot length, cutter steel
Screw	Hexagonal head screw
Unpolished strap steel	18-inch length

Production Planning and Control

This plant supplies expansive bits to several large distributors. Past sales records and inventory records provide a basis for production planning. Production scheduling is the function of the plant superintendent in conjunction with personnel of the parent company. Raw materials are purchased by parent company.

Materials Movement

This plant employs 2 men in the forge shop to move materials and keep workers supplied with work. Materials are moved in metal tote boxes on hand trucks. Materials in the machine shop are moved from operation to operation in small metal tote boxes by direct labor.

Inspection

Visual inspection during production is the responsibility of the production worker. Final inspection is done on an informal sample basis (10 percent of production). The bit is checked for overall appearance and cutting quality. An average of 2 percent of total production is rejected, principally for poor cutting quality. These rejects are generally sold as "seconds."

Employment

Average plant employment during 1951 was approximately 150 workers. Thirty-five of these workers, including 7 women, were employed in the machine shop, where the expansive bits are made. All but a few of the total plant employees were production or related workers. This plant is owned by a larger firm which handles much of the administrative and sales work for the plant.

These indirect workers were reported by plant F:

Forge shop and heat-treating department

1 Superintendent
2 Working foremen - 1 for forge shop - 1 for heat-treating
1 Tool and die maker
2 Floormen to move materials and keep workers supplied with work

Machine shop (expansive bit)

1 Superintendent
3 Working foremen
1 Tool and die maker
1 Floorman who performs custodial and miscellaneous jobs

Reported Period

The reported period in this plant extended from February 1 through February 29, 1952, and the output amounted to 3,200 expansive bits, of which 400 were seconds.

Table 16. Operations, equipment, and standard man-hours in the manufacture of expansive bits, plant F, U. S. A., 1950-51

Part and operation	Number of men required	Machine or equipment 1/	Standard man-hours per 100 units
Body:			
20-foot steel rod for shank is cut into 5-foot lengths by floormen.			
Forge	1	1,600-pound #1 Billings and Spencer board drop hammer.	0.50
Trim flash	1	1,600-pound #1 Billings and Spencer board drop hammer.	.33
Anneal	1	Homemade box-type oil-fired furnace	.10
Sandblast	1	Pangborn rotary-barrel-type sand blaster.	.06
Cold coin	1	1,600-pound Billings and Spencer board drop hammer.	.17
Mill bottoms and 10° angle on cutter.	2/1	Homemade hand miller (2 machines)	.37
Turn screws	1	Craftsman lathe	.30
Turn body	1	Logan turret lathe (3 machines)	.53
Mill flat	2/1	Sundstrand milling machines (2 machines).	.37
Mill dovetail	2/1	Sundstrand milling machines (2 machines).	.33
Burr dovetail	2/1	Abrasive sanding belt	.11
Drill hole	2/1	Delta drill press	.25
Countersink hole	2/1	Delta drill press	.14
Tap hole	2/1	Haskins automatic tapping machine	.18

See footnotes at end of table.

Table 16. Operations, equipment, and standard man-hours in the manufacture of expansive bits, plant F, U. S. A., 1950-51--continued

Part and operation	Number of men required	Machine or equipment 1/	Standard man-hours per 100 units
Body--cont.			
Mill throat and half-round.	2/1	Kent-Owens milling machine	0.45
Rough file	1	Hand file	.65
Fit bottom	1	Cincinnati milling machine	.80
Cross file	1	Hand-milling machine operation	.35
Thimble	1	Homemade thimbling machine	.35
Sharpen	1	Cincinnati milling machine	.25
Match cut (match thread onto cutting edge).	1	Cincinnati milling machine	.40
Grind throat	1	Grinding machine	.30
Cut screws	1	Hand-thread cutter - hand-screw machine.	1.30
Heat treating	1	Homemade box-type oil-fired furnace	.10
Total (Body)			8.69
Cutter #1:			
Forge cutter #1	1	800-pound #1 Billings and Spencer board drop hammer.	.20
Trim cutter	1	#2 type C Bliss Press	.08
Mill 1st and 2nd dovetail.	2/1	Cincinnati milling machine (2)	.65
Mill face and spur end.	2/1	Cincinnati milling machine (3)	.45
Rough grind	1	Hand file	.55

See footnotes at end of table.

Table 16. Operations, equipment, and standard man-hours in the manufacture of expansive bits, plant F, U. S. A., 1950-51--continued

Part and operation	Number of men required	Machine or equipment 1/	Standard man-hours per 100 units
Cutter #1--cont.			
Stamping (graduations)	2/1	Hydraulic stamping machine	0.15
Heat treat	1	Gas-fired salt bath, pot type furnace.	.33
Grind ends	2/1	Delta abrasive belt	.15
Rough polish ends . .	2/1	Delta abrasive belt	.19
Finish polish ends .	2/1	Delta abrasive belt	.16
Rough polish face . .	2/1	Delta abrasive belt	.19
Finish polish face .	2/1	Delta abrasive belt	.16
Finish grind	2/1	Hand file	.25
Total (Cutter #1) . . .			3.51
Cutter #2:			
Forge cutter #2 . . .	1	800-pound #1 Billings and Spencer board drop hammer.	.20
Trim cutter #2 . . .	1	Bliss press #2 type	.08
Mill 1st and 2nd . . dovetail.	2/1	Cincinnati milling machines (2)	.75
Mill face and spur end	2/1	Cincinnati milling machines (3)	.49
Rough grind	1	Hand file	.45
Stamping (graduation)	2/1	Hydraulic stamping machine	.15
Heat treat	1	Gas-fired, salt bath, pot-type furnace.	.33
Grind ends	2/1	Delta abrasive belt	.15

See footnotes at end of table.

