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Case study data on
productivity and factory performance...

5-HORSEPOWER, INDUCTION MOTORS

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Case study data on productivity and factory performance...

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By the
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Case Study Data on
Productivity and Factory Performance

5-HORSEPOWER, INDUCTION MOTORS

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FOREWORD

This report is primarily for the use of European production managers, superintendents, and methods engineers who are concerned with productivity problems. A study of the technical portions of this report should make it possible for these plant officials to compare manufacturing operations in their plants with the operations in one or more of the plants in this study. In addition, the general discussion of productivity and the presentation of man-hours per unit in the manufacture of 5-horsepower induction motors may 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

This report is divided into three chapters. Chapter I is directed primarily to the reader interested in the less detailed aspects of productivity in the industry. Chapter II presents detailed case studies of each plant and will be of value to the plant superintendent or the production engineer. Chapter III 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 changes, industry background information, and a copy of the questionnaire used. A glossary of trade and technical terms completes the report.

The data used for the case studies were obtained from plant records and from plant officials by representatives of the Bureau of Labor Statistics, who visited each plant for the express purpose of making this study. The amount of detail shown in the case studies varies, because some information 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 tables A and B and to the case studies in Chapter II, 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 III contains a reproduction of the questionnaire used to obtain the information from the United States plants in this study. If the European production official will use this questionnaire to calculate labor requirements in his plant, he will be able to compare performance in his plant with performance in the plants discussed in this report, and to isolate areas where his plant's performance is relatively good, or relatively poor.

3. The European plant official can compare the machinery and methods described in the report with those existing in his own plant, for those problem areas he has isolated. At this point, the report does not give him the precise engineering information 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 consulants, 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 conditions.

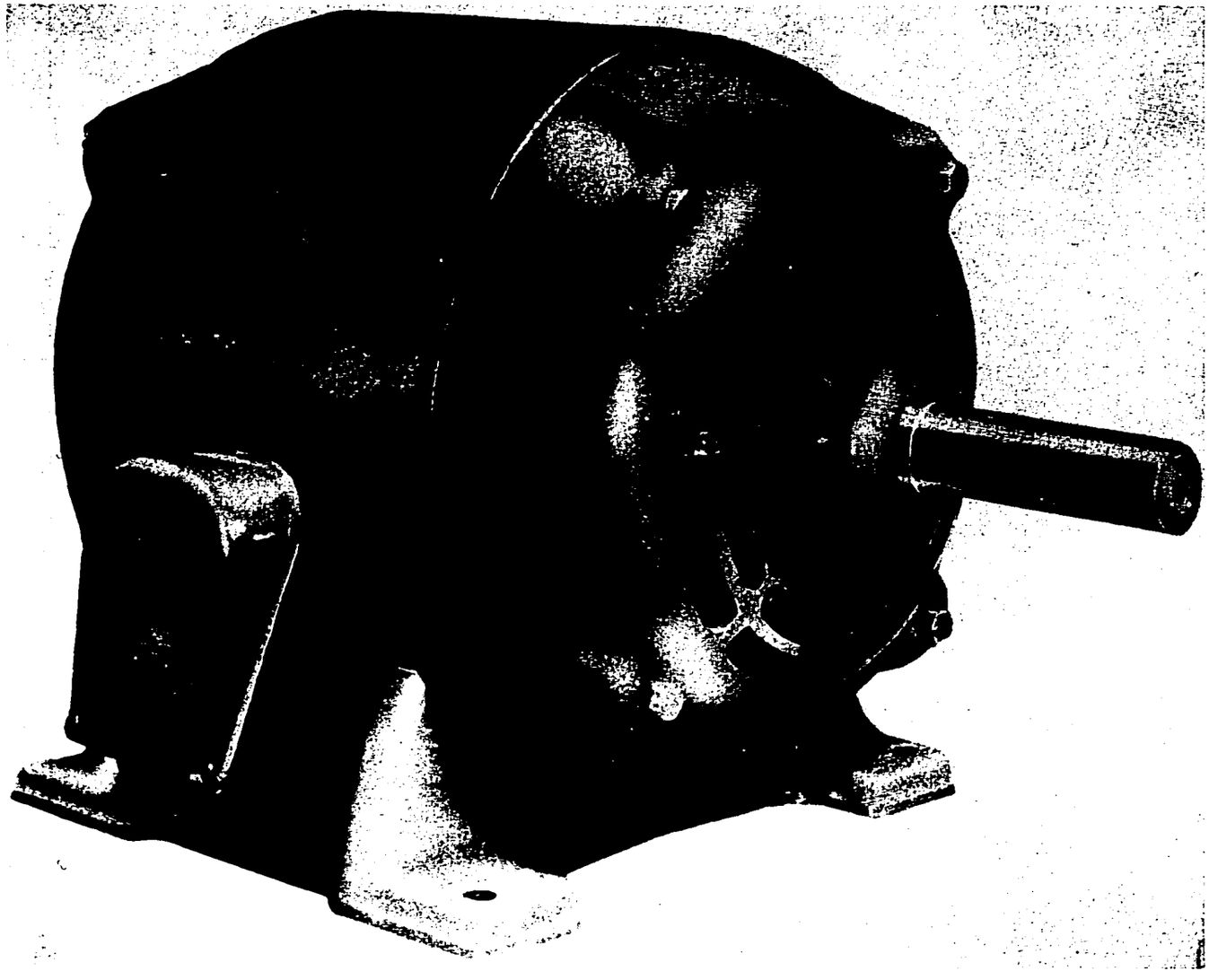

Figure A A 5-horsepower, squirrel-cage, induction motor (frontispiece).

Case Study Data on
Productivity and Factory Performance

5-HORSEPOWER, INDUCTION MOTORS 1/

CHAPTER I: GENERAL REPORT

Highlights

This report discusses manufacturing operations for 5-horsepower, induction motors of squirrel-cage design, made in 5 selected plants. Two plants produce a motor of this type in about 9 man-hours of total factory labor. Another highly integrated plant produces a finished motor in 12 man-hours, and a third plant takes almost 19 man-hours to produce a 5-horsepower motor. (Tables A and B.)

These man-hour requirements are for small lot final assembly of the reported motor. This is true even in the larger companies. Despite small lot assembly, man-hour requirements per motor are kept low through fabrication of parts in relatively large lots, and through careful planning of production for the large variety of motors produced in 4 of the 5 reporting plants. This is possible because parts are frequently standardized for several types of motors in any one plant.

Three of the five companies will process a motor of particular size and specification through the final assembly stages simultaneously with the processing of many other sizes and types of motors. Each operator at his particular stand performs the same type of operation on the different sizes and designs of motors.

The larger companies find it economical to arrange for the fabrication of parts in quantity, since many parts used in one motor are also used in other motors made in the plant. Heavy duty machinery with automatic features is justified for this purpose because parts can be manufactured in lots of 50 to 500, even though final assembly is in lots of 1 to 25 motors. Standardization of motor parts and other electrical apparatus is actively promoted by manufacturers through their trade association, the National Electrical Manufacturers Association.

Efficient production of the wide variety of motors manufactured by four of the plants is also made possible by well developed production planning, scheduling, and control systems. In these the sales, engineering, and

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1/ Prepared by Harry Greenspan, Harold Burak, and Reno Pretti, in the Division of Productivity and Technological Developments, Bureau of Labor Statistics, U. S. Department of Labor

production control departments work in close liaison. The sales department estimates in advance of each production period the number and types of motors required. This is done on the basis of estimated sales, or orders on hand, or both. Availability of raw materials is checked and any deficiencies are corrected. Some parts will be produced for stock, as well as for assembly into scheduled motors, to assure an economical size of run. Other parts will not be manufactured because the amount in stock will be adequate for the production period. The raw materials are scheduled in advance to the most efficient machines that will be available, and routing of parts and subassemblies to assembly areas is planned for the smooth integration of components into motors of the particular specifications ordered.

The number of United States establishments making motors and generators increased from 132 in 1939, to 256 in 1947. In the same period, employment more than doubled and wage payments in the industry more than quadrupled.2/ This growth reflects the increasing demand of the American economy for motors and related products. Successful motor manufacturers have not only increased their output of motors, but have also expanded their activities in the manufacture of other electrical and nonelectrical equipment.

Product Description

All plants in this study reported on the manufacture of a 5-horsepower, induction motor of squirrel-cage design, 1,700-1,800 r.p.m. for 220-440 volt, 60 cycle, 3-phase current, (Fig. A).

An electric motor converts electrical energy to mechanical energy. It can do this because an electric current flowing through a wire wound around a piece of iron creates a magnetic field. If a similarly created electromagnetic force is situated within such a magnetic field it tends to react with it and be forced out of the field. In an electric motor this force is used to turn the motor shaft which then can provide mechanical power to drive other machinery.

Physically an electric motor consists of three major parts:

1. The housings for 5 horsepower motors usually consist of a rolled sheet metal stator frame for the cylinder and gray iron castings for the end covers.

2. The stator, or field, a thicker cylinder made of soft iron or steel, which fits inside the housing. Wire wound into slots in the inner periphery of the stator carries the electric current which sets up the magnetic field. The projecting parts of the stator core between the slots become, alternately, north and south magnetic poles when electricity flows through the windings.

2/ United States Census of Manufactures, 1947.

3. The rotor, or armature, fits into the hollow of the stator but does not touch it as the shaft extending through the rotor's center is supported by the bearings in the housing ends. The rotor carries a second set of windings in slots in its outer periphery to carry the electric current which creates a second magnetic field to react with the stator magnetic field and produce torque or turning force.