Table 16. Operations, equipment, and standard man-hours in the manufacture of expansive bits, plant F, U. S. A., 1950-51--continued

Part and operation	Number of men required	Machine or equipment1/	Standard man-hours per 100 units
Cutter #2--cont.			
Rough polish ends	2/1	Delta abrasive belt	0.19
Finish polish ends	2/1	Delta abrasive belt	.16
Rough polish face	2/1	Delta abrasive belt	.19
Finish polish face	2/1	Delta abrasive belt	.16
Finish grind	2/1	Hand file	.25
Total (Cutter #2)			3.55
Straps:			
Cutoff	1	Abrasive cutoff wheel	.27
Burr	2/1	Abrasive sander	.20
Drill hole	2/1	Delta drill press	.27
Countersink hole	2/1	Delta drill press	.19
Stamp	2/1	Hydraulic press	.15
Heat treat	1	Gas-fired salt bath, pot-type furnace.	.33
Total (Strap)			1.41
Finishing, Assembling, Inspecting, and Packing:			
Fix straps	1	Hand operation	.85
Rough strap and shoulder.	1	Delta abrasive belt (hand)	.60
Rough strap and shank	1	Delta abrasive belt (hand)	1.28
Smooth strap, shoulder, body, and shank.	1	Delta abrasive belt (hand)	.48

See footnotes at end of table.

Table 16. Operations, equipment, and standard man-hours in the manufacture of expansive bits, plant F, U. S. A., 1950-51--continued

Part and operation	Number of men required	Machine or equipment 1/	Standard man-hours per 100 units
Finishing, Assembling, Inspecting, and Packing cont.			
Stamp	1	Hydraulic stamping machine Martin #12.	0.07
Finish file	1	Hand filing (cut and spur).	.65
Brighten screws . . .	1	Hand-chuck boring machine.	.45
Finish strap, ... shoulder, body and shank.	2/1	Polisher (Delta abrasive belt).	.52
Degrease and dip . . nib in air-dry lacquer.	1		.67
Dip in oil	1		.03
Wrap and box	2/1		1.10
Packing	2/1		.83
Total (Assembling, finishing, inspecting, and packing)			8.48

1/ 1 machine unless otherwide stated.
2/ Male or female.

CASE STUDY, PLANT G

Buildings

This company performs its extensive manufacturing operations in a large multibuilding plant. The buildings are very old improved brick structures connected to one another. All operations except machining are performed in the various departments throughout the plant.

Machining of the expansive bit is performed in a 60- by 40-foot area in the third story of one of the smaller structures.

Kinds of Products Made

This firm manufactures a wide line of mechanics' tools which are distributed under its own brand name. The major products of this company include a wide line of metalworking equipment.

The reported product is Clark's pattern expansive bit with boring range of 1/2 inch to 1-1/2 inches, bright round shank, tapered end, and weight of 4 ounces.

The plant generally produces 2 sizes of the reported product in production lots of 3,000 to 4,000 bits. Forgings for the bodies and cutters are run through, generally, in production runs of 10,000. The shop which machines this bit may be producing 1 or 2 other tools at the same time.

Raw Materials Purchased

The following materials were purchased by plant G:

Raw materials and parts	Description	Quantity usually received at one time
Body 1050 round steel	7/16-inch round, 20-foot length.	10,000 pounds
Strap - steel stock	9/16-inch flat, 10-foot length.	2,000 pounds
Cutter 1055 steel	3/8-inch square, 20-foot length.	10,000 pounds
Screws	13/64 x 24 threads per inch.	10,000 units

Production Planning and Control

Reported product is produced for stock. Orders for production department originate from production control section and are based on past and anticipated sales.

Materials Movement

Within the department, materials are moved in tote boxes by hand truck. Interdepartmental movement throughout the entire plant is handled by 3, full-time persons with 3 electric trucks.

Inspection

Roving spot inspection is performed in the machine shop by a setup man and 1 floor man. In the forge shop 1 full-time inspector inspects each heat.

During final inspection, which is included as direct labor, the bit is examined for appearance and checked for cutting quality. Approximately 3 percent of the total output is rejected at this stage. Improper hardening of the screw and the cutter is the major cause of rejection. Almost all rejects are handled as scrap.

Employment

Average company employment during 1951 was 630. Four hundred and eighty of these employees were directly or indirectly engaged in manufacturing activities.

No breakdown of indirect labor for expansive bits was available in plant G because these workers perform functions related to total plant output. Approximately one-third of all production or related workers performed indirect functions throughout the plant. Indirect workers performed such functions as shipping and receiving, machine setup, machine maintenance, inspection, floormen, supervision, timekeeping, elevator operators, tool-and-die-makers, and materials handling. Plant G required many more indirect workers than plant F because of the greater scope and diversity of production in plant G.

Reported Period

In this plant, standard man-hours were taken for the production in 1951 of expansive bits.

Table 17. Operations, equipment, and standard man-hours in the manufacture of expansive bits, plant G, 1950-51

Part and operation (1 worker at each operation)	Machine or equipment (1 unit of each)	Standard man-hours per 100 pieces
Body:		
Forge and hot trim	Drop forge board hammer	1.01
Hot head	Ajax machine	.59
Anneal	Gas-fired furnace	.072
Wheelebrate	"Wheelebrator" barrel-type tumbler with metal shot.	.016
Grind shank	Abrasive mill	.40
Straighten body	Hand smithing	.34
Turn point	Lathe	.35
Turn body	Lathe	.74
Mill off flash	Hand-milling operation	.45
Mill stock after pointing	Hand-milling operation	.20
Mill stock in dovetail	Hand-milling operation	.55
Profile dovetail	Milling machine	1.45
Drill hole	Drill press	.31
Tap hole	Drill press	.36
Mill throat	Miller	.45
Mill groove	Miller	.13
Washing body	Sal-soda solution	.043
Mill off stock	Milling machine	.20
Mill base of thread	Milling machine	.20
Mill groove for spur	Milling machine	.15