The squirrel-cage, induction motor in this report has rotor windings that are not physically connected to an electric current. In this type the rotor bars (windings) are usually copper bars, or aluminum, cast into the rotor core slots and short circuited by end rings making the so-called "squirrel cage." No insulation is used on the rotor windings. Alternating current in the stator windings creates a rotating magnetic field which induces current in the rotor windings, thus magnetizing the rotor core which is then pulled around at a speed slightly below the speed of rotation of the magnetic field of the stator. Four of the plants provided data on squirrel-cage rotors of the type that are constructed of copper rotor bars welded to end rings, and the fifth, plant B, furnished data on a type of squirrel cage which is cast integrally of aluminum.

The reported motors are of the open type, having ventilating openings in the end covers which permit the passage of air from the outside to cool the windings of the stator and rotor. An additional feature of these motors is that the ventilating holes in the end covers are so constructed that any liquid or solid particles falling on the motor cannot enter the motor.

The 5-horsepower, squirrel-cage, induction motor in this report is sturdy, simple in construction, and has constant speed characteristics.

Plant Characteristics

The five plants in this study differ markedly in size, plant layout, type of machinery, products made, and integration of manufacturing operations. Except for plant E, they not only make 5-horsepower motors, but also a large variety of fractional and integral horsepower motors as well as other electrical and metal products. These plants also design and produce motors to meet the electrical specifications requested by a customer.

Buildings and Plant Layout. Except for plant A, none of the buildings were originally constructed for modern production techniques. Most of the older buildings have, however, been modified or enlarged for integration and smooth flow of operations. Only in plant D, is the reported product manufactured in more than one building. The area available varies from 3,500 square feet in plant E, to 500,000 square feet in plant A. Plants A, B, and C are well laid out for materials handling by powered equipment, hand trucks, and conveyors.

Machinery. The degree of mechanization is somewhat similar in all plants, except in E, where automatic precision machinery is absent, and where greater reliance is placed upon the use of handtools. Materials moving is highly conveyorized in plant C which has the lowest man-hour requirements.

Manufacturing Operations. Manufacturing operations are similar but vary with the degree of integration, i.e., amount of work performed and/ or parts manufactured within each plant. Plant comparisons are difficult because of the lack of detail in plants D and E. Plants A and B are similar in their degree of integration, both being highly integrated. All parts, except bearings, small hardware, and insulation are manufactured in plants A and B. Parts are machined or fabricated in lots of 50 or more, although final assembly is in small lots. Frequently, a single motor of the reported specifications will be processed through final assembly. In both plants A and B, the final assembly line simultaneously handles motors ranging in size from 1- to 300-horsepower.

Plants C and D are less integrated than plants A and B and require fewer direct man-hours for fabrication and assembly of a motor. An analysis of the individual operations for the major divisions of the manufacturing process indicates that their superiority in indirect man-hour performance, over plants A and B, is due in part, to the degree of integration. (See figure B for typical work-flow chart in the manufacture of integral horsepower, induction motors.)

The reasons for the high man-hour requirements in plant E are difficult to determine, because, data are lacking for a fine breakdown of operations. However, 2 noticeable factors contribute to the 17 direct man-hours to produce a single motor. They are: (1) specialization in the manufacture of single motors to customer specifications, and (2) a small volume of output which will not justify automatic machinery, special jigs and fixtures, or powered materials-moving equipment.

Size of Runs. Plant A shows the largest size run with 25 to 50 motors on final assembly. All other plants produce a much smaller number. Along with regular production, motors of custom specifications are scheduled through final assembly, their number depending upon the orders received. In plant B, some parts are run through the production line in lots of 50 to 500, although only a few motors are scheduled for final assembly.

Employment Characteristics. As to employment, plants of three distinct sizes are included in the study. One (plant E) has only 10 employees; 2 (plants C and D) are of medium size with about 400 and 500 employees, and the remaining 2 (plants A and B) have over 1,500 employees. Their relative employment does not, however, measure their relative importance in motor manufacture, since plants A and B produce a wide range of electrical products, whereas, plants C and D concentrate most of their efforts on motors.

Wage Systems and Training of New Workers. Direct labor is usually paid by piece rate with a guaranteed minimum. Indirect labor is normally paid on hourly rate or a flat monthly salary. One plant is attempting to install a bonus system for its production workers and a profit-sharing plan for its administrative and supervisory employees. The same plant also employs many handicapped workers. Employees receive little formal training. A new employee is trained on-the-job under the supervision of a foreman or experienced worker. The amount of such training depends upon the nature of the job, but averages about 10 days. In the larger plants, apprentice courses are given in

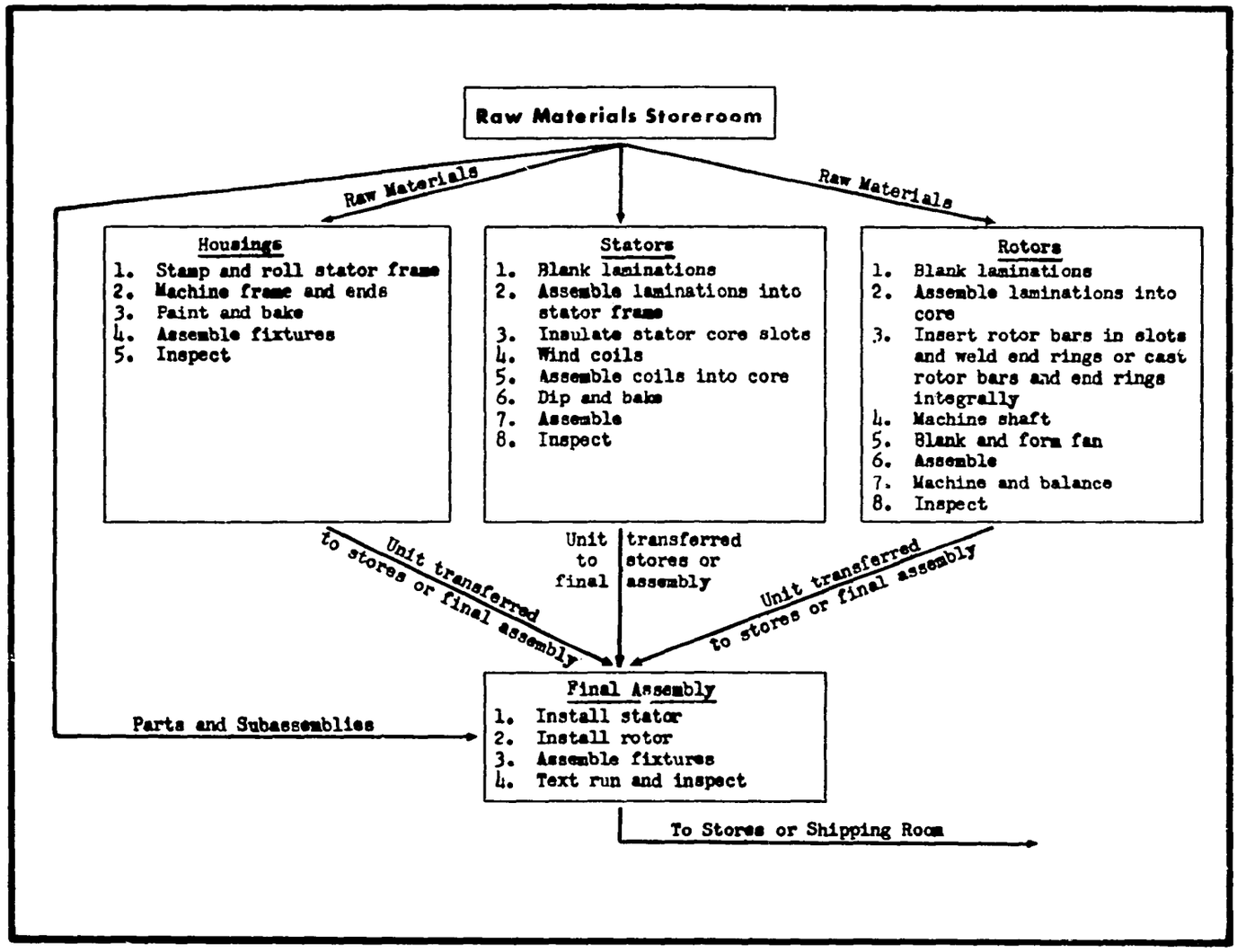

Figure B Work-flow chart for manufacture of 5-horsepower, squirrel-cage, induction motors.

tool-and-die making to selected employees. Supervisors are normally chosen by promotion from within the ranks of the workers.

Engineering Services. All plants stress professional engineering services. These engineers design plant layouts, motors, and tools; they also make time studies and develop standards. Plants A, B, C, and D employ several engineers, and plant E maintains one part-time employee in its engineering department to design special motors for customers.

Table A. Man-hour requirements per unit for the manufacture of 5-horsepower, induction motors, 5 selected plants, U. S. A., 1951

Plant	Man-hours per unit 1/		
	Total	Direct	Indirect
A	15.40	7.30	8.10
B	12.06	9.28	2.78
C	8.56	5.55	3.01
D	9.16	6.47	2.69
E	18.70	17.00	1.70

1/ See appendix III for derivation of unit man-hours.

Table B. Direct man-hour requirements per unit for the manufacture and final assembly of major components of 5-horsepower, induction motors, 5 selected plants, U. S. A., 1951 1/

Part or operation	Direct man-hours in plant -				
	A	B	C	D	E
Housing	1.27757	2.0688	0.750	1.363	3.75
Stator	3.26670	4.3826	2.914	2.950	5.12
Rotor	1.60772	1.9698	1.537	1.306	6.13
Final assembly	1.14788	.8593	.348	.835	2.00
Total	7.29987	9.2805	5.549	6.454	17.00

1/ See appendix III for derivation of unit man-hours.

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CHAPTER II: CASE STUDIES

Introduction

This section contains 5 factory performance case studies on the manufacture of 5-horsepower, induction motors.