Table 17. Operations, equipment, and standard man-hours in the manufacture of expansive bits, plant G, 1950-51--continued

Part and operation (1 worker at each operation)	Machine or equipment (1 unit of each)	Standard man-hours per 100 pieces
Body--cont.		
Mill off knife	Milling machine	0.22
File throat clearance on spur and lip.	Hand filing	1.68
Thread point	Homemade threader	1.65
Harden	Lead bath, 1500°F	.32
Temper	Lead bath	.02
Total (Body)		11.90
Cutters #1:		
Forging	1,000 pounds Board drop hammer.	.14
Wheelebrate	"Wheelebrator" barrel-type tumbler with metal shot.	.01
Anneal	Gas-fired furnace	.01
Wheelebrate	Wheelebrator, barrel-type tumbler with metal shot.	.01
Straighten	Hand-smithing	.07
Cold trim	Trim press	.11
Grind bottom	Snagging on abrasive wheel	.11
Mill dovetail	Milling machine	.55
Mill top surface	Milling machine	.55
Burr bottom	Abrasive wheel	.12
Burr groove	Abrasive wheel	.11
Mill spur end	Milling machine	.34

Table 17. Operations, equipment, and standard man-hours in the manufacture of expansive bits, plant G, 1950-51--continued

Part and operation (1 worker at each operation)	Machine or equipment (1 unit of each)	Standard man-hours per 100 piece
Cutters #1--cont.		
Burr top of bottom edge . .	Abrasive wheel	0.11
Profile cutting edge	Profiler	.59
Wash	Sal-soda solution	.01
File	Benchwork	.63
Rough polish	Polishing jack	.78
Mark graduations	Stamping machine	.17
Harden	Lead bath	.07
Temper	Lead bath	.01
Finish, polish, and oil . .	Polishing wheel	.88
Sharpen knife on wheel . . .	Honing wheel	.35
File	Hand benchwork	.34
Total (Cutter #1)		6.07
Cutters #2:		
Forging	1,000 pounds Board drop hammer.	.14
Wheelebrate	"Wheelebrator," barrel-type tumbler with metal shot.	.01
Anneal	Gas-fired furnace	.01
Wheelebrate	"Wheelebrator," barrel-type tumbler with metal shot.	.01
Straighten	Straighten flash before trir	.07
Cold trim	Trim press	.11

Table 17. Operations, equipment, and standard man-hours in the manufacture of expansive bits, plant G, 1950-51--continued

Part and operation (1 worker at each operation)	Machine or equipment (1 unit of each)	Standard man-hours per 100 pieces
Cutters #2--cont.		
Grind bottom	Snagging on abrasive wheel	0.11
Mill dovetail	Milling machine	.55
Mill top surface	Milling machine	.55
Burr bottom	Abrasive wheel	.12
Burr groove	Abrasive wheel	.11
Mill spur end	Milling machine	.34
Burr top of bottom edge	Abrasive wheel	.11
Profile cutting edge	Profiler	.59
Wash cutter	Sal-soda bath	.01
File	Bench file work	.63
Rough polish	Polishing jack	.71
Mark graduations	Brander hydraulic press	.19
Harden in lead bath	Pot-type furnace	.07
Temper in lead bath	Pot-type furnace	.01
Finish, polish, and oil	Polishing wheel	.78
Sharpen knife	Honing wheel	.31
File	Hand bench work	.34
Inspect	Visual inspection	.18
Total (Cutter #2)		6.06

Table 17. Operations, equipment, and standard man-hours in the manufacture of expansive bits, plant G, 1950-51--continued

Part and operation (1 worker at each operation)	Machine or equipment (1 unit of each)	Standard man-hours per 100 pieces
Strap:		
Nickel plating strap screw .		0.22
Strap cut to length	Clip press	.36
Washing cap	Sal-soda bath	.01
Grind lever	Abrasive wheel	.13
Drill hole	Drill press	.37
Counter sink	Drill press	.14
Total (Strap)		1.23
Assembling, finishing, inspecting, and packing:		
Assemble strap to bit . . .	Benchwork	1.06
Mark cap	Brander hydraulic press	.15
Polish head and shank . . .	Polishing jack	5.85
Oil bit		.13
File throat, point, and assemble. . .	Hand filing work	3.90
Brighten thread and test knife.	Chucked in lathe and tested on board.	.78
Inspect appearance and wipe,	Chamois used for re-oil	.87
Brand	Hydraulic press	.19
Pack		1.29
Total (Assembling, Finishing, inspecting, packing)		14.22

Case Study Data on
Productivity and Factory Performance

HAND TOOLS
(Machinist's Flat File,
Monkey Wrench, and
Expansive Bit)