By describing the plants in this study and their operating practices, the case studies attempt to present a cross-section of methods used in the manufacture of 5-horsepower, induction motors.

The specifications of the reported product are similar among the 5 plants, all being 3-phase, 60 cycle, 220-440 volt, squirrel-cage design, induction motors, NEMA frame No. 254. Despite the similarity of the final product, it is difficult to make overall comparisons of efficiency between these plants because of differences in integration of manufacturing operations and in the amount of information supplied. It is hoped that the European technician interested in production problems will be able to find descriptions of operations with which he is concerned and will be able to evaluate the efficiency of the methods reported in relation to methods with which he is familiar. The man-hours shown per motor for individual operations are averages for production runs of a few days to 3 months and must be interpreted accordingly. Plants and their respective manufacturing operations are described as fully as permitted by the information supplied and the necessity of safeguarding the identity of the reporting plants.

Manufacturing Process

Manufacture of motors requires the fabrication of parts for the housing, stator, and rotor, their subassembly, and subsequent final assembly into a complete motor which then is carefully tested before shipment.

Housing Fabrication. The motor housing consists of the 2 end covers, the center band or stator frame, a base, terminal box, bearing caps, and additional small parts as shown in the list following table 1. All plants purchase the bearings which are centered in the motor ends and support the shaft.

End covers are received as gray iron castings. They must be drilled for bolt holes and bearings and the inner edge faced and turned concentric with the bearing hole to fit the stator frame. Additional drilling or

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turning operations may be necessary, depending on the design of the motor. The tools most commonly used by the five reporting plants were, multispindle drills for ordinary hole operations, turret or engine lathes for turning the end covers to fit the stator frame and for rough boring of bearing holes, and boring machines for finishing bearing holes. The surface of the bearing hole is finished by diamond boring in plants B, C, and D. Plant E uses a drill press to make its bearing hole.

Only plants A and B reported drilling holes for fastening baffle plates. Plant A, in addition, spends about one-fifth of an hour of direct labor to drill, tap, mill, and paint the oil reservoirs for its sleeve bearing motor and to chamfer the bearings, which in other respects, are purchased finished.

After reduction of direct labor per unit of plants A and B for the operations not reported or not included as direct labor by the other plants, all plants, except C and E, appear to require from four-tenths to one-half hour for common operations.

Plant C appears to have unusually low man-hours and plant E unusually high man-hours. The high man-hours of plant E are explainable by this plant's concentration on production of special design motors, its production of major components in small lots, and the absence of high speed automatic equipment for the machining of housing parts. Plant E would require even higher man-hours if it did not purchase the terminal box and parts for the motor base. Plant C reported low labor requirements for machining, using fewer transfers between machine tools. Unlike plants A and B, plant C does not paint the housing until final assembly.

The stator frame of these motors is a cylinder open at both ends, about 8 inches long and 11 inches outer diameter. Except for the motor of plant D, the stator frame is made of sheet steel about two-tenths inches thick, which is cut to size, rolled, and welded to form a cylinder. For the base, all plants, except plant D, weld feet and feet braces made of sheet steel to the frame cylinder. Plant D purchases a gray iron casting which serves as both stator frame and base. The rolled steel frames are usually welded along their seams while the stator core is being squeezed within the frame. A holding fixture is used in all plants during welding to position the frame, feet, and braces while they are joined by arc-welding. The feet are milled, or ground level, and the edges of the stator ring turned to fit the end covers. At least 4 of the 5 plants provide for air circulation between the stator core and the frame ring. Holes are drilled or perforated for name-plate screws, terminal box screws, and leads.

Methods of making the stator frame and base vary among plants. Only plant B fabricates both frame and base from raw sheet steel. Plant A makes the frame from sheet steel, but purchases the frame feet and braces precut and then finishes them by drilling and grinding. Plant C purchases the frame precut and preformed but fabricates the feet and braces. Plant D purchases a one-piece casting for frame and base and machines this for end cover fit, to receive stator core, and to level the base. Plant E purchases prefabricated parts for its frame and base, welds, and machines them.

Plants D and E did not provide a detailed breakdown of their operations, but the relatively high man-hours of plant D may be due to longer machining time on the gray iron casting design. Plant E's estimated man-hours are high because of the relatively small runs, and the use of light tools without automatic features. Although plant B performs some operations not performed by plants A and C, its relatively high man-hours are largely due to slower times at operations also done by plants A and C. Man-hours and machinery for these individual machining and assembly operations are shown in the tables of case studies of the respective plants.

The terminal box of plant B requires more time than that of plant A largely because of its design, which requires machining a nipple from steel rod and welding the nipple to the sheet-metal box. For its terminal box, plant C drills purchased gray iron casting bases and stamps a sheet-metal cover.

Plant B again has higher man-hours than plants A and C for the remaining operations on the housing. In part, this is due to differences in integration. For example, this plant takes three and one-half minutes to fabricate 3 bolts from steel rod. These bolts are purchased by all other plants. In part, the higher labor requirements are due to design differences. Only plant B makes both inside and outside bearing caps from separate gray iron castings. One quarter hour is devoted to boring, drilling, and tapping the rough castings. The higher man-hours also appear to be due, in part, to slower times at similar operations. A detailed breakdown is given in the tables of this chapter II.

Stator Fabrication and Assembly. The stator assembly consists of a core, windings, leads, and insulation. The stator core is made of annealed, electrical, sheet steel laminations lined up on a close-fitting mandrel and tightly compressed. The number of laminations assembled in each core is measured by weight and varies among plants. For example, plant A uses 198 laminations per motor, whereas, plant B uses only 120 laminations in the core.

Laminations are blanked, notched, slotted, bored, and compressed in all five plants. Punch and notching presses perform the blanking and notching operations which produce stator and rotor laminations simultaneously from sheet metal about .025 inches thick. Slots are punched out smooth and straight by using high-grade punching dies. Stator laminations are welded together under pressure, using special hydraulic machines to form the stator core. The stator core is ground concentric with the frame edge to assure an even air gap between rotor and stator and a balanced magnetic path.

The stator windings consist of preformed coils of heavy insulated wire. The coils for each pole are wound with one continuous wire on forms and then assembled to the stator core. In all five plants, coils were wound on specially designed forms. In plant A, a special coil winding machine and jig were built for this purpose, in plant B, a specially constructed winding lathe and form were used.

These coils are then placed in slots lined with a tough insulator of high dielectric strength. After the coils are placed in position and wedged

securely, all interpole connections are made and terminal leads are attached and firmly secured. After the windings are assembled, the wound stator is baked to drive out all moisture and then completely submerged in a heavy insulating varnish, selected for its penetrating and insulating qualities. When the entire assembly has been sufficiently impregnated, it is baked until completely dried; two dippings and bakings are generally necessary. Cleaning of excess varnish, inspection, and testing are usually the final operations on the stator.

The insulation, sleeving, leads, and cable parts which go into the stator assembly are manufactured in plants A and B, whereas, in plants C, D, and E they are purchased. The insulating parts manufactured in plants A and B are made from 100-percent rag-base insulation paper and pressed board.

Plants C, D, and E did not provide a detailed breakdown of their operations, but the relatively high hours of plant E are probably due to the fact that this firm is small and operates as a job shop relying upon specialty orders. The relatively low man-hours for stator fabrication and assembly, reported by plants C and D, can be attributed to the fact that they purchase all of their insulation, sleeving, leads, and cable parts, whereas, plants A and B manufacture them. The relatively high man-hours of plant B are found almost entirely in the assembly of the insulation and windings to the stator core.

Rotor Fabrication and Assembly. The rotor consists of punched laminations, rotor bars, end rings, shaft, fan or blower, balance weights, rotor core, pulley keys, and additional small parts, such as washers, and baffle spacers. Most of these parts are manufactured by the five plants. Plant A makes all the component parts of the rotor except the balancing weights, which it purchases from the outside. Plant B manufactures all its parts. On the other hand, plants C and D purchase partly finished fans and plant E buys its fans completely finished.

The rotors in these five reporting plants are of the squirrel-cage type—a self-contained unit with a series of conductors around its periphery, permanently short circuited at both ends. There is no mechanical connection with the outside supply or control circuit. Current is induced in the windings by the rotating magnetic field of the stator. The rotor core is made up of laminations punched from annealed electrical grade sheet steel. Each of the plants punch, center, and slot their own laminations on punch presses. The slots are usually skewed to reduce magnetic noise, and to eliminate variation in starting-torque at different positions of the rotor. These laminations are reannealed after punching and assembled under heavy hydraulic pressure into a core.

The windings or bars are punched from copper sheeting on punch presses in plants A, C, D, and E. In three of these plants, small presses are used, but in plant D, a special fixture has been attached to an 80-ton hydraulic press to perform this operation. These bars are then inserted into the skewed slots of the rotor core and welded to the end rings. The rings in plant A consist of 2 copper laminations, punched from copper sheeting, whereas,

in plant C, these 2 rings are cut, formed, pressed into shape, and welded. Assembly of copper bars into the core and welding of the end rings are accomplished on specially constructed fixtures. For instance, plant C uses a special end ring roller and welding jig and plant D employs a turn-table fixture for welding the bars; plant E uses handtools for this operation and makes little effort to erect jigs and fixtures to cut assembly time.

Plant B uses an entirely different technique in the forming and assembly of rotor bars and end rings. This plant molds the rotor bars and ring ends in the rotor core. After the core is built up and the slots skewed 6 degrees, the squirrel-cage is then constructed of aluminum, cast under heavy pressure, to fill the rotor slots, and to form the end rings.

The rotor shaft is cut, turned, milled, threaded, ground, and chamfered and a rotor and pulley keyway milled in all five reporting plants. The machines most commonly used in these operations are, cutoff and centering machines, engine and turret lathes, milling machines, threaders, grinders, and punch presses. Burrs are filed off by hand on workbenches. The machined shaft is then polished and inspected.