SECTION D - LABOR IN THE HAND TOOLS INDUSTRY

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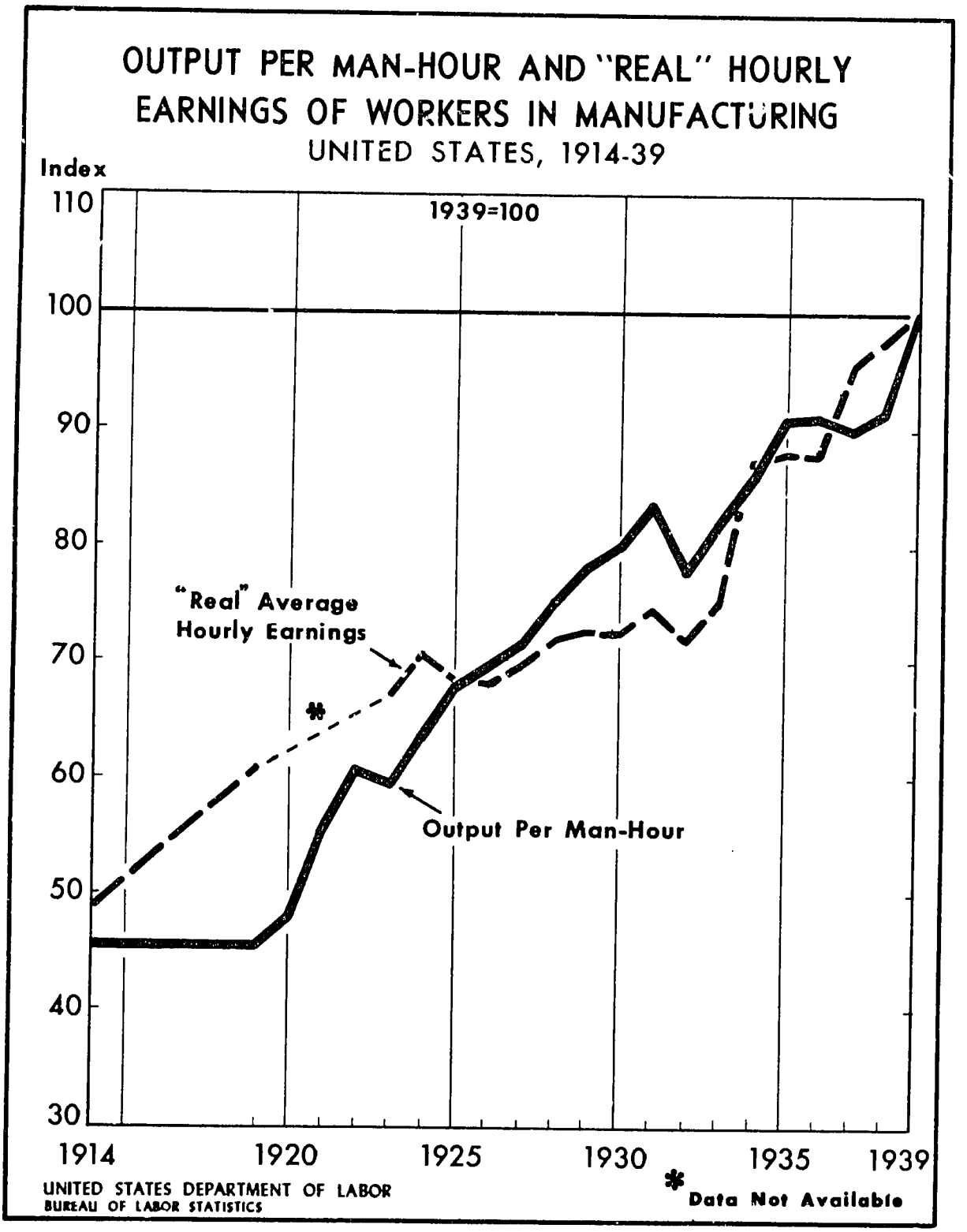

Fig. 16. Output per man-hour and "real" average hourly earnings, manufacturing, U. S. A., 1914-39.

SECTION D - LABOR IN THE HAND TOOLS INDUSTRY

(NOTE: THIS SECTION IS NOT INTENDED TO BE A COMPLETE STUDY OF LABOR OR LABOR CONDITIONS IN THIS INDUSTRY. IT IS PRESENTED PRIMARILY TO ILLUSTRATE THE HIGH STANDARD OF LIVING ACHIEVED BY THE UNITED STATES FACTORY WORKER IN AN INCREASINGLY PRODUCTIVE ECONOMY.)

LABOR BACKGROUND

Factory workers' earnings together 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 between 1909 and 1947, whereas the workweek declined one-fifth during this same period according to estimates of the Bureau of Labor Statistics. 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 a share of the gain from increased productivity. In addition to increased pay and shorter hours, workers have chosen to take some of the returns from greater productivity in the form of "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 human resentment to change. Management and labor have made many successful efforts to deal with these problems. Several outstanding examples appear in Appendix I. While these are not in the hand tools industry, the techniques and procedures described have broad applicability.

Table 19 shows the gross average hourly earnings of industrial workers - earnings which include overtime and night shift differentials. These data are to be distinguished from those data on earnings shown in table 21, which exclude premium pay for overtime, nightwork, and shift differentials but include incentive pay.

Real gross average hourly earnings of workers in the hand tools industry rose 12.8 percent between 1947 and March 1952. Gross average hourly earnings, not corrected for changes in the cost of living, rose 33.3 percent, over the same period. Workers in the hand tools industry earned slightly more per hour than the average for workers in all manufacturing in the United States.

Table 18. Indexes of productivity and real average hourly earnings, U. S. A., selected years, 1914-39 1/

(1939 = 100)

Years	Index of output per man-hour, all manufacturing	Index of real average hourly earnings
1914	45.5	48.8
1919	45.3	60.4
1920	48.0	(2/)
1921	55.2	(2/)
1922	60.5	(2/)
1923	59.5	67.2
1924	63.4	70.3
1925	67.6	68.4
1926	69.5	68.1
1927	71.3	69.7
1928	75.1	71.9
1929	78.1	72.5
1930	80.0	72.5
1931	83.5	74.4
1932	77.8	71.7
1933	81.9	75.0
1934	85.9	87.3
1935	90.8	88.1
1936	91.0	88.1
1937	90.0	95.4
1938	91.6	97.6
1939	100.0	100.0

1/ The productivity index has not been computed for years subsequent to 1939. Beginning with World War II, factories changed from peacetime goods to the production of wartime goods, and the lack of comparability of products made it difficult to carry forward a comparable productivity index for these years.

2/ Information not available.

Table 19. Average hours and earnings of production workers in all manufacturing and in the hand tools industry, U. S. A., selected years, 1909-51

Year	Average weekly earnings 1/ (In dollars)		Average weekly hours		Average hourly earnings 1/ (In dollars)		"Real" average hourly earnings 3/ (In dollars)	
	Hand-tools	All mfg.	Hand-tools	All mfg.	Hand-tools	All mfg.	Hand-tools	All mfg.
1909...	(2/)	9.84	(2/)	51.0	(2/)	0.193	(2/)	(2/)
1939...	(2/)	23.86	(2/)	37.7	(2/)	.633	(2/)	0.637
1947...	51.66	49.97	41.2	40.4	1.254	1.237	0.786	.775
1950...	61.33	59.33	41.2	40.5	1.488	1.465	.866	.852
1951...	69.49	64.88	42.5	40.7	1.635	1.594	.881	.859

1/ Gross earnings before taxes, social security, and other items are deducted.

2/ Information not available.

3/ In 1939 dollars, computation is made by dividing figures in columns headed "average hourly earnings," by the Consumers' Price Index, having a base of 1937-39 = 100.

Table 20. Weekly hours and gross hourly earnings of production workers in selected firms engaged in the manufacture of wrenches, files, and expansive bits, annual averages, 1951

Plant	Average weekly hours	Average hourly earnings 1/
A	38.1	$1.591
B	44.0	1.807
C	42.1	1.813
D	39.8	1.477
E	46.6	1.687
F	32.7	1.798
G	45.2	1.517

1/ Gross earnings before deductions for taxes, social security, or other items.

The cost of common commodities in terms of worktime required of the average factory worker to buy food and commodities in 1947 is shown in table 22.

The gross average hourly earnings of workers employed in the 7 plants in this study are shown in table 20.

Table 21 records the results of a study of straight time average hourly earnings by occupation in the cutlery, hand tools, and general hardware industry for the winter months of 1951-52, in the Chicago metropolitan area. Men tool and die makers were the highest paid workers studied. Women employed on repetitive assembling and inspecting work generally earned the least among the jobs studied. Earnings of workers employed as machine tool operators were found to vary according to the type of machine operated, the degree of skill required, and the method of wage payment employment.

FRINGE BENEFITS 5/

Paid Vacations

The practice of granting a week of vacation after a year of service was widespread among the establishments studied in 7 cities in the cutlery, handtools, and general hardware industry during a survey of this industry made in the winter of 1951-52.

Information is also available regarding paid vacation practices for 5 of the 7 plants manufacturing wrenches, files, and expansive bits which were studied in the present survey of productivity (table 24).

Insurance Plans

In the survey of the cutlery, hand tools, and general hardware industry, the coverage of company financed life insurance plans in 1951-52 ranged from 51.2 percent of the workers in Cleveland to 100 percent in St. Louis. Hospitalization and other health insurance plans embraced the majority of the workers studied in this industry in all 7 cities.

On an individual plant basis information regarding insurance plans is available for 4 of the 7 firms in this study (table 24).

Pension Plans

Virtually every worker in the United States employed by business or industrial firms, including the employees of the firms in this study, is eligible to receive a pension at the age of 65. The benefits from this pension plan are distributed either to the worker and his wife, or, on his death, to his surviving wife and children, and range in amount from a minimum of $25 to a maximum of $168.75 per month. The amount of the benefits depends upon the average wage received and the number of dependents. A worker who had averaged, during his period of employment, $67.97 per week, which is the national

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5/ Includes nonwage benefits such as paid vacations, holidays, and pensions.

Table 21. Straight time average hourly earnings for plant workers in selected occupations in the cutlery, hand tools, and general hardware industry in the Chicago metropolitan area of the United States, January, 1952

Occupations 1/	Straight time average hourly earnings
Assemblers, class B	$1.62
Assemblers, class C	1.50
Assemblers, class C (women)	1.08
Heat treaters, class B	1.70
Inspectors, class B	1.66
Inspectors, class C	1.49
Inspectors, class C (women)	1.14
Machine tool operators, production, class A	1.93
class B	1.69
class C	1.49
class C (women)	1.20
Machine tool operators, toolroom	1.74
Polishers and buffers, metal	1.83
Polishing and buffing machine operators	1.49
Setup men, machine tools	1.83
Stock handlers and hand truckers	1.33
Tool and die makers	2.19

1/ Detailed job descriptions that were used as a basis for this survey, may be obtained on request from the Division of Wages and Industrial Relations, Bureau of Labor Statistics, U. S. Department of Labor.

Table 22. Amount of worktime required of average factory worker and of average worker in the hand tools industry to buy selected food and clothing items, U. S. A., 1947

Item	Unit of measure	Average factory worker		Average worker in hand tools industry	
		Hours	Minutes	Hours	Minutes
Food					
Milk	1 liter	--	9	--	9
Eggs	1 dozen	--	34	--	34
Oranges	1 dozen	--	21	--	21
White flour	1 kilogram	--	11	--	11
White wheat bread	1 kilogram	--	13	--	13
Butter	1 kilogram	1	28	1	27
Salt pork	1 kilogram	--	49	--	48
Potatoes	1 kilogram	--	7	--	7
Coffee	1 kilogram	--	51	--	50
Clothing					
Men:					
Heavy wool suit	1	36	43	36	13
Work shirt	1	1	19	1	18
Socks	1 pair	--	16	--	16
Street shoes	1 pair	6	32	6	27
Workshoes	1 pair	5	56	5	57
Women:					
Wool coat	1	17	53	17	38
Street dress	1	8	20	8	13
Housedress	1	2	31	2	29
Rayon and nylon stockings	1 pair	--	53	--	52
Street shoes	1 pair	5	26	5	22

average production worker's earnings for 1952, would be eligible at 65 for a pension amounting to $84.18, and his wife would receive an additional $42.09, totaling $126.27 per month.

This program is required by Federal law and is known as Old Age and Survivors Insurance. To finance this pension plan, employers are required to contribute periodically an amount equal to 1-1/2 percent of each employees wages, while the employee contributes an equal amount.

In addition to benefits under this Federal law, some States have extensive payments to aged workers which serve to supplement the above amounts.

Over and above these legally required pension plans, some employers, often after negotiations with the unions in their plants, have set up pension funds to which the employers contribute all or part of the cost. In the event that all the cost is not paid by the employer, the employees contribute the remainder. Table 24 shows the firms in this study which have installed such pension plans.