Fans and blowers, fixed to the shaft, cool the 5-horsepower motors in this study. Plants A and B manufacture their fans and plants C and D purchase them partly finished. Only in plant E are the fans purchased entirely finished. The semifinished fans bought by plant C are bored and reamed in the plant; in plant D, some machining is done on its fans. In plant A, the ventilating fan hub is blanked from hot-rolled deep drawing steel, pierced, and drawn. The ventilating fan blades (6 per motor) are blanked from steel strips, formed, and inspected. These operations are performed on a half-ton punch press. The blowers of plant B are cast of aluminum. Center holes are bored, chamfered, and reamed on a turret lathe. The blower casting is then sawed into 2 pieces, and inserted, 1 at each end of the assembled rotor.

Balancing constitutes one of the principal operations of this phase of 5-horsepower motor construction and must be performed on all complete rotors to insure smooth running and freedom from vibration. Each rotor is generally statically and dynamically balanced, and this balancing is normally accomplished by adjusting balancing weights which are mounted at each end of the rotor between the end-rings and fans, or weights attached to the ventilating fan.

Other parts or operations consist of manufacturing washers, baffle plates, rotor and pulley keys, and balancing weights. Most of these parts are manufactured in plants A and B, but purchased by plants C, D, and E.

Because plants D and E did not provide the necessary detailed breakdown of their operations, it is difficult to determine the specific reasons for the low man-hour requirements in plant D and the exceedingly high requirements in plant E. In plant E, these high man-hour requirements are again probably due to the relatively small runs, the use of light tools without automatic features, and the production of special design motors. Plant B again, has higher direct man-hours than plants A and C. Man-hours and machinery used for these individual operations are shown in the tables of the case studies of the respective plants.

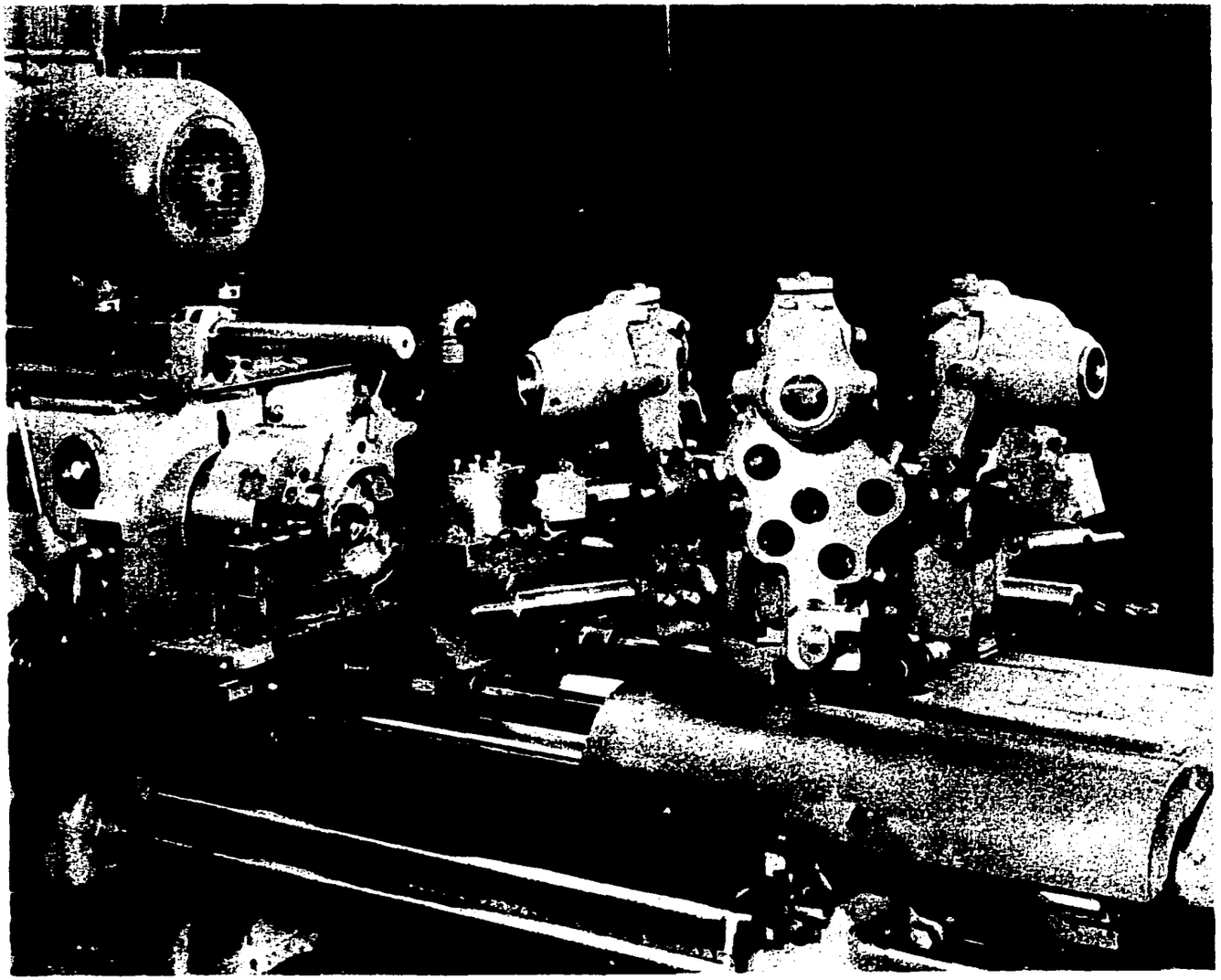

Figure 1 Machining end bells on a turret lathe.

Figure 2 Pressing stator core into frame ring.

Figure 3 Machines and forms for winding coils.

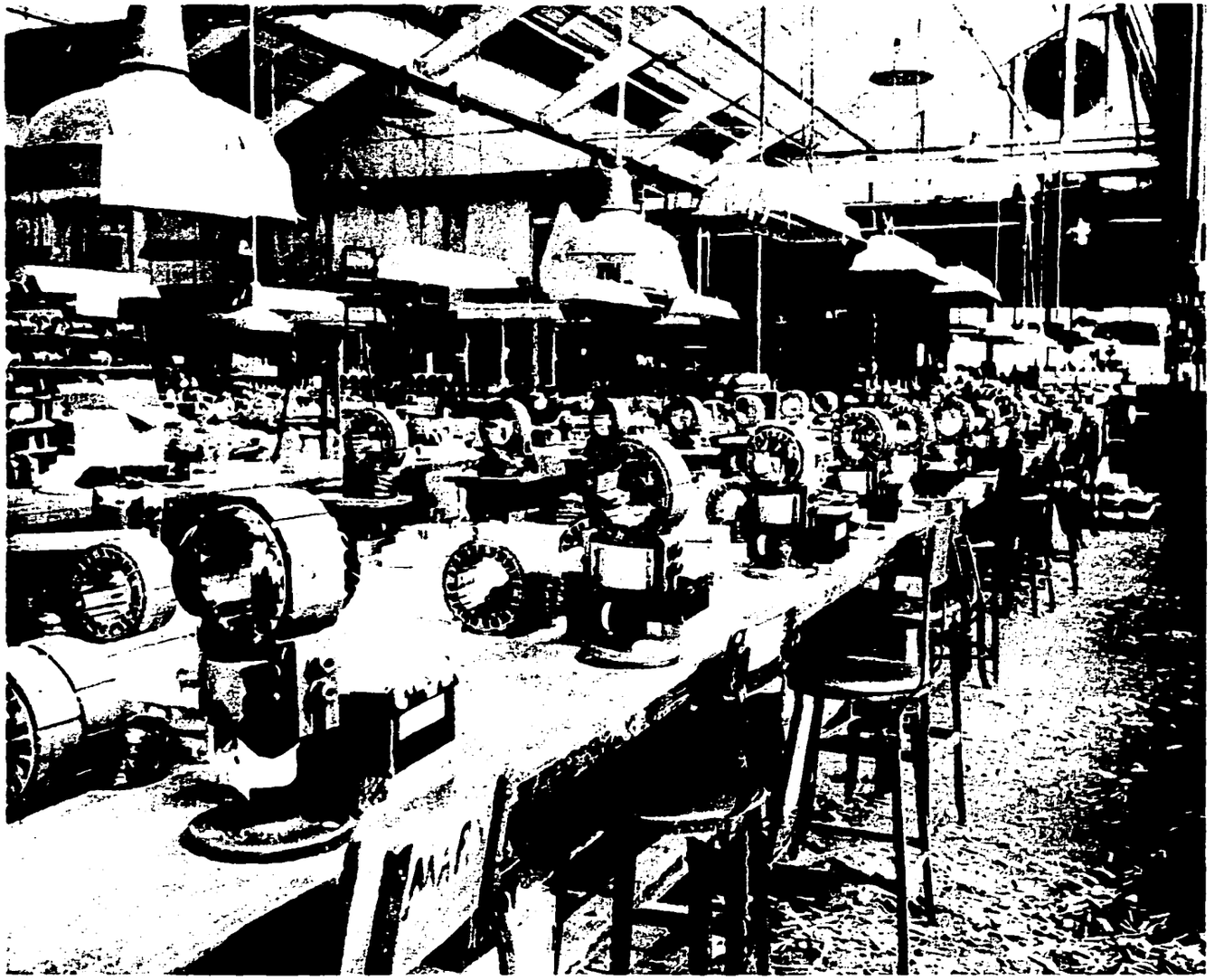

Figure 4 View of insulation and coil insertion procedures for stator assembly.

Figure 5 Dynamic balancing of motors.