Paid Holidays

In the cutlery, hand tools, and general hardware industry, in the 7 cities studied in 1951-52, the prevalent practice was to provide 6 holidays, with pay, a year. However, the number of paid holidays ranged from 6 up to 10 a year for the 5 out of 7 plants in this survey for which information is available (table 23).

Overtime Pay Provisions

Of the 7 plants studied, information is available as to overtime provisions in 5 of them (table 23). Data on shift differential payments are also shown in that table.

UNIONS IN THE INDUSTRY

The unions known to exist in the plants included in this survey and their nationwide membership in all fields are: United Steelworkers of America (C.I.O.), membership 1,100,000; International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers (A.F.L.), membership 150,000; Metal Polishers, Buffers, Platers and Helpers International Union (A.F.L.), membership 20,000; International Die Sinkers' Conference (Independent), membership 4,000; United Electrical, Radio and Machine Workers of America, (Independent), membership not known; United Automobile Workers of America, International Union (A.F.L.), membership 100,000. All figures are based on reports furnished by the unions in the spring of 1952. 6/

6/ Directory of Labor Unions in the United States, 1953, Bureau of Labor Statistics Bulletin No. 1127.

Table 23. Fringe benefits for plant workers in 5 selected firms engaged in the manufacture of wrenches, files, or expansive bits, by wage systems, shifts, and holidays, U. S. A., 1951-52

Plants 1/	With union	Workers on incentive wages	Shift differential 2/ (in cents per hour)		Number of paid holidays a year	Non-production bonuses
			second shift	third shift		
A.....	Yes	Yes	4	6	6	No
B.....	Yes	Yes	(3/)	(3/)	8	No
D.....	Yes	Yes	8	10	10	No
E.....	Yes	Yes	(4/)	(4/)	7	No
G.....	Yes	No	(4/)	(4/)	6	(3/)

1/ Information on plants C and F not available.

2/ Differentials are given in cents-per-hour additional, relative to first shift.

3/ Information not available.

4/ 10 percent added to first-shift rate.

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 in many instances, have been reached 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 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 besides 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.

Table 24. Vacations, insurance, and benefit plans in 5 selected firms engaged in the manufacture of wrenches, files, or expansive bits, by plant, U. S. A., 1951-52

Plants 1/	Number of days of paid vacation			Type of insurance and pension plans			
	Under 1 year of service	1 to 5 years' service	5 or more years' service	Life insurance	Hospitalization	Health, accident, and sickness other than hospital	Retirement pension 2/
A . . .	(3/)	5	10	(3/)	(3/)	(3/)	(3/)
B . . .	4/ 10	10	10	Yes	Yes	Yes	Yes
D . . .	5/ 5	6/ 5-10	10	Yes	No	Yes	No
E . . .	4/ 5	10	10	Yes	Yes	Yes	No
G . . .	0	5	10	(3/)	(3/)	(3/)	(3/)

1/ Information on plants C and F not available.

2/ Compulsory pension plans, required by Federal or State laws, such as Old Age and Survivors Insurance, are not shown.

3/ Information not available.

4/ Vacation eligibility begins if employee has 6 months of service as of July 1.

5/ Eligibility begins if employee has 30 weeks of service as of September 1.

6/ 10-day vacation eligibility after 2 years of service.

Case Study Data on
Productivity and Factory Performance

HAND TOOLS
(Machinist's Flat File,
Monkey Wrench, and
Expansive Bit)

APPENDIX I: ADJUSTMENTS TO TECHNOLOGICAL CHANGE

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

Case Study, Plant X 7/

"Steelworkers, in common with all other workers in the United States, naturally welcome increasing labor productivity, if only because they realize that it augments the fund from which higher living standards may be realized. Yet increasing labor 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 longstanding 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 plant X 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 Morgan rod mill was installed at this plant in 1949. The same case illustrates the painstaking attention which is given to the classification of jobs involving 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 8 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

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7/ Abstracted from Causes of Industrial Peace Under Collective Bargaining, Case Study No. 9, National Planning Association, Washington, D. C., 1951.

no demotions, but take-home pay was diminished in those 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 premiums for work in excess of 8 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 reexamination of the company's tentative classifications in the light of the agreed-upon job descriptions. Based on the 30 labor grades established by the national committee studying wage inequities, a method of pooled 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 7, and the union provisionally withdrew objections on the remaining 6. 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.

"Essentially the same mutuality exists at this plant 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 its turn acts directly through its committee on wage inequities rather than indirectly through the grievance procedure. Sometimes the advice of the wage experts in the national headquarters of the union 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."

Case Study, Plant Y 8/

"This company has directly encouraged the development of a high degree of responsibility on the part of the union. Management has not hesitated to call upon union representatives to produce a constructive proposal for correcting a source of discontent or unrest instead of merely complaining about it.

"A serious bone of contention between the union and the outgoing management had been the matter of work schedules. The approach to this problem by plant Y's president was straightforward. In essence, he told the union:

> Here, too, you fellows are going to have to accept some responsibility. As far as the company is concerned, we're primarily interested in getting twenty-one turns a week in the blast furnaces and open hearths and eighteen turns a week in the rolling mills. You fellows go ahead and work out the schedules that suit you best. We don't intend to pay any unnecessary overtime, but we will adopt the schedules that are most convenient for you if they give us the production turns that we need on the furnaces and in the mills.

"Most officials of the union were able to adapt themselves to the new management approach and to meet the challenge which it presented to them. One or two, however, were lost in the presence of a situation where more was required of union officials than simply the ability to talk tough and pound the table. They had said 'no' so long that they didn't know how to say 'yes.' This group quickly faded into the background, and a new era of union leadership dawned at this plant. The management of this company thereby proved that the way to develop effective and responsible leadership in a union local is to give a reasonable amount of responsibility to the union. This is perhaps one of the chief lessons to be drawn from this firm's experience.