Final Assembly. Final assembly consists of putting together the previously fabricated housing, stator, and rotor. In the five reporting plants, cleaning, painting, inspecting, testing, labeling, and crating are an essential part of this operation. Materials movement is by conveyor in plants A, B, and C and by hand trucks in plants D and E.

Table 1. Housing fabrication, 5-horsepower, induction motor: Direct man-hours required per unit, 5 selected plants, U. S. A., 1951

Part	Direct man-hour requirements per unit				
	Plant A	Plant B	Plant C	Plant D	Plant E
Total	1.27757	2.0688	0.750	1.363	3.75
Pair of end covers 1/. .	.68231	.5256	.225	.495	1.50
Stator frame and base. .	.46496	.8816	2/.428	.848	2.25
Terminal box	.04973	.1185	1/.027	.017	(3/)
All other	.08057	.5431	.070	.003	(4/)

1/ Purchased semifinished.
2/ Stator frame purchased precut and preformed. Includes fabrication of base angles and blocks, machining, and welding.
3/ Purchased.
4/ Data not available.

Listed below are other parts manufactured or operations performed, and purchased parts for housing fabrication in these 5 plants.

Plant A	Plant B	Plant C	Plant D	Plant E
Other manufactured parts or operations performed				
Bearing caps Baffle plate 2 caps for oil wells 2 sleeve bearings 2/ 2 oil rings 2 retainer washers 2 thrust washer retainers Insulating bushing	2 outside bearing caps 2 inside bearing caps 2 baffle plates 4 shims 4 bolts 4 cover screws 2/ Assemble 2 end plates and vent shields Conduit nipple	2 grease caps 2 dust caps Bearings Lock washers	Grease caps	(1/)

See footnotes at end of list.

Listed below are other parts manufactured or operations performed, and purchased parts for housing fabrication in these 5 plants--Continued

Purchased parts				
Plant A	Plant B	Plant C	Plant D	Plant E
Sleeve bearings 2/ Oil well parts, gaskets, screws, and plugs Felt washer Thrust washer Screws, nuts, and bolts Frame feet 2/	Ball bearings Screws Washers Gaskets	Ball bearings Oil well caps Stator frame 3/ Bolts Nuts Washers Screws Gaskets Iron castings for terminal box and cover	Ball bearings Grease fittings Stator frame 2/ Small hardware	Ball bearings Terminal box Frame feet and braces Nuts and bolts

1/ Data not available.
2/ Purchased semifinished.
3/ Stator frame purchased precut and preformed. Includes fabrication of base angles and blocks, machining, and welding.

Table 2. Stator fabrication, 5-horsepower, induction motor: Direct man-hours required per unit, 5 selected plants, U. S. A., 1951

Operation	Direct man-hour requirements per unit				
	Plant A	Plant B	Plant C	Plant D	Plant E
Total	3.26670	4.3827	2.914	2.950	5.12
Planking and notching stator laminations	.22512	.2749	.351	.155	.87
Wind coils	.28765	.3767	.300		
Assemble insulation and coils to stator and connect	1.90629	3.0133	1.682	2.795	4.00
Dip in varnish and bake	.38090	.0753	.489		.25
Other	.46674	.6425	.092		(1/)

1/ None reported.

Listed below are other parts manufactured or operations performed, and purchased parts for stator fabrication in these 5 plants.

Other manufactured parts or operations include 1/

Plant A	Plant B	Plant C	Plant D	Plant E
36 slot linings 9 main leads 9 lead tags 2/ 36 sleeving	36 slot linings 36 center strips 36 top cell insulation 72 string 24 sleeving 10 connect insulation, 3-1/2" 6 connect insulation 6" 3 cables, 2' 3 cables, 1-1/2' 3 cables, 1'	Slot insulation 2/	None	None

Purchased parts 1/

Plant A	Plant B	Plant C	Plant D	Plant E
36 field coil wedges 1 field rivet	36 field coil wedges 24 phase insulation terminals	Sleeving Oil muslin Pressed board Slot sticks Friction tape Rivets	Insulation, all types	Insulation Varnish Sleeving Friction tape Rag paper

1/ Other manufactured parts and purchased parts are almost entirely insulation or insulation accessories, although the terminology differs between plants.

2/ Purchased semifinished.

Table 3. Rotor fabrication, 5-horsepower, induction motor: Direct man-hours required per unit, 5 selected plants, U. S. A., 1951

Part or operation	Direct man-hours by components				
	Plant A	Plant B	Plant C	Plant D	Plant E
Total	1.60772	1.9698	1.537	1.306	6.13
Fabrication of rotor laminations	.36076	.2101	.298	.156	.88
Fabrication of rotor shaft	.33482	.6416	.550	.487	2.00
Fan	.02284	.1916	1/.046	1/.068	(2/)
Fabrication of rotor bars and assembly of rotor . .	.69696	.5885	.473	.595	2.25
Balance	.15846	.1437	.152	(2/)	1.00
Other	.03388	.1943	.018	(2/)	(2/)

Other manufactured parts or operations include

Plant A	Plant B	Plant C	Plant D	Plant E
2 shaft sleeves 4 end play washers 1 rotor core key 1 pulley key 1 balancing disc	2 baffle spacers 1 baffle nut 1 rotor core key 1 pulley key 6 balance weights 4 shims	1 rotor core key 1 pulley key	None	None

Purchased parts

4 balancing weights	None	1 fan 1/ Small hardware	1 fan 1/ Small hardware	1 fan Small hardware

1/ Purchased semifinished.
2/ Not reported.

Table 4. Final assembly, 5-horsepower, induction motor: Direct man-hours required per unit, 5 selected plants, U. S. A., 1951

Part or operation	Direct man-hours by components				
	Plant A	Plant B	Plant C	Plant D	Plant E
Final assembly	1.14788	0.8593	0.348	0.835	2.00

Other manufactured parts or operations include

Plant A	Plant B	Plant C	Plant D	Plant E
1 packing crate 1/	None	1 name plate	None	None
Purchased parts 2/				
1 name plate 4 name plate screws 3 direction tags 1 packing crate 1/	1 name plate 2 drive screws 1 eye-bolt 4 pipe plugs 10 screws 14 lockwashers 2 nuts 2 screw bolts 1 crate 1 skid 4 carriage bolts 1 wrapping paper 12 nails	Name plate screws Wire, No. 16 Paint	Miscellaneous small parts	Small hardware

1/ Purchased partly finished.
2/ Detailed listings of purchased parts are given where such information is available.

Case Study, Plant A

Product Description

5-horsepower, induction motor, squirrel-cage design, 60-cycle, 3-phase, 4-pole, 1,750-r.p.m., 220-440 volt, with sleeve bearings. NEMA frame No. 254, open, drip proof.

General Plant Information

Buildings. The reported motor and other electrical products are manufactured in a large, steel frame, multistory building, of over 500,000 square feet, constructed in the last 10 years, and designed for modern production techniques.

Machinery. This plant is highly mechanized. In the production of the 5-horsepower motor reported, it uses several presses of different capacities, both large and small multispindle drill presses, 4 models of turret lathes, 2 of automatic screw machines and milling machines, surface, cylindrical, and centerless grinders, 2 sizes of power shears, tumbling machines, spray booths, baking ovens, an annealing oven, an arc-welder, powered handtools, such as automatic screwdrivers and air chippers, and special motor-manufacturing machinery, such as coil winders, wire cutters, and strippers, balancing machines, and test benches. Jigs and fixtures are used extensively. Materials movement is by lift truck, conveyor, and hoists at some work stations.

Employment and Wage Practices

More than 1,500 employees work in this plant; about 40 percent of them are classified as indirect labor. Direct labor is paid on a piece rate basis with a guaranteed minimum hourly rate. New employees are given only on-the-job training. More than one-third of the production employees are women.

Operating Practices

Variety of Products. This plant makes a large variety of fractional and integral horsepower motors, plus other electrical and metal products. Orders are accepted for custom-designed motors if the customer is prepared to pay the cost of special setup and machining required.

Size of Runs. The minimum-size run of 25 motors, reported by plant A, for final assembly of this 5-horsepower motor, is larger than the minimum reported by any of the other plants in the report. The largest number in 1 final assembly run for this plant's motor has been 50, also the largest run reported. Information was not provided on the size of runs for component parts, but the special tooling and setups indicate larger runs on component parts. Special tooling and larger runs on components are economic, because many parts are standard for several types or sizes of motors.

Professional Engineering Services. This plant employs about 200 workers for specialized engineering services. Their work is divided into three departments - design, methods, and standards. The design department designs the standard motors and other products manufactured and, using standard products as a basis, also designs and develops products for customers. The methods department determines the processing methods for all manufactured parts. Manufacture of the reported motor is divided into approximately 200 different labor operations. This department also designs and builds tools and decides which tools are to be purchased. It is responsible for jigs, fixtures, dies, and gages. The standards department makes time studies and sets rates for all jobs.

The company believes the efficiency of its engineering services is proven. Despite wage increases, unit labor costs have not increased in recent years.

Production Scheduling and Control. Production scheduling for the reported item is accomplished by the following methods. An effort is made by frequent survey, to accumulate sufficient orders, for both stock and customers, to keep the factory at volume operation. If the accumulated work-flow factor is less than that required for full operation, the work force is altered accordingly. Inventory is kept at a minimum by filling orders from stock materials in preference to manufacturing.

Manufacturing Process. The housing end covers for plant A's 5-horsepower motor are made from 2 gray iron castings. These castings are machined concentric with the bearing housing on a turret lathe, the bearing-hole center is bored and additional holes are drilled. Additional holes are also drilled for breather and oil purposes on large multispindle drills. The bearing caps and oil well caps, made of sheet steel, are blanked and formed on a light punch press. Baffle plates are cut, blanked, and pierced from sheet steel. Sleeve bearings are purchased and require only minor finishing.

The stator frame is made from sheet steel, cut to size on a punch press, rolled and welded in the form of a cylinder. Base pads purchased partly finished are welded to the outside of the frame. Eight stator core holding bars, which have been cut and formed, are welded around the inside of the cylinder. The terminal box and cap are blanked and formed from hot-rolled, deep-drawing, steel sheeting.

Laminations for the stator and rotor cores are stamped simultaneously. The stator core is composed of 198 laminations which are blanked and slotted from sheet steel on punch presses. The weighed stack of 198 stator laminations is placed over a tightly fitted mandrel, and rivet is inserted. The bore of the stator core is ground with an internal grinder. Insulation is inserted into the 36 slots of the core. Stator coils are wound on a coil winding machine (3 coils per pole, 4 poles per set), inserted in the insulated slots of the core, then dipped into insulation material and baked in an insulating oven. The stator is then tack-welded to the stator core holding bars and this assembly welded into the stator frame.

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Forty-four rotor conductors formed from copper sheeting on a three-quarter-ton punch press, are placed in the slots of the stacked rotor laminations, then this core is skewed and assembled under heavy hydraulic pressure. After a heat treatment, the conductor bars are welded to the end rings.

The rotor core is pressed onto a cold drawn steel shaft machined to proper dimensions, with an embedded rotor-core key inserted in the keyway, to give the rotor the proper skew for an even torque in all positions of rotation. The ventilating fan is then pressed onto the shaft. The pressing operations are done on a 25-ton hydraulic press with fixtures and jigs attached. The rotor assembly is both statically, and dynamically balanced.

In the final assembly, the stator is assembled to one housing end and leads are connected. The rotor assembly is positioned inside the stator and the other housing end is tapped into place. Detailed descriptions of the individual operations for making the above parts, and for final assembly, are given, together with labor requirements, in the accompanying tables.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
Total direct man-hours to fabricate and assemble complete housing . .	1.81654	1.27757	
A PAIR OF MOTOR END COVERS:			
Material specifications: Gray-iron casting.			
1. Drill (4) 7/16" bolt holes.	0.02180	0.01533	Large multispindle drill, jig, and support.
2. Turn beading, rough center bore . . bearing hole and rough bore and face bottom of washer hole. Face field ring end, rough turn cover fit, rough face field ring seat and face inside hub. Rough bore bearing hole, finish bore bearing hole, finish center bore for bearing, ream and countersink bearing hole. Finish rough turn cover fit, finish rough face field ring seat, and finish bore washer hole.	.34000	.23911	3" x 36", Jones and Lamson turret lathe. Standard, adjustable beading tool with boring bar, adjustable, double arm tool, pulley, cover gage for location of outside end of hub, gage for rough depths and rough length of cover fit, adjustable, single arm tool with reamer, 11.520" ring gage, 1.687"-1.6875" progressive limit plug gage.
3. Drill 4 holes for baffle plate . . (1 end only.)	.01156	.00813	Large multispindle drill, pulley end cover, jig, cover support.
4. Drill 2 holes and tap 2 holes. . . Drill 7/16" oil well plug and oil well holes. Tap 1/4" No. 18, NPT, oil well plug, and oil cup.	.04600	.03235	4-spindle drill, front cover jig with bushing, plates No. 1 and No. 2, 1/4" No. 18, NPT, plug thread gage.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
A PAIR OF MOTOR END COVERS (Cont'd)			
5. Drill 3 and tap 6 holes. Drill . . (1) 1/4" breather hole and 2 No. 20, cap for oil well. Tap (4) 10-32, NF2, for baffle plate and (2) 10-32, NF2, cap for oil well.	0.09760	0.06864	4-spindle drill, and 2 jigs.
6. End mill slot in oil box.	.04180	.02940	Milwaukee milling machine, fixture, gage for lengths, and width of slot in oil box.
7. Seal reservoir. Plug bearing and . oil drain holes. Fill oil reservoir with white lacquer, drain oil reservoir, and wipe lacquer from bearing hole.	.10600	.07455	Bench.
8. Spray. Wipe and spray inside . . and outside with enamel. Load truck and allow to air dry.	.04640	.03263	(1/)
9. Inspect finish.	.00770	.00542	(1/)
10. Ream bearing hole to remove . . . paint.	.02020	.01421	Bench.
11. Finish turn cover, fit and finish, . face field ring seat.	.07716	.05427	Warner and Swasey, No. 3 turret lathe, stub mandrel, 11-1/2" ring gage, cover gage for finish depth.
12. Inspect oil reservoir for fins. . Fit oil ring and force in bearing.	.02774	.01951	Bench, hydraulic press, and support.

See footnote at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
A PAIR OF MOTOR END COVERS (Cont'd)			
13. Face inside end of bearing . . . . and hub. Bore shaft hole, 1 at a time.	0.08180	0.05753	Single-spindle drill, Heald No. 49, boring machine, standard facing fixture, No. 2, for covers, 2-1/4" facing tool with 1.481" pilot, cover face plate, cover boring bar, gages for diameter of shaft hole, for finish depth, and for roundness of shaft hole.
14. Inspect and wrap.	.04440	.03123	(1/)
Total direct man-hours . . . . . to fabricate a pair of motor end covers.	.97016	.68231	
TERMINAL BOX:			
Material specifications: 3/32" x 4-3/16" x 98", hot-rolled, deep-drawing steel. Pickled and oiled. Rockwell hardness, below D 50. Gray enamel.			
1. Pierce 2 holes, 4 lots. Extrude knockouts and blank. Size: 3/32" x 4-3/16" x 12-1/8". . . .	.00402	.00283	Toledo, No. 67 punch press, 6" stroke. Die with pin stops for 4-3/16" strips.

See footnote at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
TERMINAL BOX (Cont'd)			
2. Form 2 screw ears	0.00314	0.00221	Niagara, No. A3-1/2-ton punch press, with 3" stroke. Die with forming block for fastening lugs removed.
3. Form 2 right angles	.00314	.00221	Niagara, No. A5 punch press, with 3" stroke, and die.
4. Form curvature for ring	.00314	.00221	Niagara, No. A3-1/2-ton punch press, die.
5. Stamp type on side where out- . . lets extrude.	.00251	.00177	Punch press, with 1-3/4" stroke. Die with stencil.
6. Inspect.	.00139	.00098	(1/)
7. Spray entire inside and outside . with gray enamel. Allow to air dry.	.01738	.01221	Spray booth and bake oven.
8. Inspect finish, and wrap boxes . in paper, 5 boxes per package.	.00077	.00054	(1/)
Total direct man-hours to fabri-. cate terminal box.	.03549	.02496	
TERMINAL BOX CAP:			
Material specifications: .0438" x 33" x 92", hot-rolled, deep drawing steel, pickled and oiled.			

See footnote at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
TERMINAL BOX CAP (Cont'd)			
1. Shear to 6-5/16" x 92" strips, . . 14 pieces per strip.	0.00054	0.00038	10' shears, powered.
2. Perforate 2 holes and blank. . . .	.00333	.00234	Niagara, No. A3-1/2-ton punch press, with 3" stroke, and die.
3. Form 1st.	.00303	.00213	-Do-
4. Stamp type on inside.	.00213	.00150	Punch press, 1-3/4" stroke, and die with locating pins.
5. Form 2d.	.00363	.00255	Niagara, No. A3-1/2-ton punch press, with 3" stroke, and die.
6. Inspect.	(2/)	(2/)	(1/)
7. Spray entire inside and outside . surface with gray enamel. Allow to air dry.	.00911	.00641	Spray booth.
8. Inspect finish, wrap in paper, . . 5 caps per package.	.00077	.00054	(1/)
Total direct man-hours to fabri- . cate terminal box cap.	.02254	.01585	
ASSEMBLY OF TERMINAL BOX:			
1. Unwrap outlet box and cap, tap . . (2) 10-32 screw holes, fasten cap to box, wrap assembly in paper and place on truck.	.01268	.00892	Haskins tapper and Detroit automatic screwdriver. Standard adjustable support for tapping and standard adjustable support for assembling.
Total direct man-hours to fabri- . cate and assemble terminal box.	.07071	.04973	

See footnotes at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
FRONT COVER BEARING CAP:			
Material specification: .031" x 30" x 96", S29B3 steel.			
1. Shear sheets into strips, ... 2-9/16" x 96" (38 pieces can be blanked from each strip).	0.00018	0.00013	10' shears, powered.
2. Blank disc to 2-9/16" x 2-1/2", . . and draw cup.	.00158	.00111	Niagara, No. A3-1/2-ton punch press, with 3" stroke, and die.
3. Form lip.	.00230	.00161	-Do-
4. Inspect.	(2/)	(2/)	(1/)
5. Burnish for 35 minutes in tum- . . bling barrel with burnishing balls, polishing compound, and water. 40 lb. of bearing caps and 300 lb. of burnishing balls per barrel load.	.00069	.00049	Crown tumbler. (1/)
6. Barrel nickel brite, 30 minutes . . at 12 to 14 volts. Use standard barrel method. 1,000 pieces per load.			
7. Inspect finish.	(2/)	(2/)	(1/)
Total direct man-hours to fabri- . cate front cover bearing cap.	.00475	.00334	