"Even in the days when the union's position was anything but strong, the company actively contributed to the development of a strong union. The early local union officers at this plant frequently failed to push legitimate grievances promptly, thereby causing considerable bad feeling over relatively simple matters. On several occasions certain members refused to pay their dues until their grievance was pushed by the union. Even under such circumstances, management did not take advantage of the union's relatively weak position, but continued to deal with the grievance committeemen in good faith. Furthermore, management even tried to strengthen the union's position by actively encouraging membership in the union. Such assistance during the period when the union was relatively weak played a considerable part in strengthing the locals. It also did much to influence the union's attitude toward collective bargaining in general and toward the company in particular."

8/ Abstracted from Causes of Industrial Peace Under Collective Bargaining, Case Study, No. 5, National Planning Association, Washington, D. C.

APPENDIX II: DATA COLLECTION

The data on individual plants were obtained by direct visits to these plants by representatives of the Bureau of Labor Statistics. In keeping with the Bureau's policies, all information was obtained from the plants on a voluntary basis, and care was taken to present the information in such a way as not to disclose the identity of any of the cooperating plants.

In plant A the source of data on direct man-hours for each operation consisted in adjusted standard man-hours, while the other 6 plants in this study used unadjusted standard man-hours. Standard man-hours are based on time studies made by company or consulting engineers. Plant managers asserted that actual hours may vary from standards in either direction.

A copy of the questionnaire which was completed by the Bureau's representatives while visiting the plants is reproduced on the following pages. The amount of space for answers to questions has been drastically reduced for reproduction purposes in this report. Field agents were requested to answer as fully as possible, using additional paper if necessary.

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

CONFIDENTIAL

PRODUCTIVITY AND FACTORY PERFORMANCE

Wrenches, Files, and Expansive Bits

Plant name _____ Address _____
Plant name _____ Address _____
Parent company _____ Address _____
Officials interviewed: (Cross out "Co." or "Plant")
(Co.)(Plant) _____ Title _____
(Co.)(Plant) _____ Title _____
(Co.)(Plant) _____ Title _____

The data submitted on this schedule 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 the company's written permission.

Survey made by _____ Date _____

A. PRODUCT INFORMATION

1. Plant Production:
   Does this plant make any of the following products:
   a. _____ Monkey Wrench; 9-inch length
   b. _____ Files; flat, bastard, double-cut, tapered mood, 10-inch length, approximately 1x¼-inch size, cut on both edges.
   c. _____ Auger bits; expansive, ½-1½-inch diameter, 2 cutters, polished, bright round shank, tapered, square end.
2. Reported Product:
   a. Give complete description and specifications of reported product. (Obtain a picture of the reported product, if available) _____

B. PRODUCTION AND MAN-HOURS

1. Report production and man-hours for a recent period or a full year 1951, whichever is most convenient.
   a. Production period covered: From _____ To _____

Number of units of reported product manufactured during reported period _____
Direct man-hours for reported product during reported period _____
Indirect man-hours for reported product during reported period _____
Total man-hours (production and related workers) for reported product during reported period. . . . . _____

b. Indicate the labor accounts included in the above direct and indirect man-hour totals:

Direct labor accounts	Man-hours	Indirect labor accounts	Man-hours

c. How were direct man-hours computed? Time cards ___ Standards adjusted for variance ___ Unadjusted standards ___ Other ___

d. How were indirect man-hours computed? ___

2. Output for 1951

Enter below for the reported product, and for all models of the reported product the dollar value of 1951 shipments or the approximate percentage of total production.

Product	Value of shipments (dollars)	Percent of total plant production
Reported product		
All models of reported product		
Total plant production		

3. Plant Employment

For the payroll period ending nearest the 15th of the month of the reported period (or for the year as an average) enter the:

a. Total number of employees in this plant ___

b. Number of production and related workers ___ (direct plus indirect workers).

C. PLANT PRACTICES

1. Raw Materials and Parts:

What raw materials and parts are purchased for use in the reported product?

Raw materials or parts	Description or specifications	Quantities usually received at one time

2. Production Planning

a. What production planning procedures were used to assure the availability of machine time, worker time, special equipment, purchased materials and parts, etc., at the proper time. (Attach all forms used)

___

b. Is reported product produced primarily for orders on hand_____, for stock _____.

c. If produced for orders on hand, what is policy of order accumulation? _____.

d. If produced for stock, how many months' supply are produced in one run? _____.

3. Inspection and Quality Control

a. Describe inspection systems in use and indicate points of application _____

b. Rejects: Percent of total production _____; reasons for rejects: _____

c. Describe procedure for handling rejects: (Sold for scrap, reworked, etc.) _____

4. Standardization of Output During 1951

a. What were the major categories of products produced in this plant _____

_____

b. Average number of different products scheduled through the plant at one time: _____.

c. What is the smallest production lot or run (in units of the reported product?) _____.

d. What is the usual production lot or run (in units of the reported product?) _____.

e. What is range of sizes of reported product produced in lot? _____

f. How many individual items does company produce at one time? _____

D. OVER-ALL PLANT INFORMATION

1. Plant Buildings

a. Describe the size structure, and major use of plant buildings. Obtain whenever possible the number of square feet in the production area and a sketch of the plant layout:

_____

b. Describe any major changes that have been made in the plant's buildings since 1947, giving the approximate month and year in which the change was made, and its effect, if any, on production methods:

_____

2. Cost Distribution

What percent of the total manufacturing cost of the reported product in 1951 was:

	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 nonproduction workers, cost of office supplies, maintenance, depreciation, etc.) . .	_____
Total.	100.0

E. OPERATIONS ANALYSIS SHEETS

A. The attached sheets are to be used for obtaining detailed information by operation on production, man-hours, occupations, machinery, and related matters. One sheet should be filled out for each key operation or group of operations.