See footnotes at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
PULLEY END BEARING CAP:			
Material specifications: No. 22 gage, .0299" x 30" x 96", S28B1 steel.			
1. Shear sheets into strips, ... 2-9/16" x 96", (38 pieces can be blanked from each strip).	0.00018	0.00013	10' shears, powered.
2. Blank disc to 2-9/16" x 2-1/2", . and draw cup.	.00158	.00111	Niagara, 1/2-ton punch press, with 3" stroke, and die.
3. Form lip.	.00230	.00161	Niagara, No. A3-1/2-ton punch press, with 3" stroke, and die.
4. Pierce center hole	.00209	.00147	Punch press, with die.
5. Inspect.	(2/)	(2/)	(1/)
6. Burnish for 35 minutes in tumbling barrel with burnishing balls, polishing compound, and water. 40 lb. of bearing caps and 300 lb. of burnishing balls per barrel load.	(2/)	(2/)	Crown tumbler.
7. Barrel nickel brite, 30 . . . . . minutes at 12 to 14 volts. Use standard barrel method. 1,000 pieces per load.	.00069	.00049	(1/)
8. Inspect finish.	(2/)	(2/)	(1/)
Total direct man-hours to fabricate pulley end bearing cap.	.00684	.00481	

See footnotes at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
CAP FOR OIL WELL (2 per motor):			
Material specifications: No. 18 gage, .0478" x 30" x 96", S29B2 steel.			
1. Shear sheets into 15/16" . . . . . x 96" strips, 31 strips per sheet. (Each strip makes 23 pieces.)	0.00052	0.00037	10' shears, powered.
2. Pierce 2 holes and cut off. . . . Dimensions: .0478" x 15/16" x 4-5/32".	.00186	.00131	Punch press, with 7/8" stroke.
3. Inspect.	(2/)	(2/)	(1/)
4. Spray entire piece with gray . . . enamel. Air dry, pack in box.	.00690	.00485	(1/)
Total direct man-hours to fabri- . cate 2 oil well caps.	.00928	.00653	
OIL RING (2 per motor):			
Material specifications: Tubing, 3" outside diameter x 2-3/4" inside diameter x 12', B5A2 brass.			
1. Chamfer both ends and cut off. . .	.01960	.01378	Jones and Lamson lathe, gage for length.
2. Remove burrs.	.02100	.01477	Polishing lathe, with emery cloth.

See footnotes at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
OIL RING (2 per motor) (Cont'd)			
3. Inspect.	(2/)	(2/)	(1/)
Total direct man-hours to fabricate 2 oil rings.	0.04060	0.02855	
RETAINER WASHERS (2 per motor) 2-5/16" x 2.751" x 1/32":			
Material specifications: .0299" x 36" x 96", S28B4 steel.			
1. Shear sheets to 2-7/8" x 96" . . . strips. 34 pieces per strip.	.00040	.00028	10' shears, powered.
2. Perforate and blank.	.00145	.00102	Niagara, No. A1-3/4-ton punch press, with 1-1/2" stroke, compound perforating and blanking die.
Total direct man-hours to fabricate retainer washers.	.00185	.00130	
SLEEVE BEARINGS (2 per motor):			
Material specifications: Bearings purchased but require machining.			
1. Grind 45 degree chamfer at both . . ends of slot.	.01760	.01238	Emery wheel.

See footnotes at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
SLEEVE BEARINGS (2 per motor) (Cont'd)			
2. Inspect.	0.00494	0.00347	(1/)
Total direct man-hours to . . . . machine sleeve bearings.	.02254	.01585	
THRUST WASHER RETAINERS FOR BACK COVER (2 per motor):			
Material specifications: .0239" x 30" x 96", S28B2 steel.			
1. Shear sheets into 2-5/16" x 30", . strips. (13 pieces per strip.)	.00010	.00007	36" shears, powered.
2. Blank outside diameter, pierce. . . center hole, and draw cup.	.00296	.00208	Niagara, No. A1-3/4-ton punch press, with 1-1/2" stroke, die, gage for inside diameter, and depth of formed lip.
3. Inspect.	(2/)	(2/)	
Total direct man-hours to fabri- . cate thrust washer retainers.	.00306	.00215	
FABRICATION OF BAFFLE PLATE:			
Material specifications: No. 18 gage, .0478" x 30" x 96", S29B2 steel.			

See footnotes at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
FABRICATION OF BAFFLE PLATE (Cont'd)			
1. Cut sheets into 9-3/8" x 96", . . . strips. (10 baffle plates to be blanked from each strip.)	0.00089	0.00063	10' shears, powered.
2. Pierce .740", center hole. . . .	.00160	.00113	Punch press, with 7/8" stroke, .740" round die.
3. Blank, 9-1/4" disc.	.00216	.00152	Punch press, with 7/8" stroke, 9-1/4" round die, with .738" pilot.
4. Pierce, 6-3/4" center hole. . . .	.00078	.00055	Toledo, No. 5A punch press, with 3" stroke. 6-3/4" round die, with .738" pilot.
5. Pierce 4 holes for screwing to . . motor end.	.00150	.00105	Niagara, No. A3-1/2-ton punch press, with 3" stroke, die, with 6-3/4" centering plug.
6. Inspect.	(2/)	(2/)	(1/)
7. Spray. Load on screen and spray . one side with gray lacquer. Allow to dry. Turn pieces over and spray side with lacquer. Allow to dry.	.01006	.00707	(1/)
8. Remove screen from iron truck. . . Unload screen and pack in box with paper between rows and layers.	.00079	.00056	(1/)
Total direct man-hours to fabri- . cate baffle plate.	.01778	.01251	

See footnotes at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
STATOR CORE HOLDING BAR FABRICATION (8 per motor):			
Material specifications: .109" x 5-1/2" x 96", S29B2 steel.			
1. Cut off and form. Size: .109" x . . 5-1/2" x 1-1/2".	0.01304	0.00917	Niagara, No. A5 punch press, with 7" stroke, die, and gage for length and curvature.
2. Inspect.	(2/)	(2/)	(1/)
Total direct man-hours to fabricate stator core holding bars.	.01304	.00917	
FABRICATION OF INSULATING BUSHING:			
Material specifications: 1" x 13/16" x 36", fiber.			
1. Drill, chamfer both ends, and . . cut off.	.00638	.00449	Warner and Swasey, No. 2 lathe.
2. Countersink to remove cut-off . . burrs.	.00128	.00090	Polishing lathe.
3. Inspect.	(2/)	(2/)	(1/)
4. Bake in oven 1 hour to dry, dip . . in priming oil, and allow to drip off and dry.	.00020	.00014	(1/)
Total direct man-hours to fabricate insulating bushing.	.00786	.00553	

See footnotes at end of table.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
STATOR FRAME AND FEET:			
Material specifications: .21875" x 7" (plus 5/32", minus .000") x 75", S11H1 steel.			
1. Feed stock to press, cut off. . . unload press and load pallet. 2 operators. Size: .21875" x 7" x 36-17/32".	0.01295	0.00911	Toledo, No. 56-1/2 punch press, with 7/8" stroke, die, and gage for length.
2. Pierce 7 holes.	.00420	.00295	Punch press, with 7/8" stroke, and die.
3. Pierce 1 hole.	.00420	.00295	-Do-
4. Drill 4 name plate holes. . . . . Locate with corner of locating blocks to front and stop relocated.	.00833	.00586	Small multispindle drill, and jig.
5. Roll stator frame.	.00880	.00619	K and R, No. 32 bender.
Note: Between operations 5 and 6, bars previously tack-welded to stator core, are tack-welded to field ring. These operations are shown with stator core assembly.			
6. Place assembled stator core in . . frame. Seam-weld stator frame.	.07420	.05218	Arc-welder and 12" field assembly machine. Jaws, plug, center plate, center sleeve, knockout plate, adapter plate, and nose.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
STATOR FRAME AND FEET (Cont'd)			
7. Weld feet onto frame.	0.20790	0.14622	Arc-welder, jig with locating plate, center sleeve clamping plate and locating pin. Gages for location of outlet box holes, parallelism of recess for field studs, and rough height of base pads.
8. Remove slag from base welds . . . and compress core to remove bulge caused by heat when welding.	.03980	.02799	Bench, air chipper, fixture with bottom plate and clamping plate.
9. Rough and finish turn cover . . . fit. Rough and finish face and break inside and outside corners of both cover fits.	.08080	.05683	Sundstrand, 16" stub lathe, jaws and flanges for chuck, plug gage, gage for location of core and for length.
10. Grind bottom of feet.	.12570	.08840	Vertical surface grinder, jig, and gage for finish height of base pads.
11. Drill (4) 17/32" holes in feet. .	.05040	.03545	Large multispindle drill, and jig.
12. Countersink top and bottom . . . . side of 4 holes in feet to remove burrs left by drilling.	.01480	.01041	Bench and tool.

Table 5. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per unit	Adjusted man-hours per unit	Machinery, tools, and gages used
STATOR FRAME AND FEET (Cont'd)			
13. Inspect.	0.[illegible]	0.00125	(1/)
Total direct man-hours for . . . stator frame and feet fabrication and assembly.	.64807	.45579	

1/ Not reported.
2/ Indirect labor.