1. List below the operations for which sheets have been filled out:

Operations	Unit Man-Hours
Total Unit Man-Hours:	

2. Enter in the right-hand column above the unit man-hours for each operation as computed from the operations analysis sheets, and total the figures obtained. If this total differs significantly from the unit man-hours total derived from Section B. 1. a. in the schedule, explain the reasons for the difference below:

---

1. Operations Sheet No. _____ of _____ sheets

Plant name _____

Operation _____

1. Briefly describe this operation: _____
2. Production for a day or other short production cycle:
   a. Length of period _____ hours
   b. Quantity produced _____
3. Employment and Man-Hours by Occupation:
   a. The total man-hours shown should correspond to the total quantity produced in the period specified above.

Plant job title and description	Number of men	Number of women	Total hours

b. Total man-hours for quantity shown in 2 b. _____

4. Machinery and Equipment:
   a. The number of machine units should be the number used to produce the quantity indicated in 2 b.

Name and brief description of equipment: type, size, controls, and special features	Number of machine units	Capacity per unit of time	Actual machinery time for reported production

5. Is incentive system in effect for this operation? Yes___ No___. If yes, describe briefly _____

6. Materials Handling:
   a. Who moves materials to this operation? _____
   b. From where? _____
   c. How? _____
   d. How much at one time? _____

7. Describe examples based on experience during the past 5 years of reductions in man-hours required or in cycle time due to the use of jigs, fixtures, adapter sleeves, combination tools, positioning devices, etc. _____

_____

GLOSSARY

Bastard-cut:	Very coarse spacing of teeth on face of file.
Brinell test:	A test for the degree of the hardness of the surface of the metal.
Chamois:	A piece of leather used in applying oil to metal surfaces.
Coarseness:	Frequency of spacing of the rows of teeth on the face of the file.
Coin:	Stamp precisely. Straighten metal.
Curved-cut:	A special purpose cut of teeth on face of the file.
Direct labor:	Labor employed in actual fabrication or assembly of the tool or its components.
Double-cut:	A double set of teeth on the face of the file. The first set of teeth is called the overcut; the second set is made at a different angle to the file axis and is known as the upcut.
Edges of file:	Surfaces perpendicular to planes of the faces of the file.
Face:	Broad, flat surface of file, on which teeth are cut.
Floorman:	A general handyman.
Gang-cut:	An operation for the simultaneous cutting of more than one file.
Heel:	Shoulder adjacent to the tang of the file. Connects surfaces of tang to surfaces of face and edge of the file.
Indirect labor:	Labor operation such as receiving, shipping, storing, supervision, inspection, maintenance, tooling, production planning, materials handling, factory clerical, and product research which are necessary for production but not directly chargeable to specified output. Indirect man-hours per product in this report are estimated by applying the plant-wide ratios of indirect to direct labor to the direct man-hour for the product.
Length of the file:	Distance from the heel, which is the shoulder adjacent to the tang, to the point of the file.

Mood: The width of the face of the file. The flat file, for example, is normally tapered in width along the length of its face, becoming narrower at the point, and is spoken of as having a tapered mood.

Overhead: In this report, overhead includes manufacturing costs other than direct and indirect labor and material costs. In most plants indirect labor was included in overhead accounts and had to be extracted from overhead in order to obtain the overhead figures used in this report.

Parkco lubriting: Parkco lubriting is a finishing process developed by Parkco Rust-Proof Company of Detroit, Michigan. Parkco lubriting puts a phosphatic coating on the monkey wrench giving it a greyish black finish.

Point: The extreme end of the file opposite the tang.

Production and related workers: Production and related workers include working foremen and all nonsupervisory workers (including leaders and trainers) engaged in fabricating, processing, assembling, inspection, receiving, storage, handling, packing, shipping, maintenance, repairs, janitors, auxiliary production for plants own use, and other services closely related to production.

Production run: The number of units of the product that are produced within a continuous time period.

Productivity: The ratio between a given quantity of production (output) to one or more of the various "input" factors required for such production. 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 industry or between the same industries in different geographic locations. Because of differences in overhead, labor, and material costs, this measure does not indicate relative manufacturing costs.

Reorder point: Point at which the inventory of raw materials or the inventory of the product to be produced drops to a certain prescribed level.

Second-cut: Medium coarse spacing of teeth on face of file.

Seconds: Products which are imperfect and do not meet quality standards of a plant, but are sold on the open market at a reduced price.

Single-cut:	A single set of parallel teeth on the face of the file, diagonal to the longitudinal axis of the file.
Smooth-cut:	Closely spaced arrangement of teeth on face of file.
Standard man-hours:	All man-hours shown in this report are standard man-hours or estimates derived from standards. Standard man-hours are established by company engineers after time study of manufacturing operations. These time standards are usually associated with wage incentive systems. Production excess of standards is generally paid to the worker.
1040 Steel:	Carbon steel, carbon range 0.35 to .45 percent; manganese range .40 to .70 percent; maximum phosphorous .045 percent; maximum sulphur .055 percent.
1050 Steel:	Carbon steel, carbon range 0.45 to .55 percent; manganese range .40 to .70 percent; maximum phosphorous .045 percent; maximum sulphur .055 percent.
1055 Steel:	Carbon steel, carbon range 0.50 to .60 percent; manganese range .90 to 1.20 percent; maximum phosphorous .040 percent; maximum sulphur .055 percent.
Swiss pattern file:	File made to more exacting requirements than machinists' file. Used for precision work.
Tang:	The long narrow neck at one end of the file. The handle of the file is subsequently affixed to this end.
Thimble:	To remove the corner of a bit. Done on a thimbling machine, homemade.
Wavy-cut:	A special purpose cut of teeth in file face.
Wheelebrator:	Trade name for a barrel type tumbler with metal shot to remove scale of rough edges from forgings or castings. Manufacturer is American Wheelebrator and Equipment Corporation.

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