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Table 6. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
Total direct man-hours for stator... fabrication and assembly.	4.64483	3.26670	
STATOR LAMINATION FABRICATION (198 laminations per motor):			
Material specifications: .025" x 32-1/8" x 109-1/4," S2B1 steel.			
1. Shear sheets into strips, 10-5/8" . . x 32-1/8". (Each strip makes 3 pieces: each piece 1 stator and 1 rotor lamination) (1/2 time for stator and 1/2 for rotor).	.04237	.02980	36" shears, powered.
2. Pierce strips for 36 field wire . . slots, 2 round holes, 4 semi-circular notches in outside diameter, and .740" center hole.	.09042	.06359	Punch press, with 7/8" stroke, die, with 36 wire slot punches inserted.
3. Blank 7", and 10-1/2" discs. Put . . punchings on stand. Put discs on stand. (1/2 of required time allotted to stator and 1/2 allotted to rotor).	.15990	.11246	Punch press, with 2" stroke. 7" and 10-1/2", compound round die, with .738" pilot.
4. Wire field laminations tightly . . . together, with 2 wires into bundles of 200. (Annealing done while laminations are in bundles.)	.02740	.01927	Bench
Total direct man-hours for fabri- . . cation of stator laminations.	.32009	.22512	

Table 6. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
STATOR CORE ASSEMBLY:			
1. Weigh, stack 198 stator laminations . . . over tight fitting mandrel. Insert holding nail.	0.06140	0.04318	Gage for 3-3/4" width of lamination stacking.
2. Insert rivet and tack-weld laminations . onto holding bars. Tack-weld holding bars onto stator frame.	.12100	.08510	Arc-welder, jig, with locating plate, clamping plate, and indicator.
3. Unload wooden truck and load iron . . . truck. Load baking oven and bake to remove moisture.	.03130	.02201	(1/)
4. Unload baking oven and load cooler. . . Unload cooler.	.10490	.07378	(1/)
5. Transfer pieces from iron truck to . . . wooden truck.	.03807	.02677	(1/)
Total direct man-hours to assemble . . . stator core.	.35667	.25084	
FABRICATE FIELD SLOT INSULATION:			
Material specifications: 100 percent rag base insulating paper.			
1. Cut off and form complete. . . . . (36 per motor).	.05436	.03823	Niagara, No. A3-1/2-ton punch press, with 3" stroke, die, with forming block, punch and stop.

See footnote at end of table.

Table 6. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951—Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
FABRICATE MAIN LEADS (9 per motor):			
Material specifications: No. 14, black lead wire.			
1. Cut wire into 28" lengths, strip . . . 1 end 1/4" other end 1" count and tie in bundles of 100. (5 per motor).	0.00495	0.00348	Automatic cutting and stripping machine.
2. Cut wire into 18" lengths, strip . . . 1 end 1/4", and other end 1", count and tie in bundles of 100. (4 per motor).	.00376	.00264	-Do-
Total direct man-hours to fabri- . . . cate leads.	.00871	.00612	
FABRICATE LEAD TAGS:			
Material specifications: Partly machined pieces.			
1. Form tags with characters in a . . . . horizontal position. (9 per motor).	.01692	.01190	Foot press, die, with nest.
FABRICATE SLEEVING:			
Material specifications: Sleeving, in 1-lb. rolls.			
1. Cut red sleeving, 2 at 1 time, ... into 20" lengths and allow to drop into box. (12 per motor).	.00564	.00397	Automatic cord cutting machine.

Table 6. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
FABRICATE SLEEVING--Continued			
2. Cut white sleeving, 2 at 1 time, into 20" lengths and allow to drop into hausner box. (12 per motor).	0.00564	0.00397	Automatic cord cutting machine.
3. Cut blue sleeving, 2 at 1 time, into 20" lengths and allow to drop into hausner box. (12 per motor).	.00564	.00397	-Do-
Total direct man-hours to fabricate sleeving.	.01692	.01191	
ASSEMBLE STATOR:			
1. Grind bore of stator core, 7.002", plus .003", minus .001".	.11440	.08046	Heald, No. 72A5 internal grinder, face plate, clamps, 7.000" -- 7.005", round tapered plus gage.
2. File 36 slots and clean with air.	.03510	.02469	Bench, .095" thickness gage.
3. Insert cuffed insulation into 36 slots.	.17300	.12167	Bench.
4. Wind coils, 3 coils per pole, 4 poles per set. Tie each coil in 2 places, 36 coils, 3 phase, lap winding, ends of winding 15" long, 33 turns per coil.	.40900	.28765	Coil winding machine, jig.

Table 6. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
ASSEMBLE STATOR--Continued			
5. Assemble field. Note: high voltage . . motor--use extreme care when insulating and test for shorts between phase before making star connection. At 1,750 volts, ground test board. Check part number on ring. Cut colored sleeving 24 pieces for between poles and ends of winding. Cut bias tape, 60 pieces for lapped coils. Insert coils and wedges into slots and insulate between lapped coils and end wire of each phase. Shellac end wire insulation to coils and trim tape. Skin, twist, solder, tape, place, and tie 1 connection. Pull leads through coils 12 ends. Skin and twist 9 connections. Tie last coils in 2 places. Finish block coils so they will clear armature bore and stud holes. Tie tag to coils on end opposite part number and tag sleeved leads. Test for opens. Refer to connection, diagram. Direction of rotation is counter clockwise, reversible, viewing end opposite part number on field ring. Sleeve ends of winding at right of field ring on part number end, with feet at bottom.	2.52550	1.77618	Bench.

Table 6. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
ASSEMBLE STATOR--Continued			
6. Inspect general appearance, blocking . . of coils, and condition of wedges. Test for grounds. Test for shorts and reverses. Refer to connection diagram. Direction of rotation is counter clockwise, reversible, viewing end opposite part number on field ring.	0.01200	0.00844	Test bench.
7. First dipping, baking, and cleaning. . . 5 operators.	.27080	.19045	Insulating oven.
8. Second dipping, baking, and cleaning. . . 5 operators.	.27080	.19045	-Do-
9. Wipe to remove dust and dirt. . . . . Protect coils and leads. Spray outside of stator frame with gray enamel. Air dry.	.05400	.03798	Spray booth.
10. Inspect.	.00656	.00461	(1/)
Total direct man-hours to machine . . . core and assemble stator.	3.87116	2.72258	

1/ Not reported.

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
Total direct man-hours for fabrication . . and assembly of rotor.	2.28596	1.60772	
FABRICATION OF ROTOR LAMINATIONS (205 laminations per motor):			
Material specifications: .025" x 32-1/8" x 109-1/4", S2B1 steel.			
1. Shear sheets into strips, 10-5/8" . . . . . x 32-1/8". (Each strip makes 3 pieces; each piece 1 stator and 1 rotor lamination) (1/2 time for stator and 1/2 for rotor).	.04237	.02980	36" shears, powered.
2. Blank, 7" and 10-1/2" discs. Put . . . . . punchings on stand. Put discs on stand. (1/2 of required time allotted to stator and 1/2 allotted to rotor.)	.15990	.11246	Punch press, with 2" stroke. 7" and 10-1/2", compound round die, with .738" pilot.
3. Pierce armature conductor slots, vent . . . holes, identification hole, and 1.815" center hole, with keyway. Put punchings on stand.	.27265	.19175	Punch press, with 7/8" stroke, die, with .738" pilot.
4. Weigh into bundles of 300 punchings. . . . Wire tightly together with 2 wires.	.02870	.02018	Bench.
Total direct man-hours to fabricate . . . . rotor laminations.	.50362	.35419	

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
ROTOR COPPER LAMINATIONS (2 per motor):			
Material specifications: .0253" x 7-1/8" copper in random lengths. 99-5/8" length preferred, C2A4 copper.			
1. Pierce armature conductor slots, vent holes, identification hole, and 1.815" center hole, with keyway and piece, 7-1/8" x 7-1/16".	0.00280	0.00197	Punch press, with 7/8" stroke, and die.
2. Blank 7" disc.	.00288	.00204	Toledo, No. A5, punch press, with 2" stroke, 7" round die, with 1.813" pilot.
3. Blank 3-3/8" disc.	.00300	.00210	Punch press, with 7/8" stroke, 3-3/8" round die, with 1.813" pilot.
4. Weigh punchings and wire together in bundles of 50.	.00065	.00046	(1/)
Total direct man-hours to fabricate rotor copper laminations.	.00933	.00657	

See footnote at end of table.

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
ROTOR CONDUCTORS (44 per motor):			
Material specifications: .050" x 1", plus .010", minus .010" x 94". C2A2 copper.			
1. Pierce, cut off, form, and . . . . . flatten. Size: .050" x 1" x 4-5/8".	0.04400	0.03095	Niagara, No. A1-3/4-ton punch press, with 1/2" stroke, die, with step adjusted for proper length.
2. Inspect.	(2/)	(2/)	---
Total direct man-hours to . . . . . fabricate rotor conductors.	.04400	.03095	
SHAFT:			
Material specifications: 1.825" rod x 12' long, S4B1 steel.			
1. Cut rod to 19-11/16".	.04350	.03059	Warner and Swasey, No. 5 lathe, with gage for length.
2. Turn first end, face and . . . . . chamfer, rough turn, 1.4975" x 3-3/4", turn 1 undercut, and center.	.06300	.04431	Warner and Swasey, No. 5 turret lathe, micrometer, gages for length and diameter of undercut, standard gage for depth of center in shaft, 15/16" and larger in diameter.
3. Turn 2d end. Face and chamfer, . . rough turn, 1.12475" x 3-3/8", turn 1/16" radius, turn 1.4975"x 4-1/4", turn 1 undercut, center, chamfer end of, 1.4975" x 4-1/4", cut.	.16148	.11357	-Do-

See footnotes at end of table.

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
SHAFT--Continued			
4. Mill armature keyway, ... 3 at 1 time.	0.00461	0.00324	Browne and Sharpe, milling machine, 1/4" keyway gage, keyway micrometer, and gage for length.
5. Grind unturned portion of . . . . shaft, 1.81175" x 8-1/4".	.06060	.04262	Grinder and micrometer.
6. Spline.	.00657	.00462	Toledo, No. 56-1/2" punch press with 7/8" stroke, die, go and no go gages for diameter of spline, and gage for length.
7. Rough grind, 1.4975" x 3-3/4" . . portion of shaft.	.01710	.01203	Grinder and micrometer.
8. Rough grind, 1.4975" x 4-1/4" . . portion.	.01785	.01255	--Do-
9. Rough grind, 1.12475" x 3-3/8". . portion.	.01420	.00999	-Do-
10. Finish grind, 1.12475" x . . . . 3-3/8" portion.	.01755	.01234	-Do-
11. Finish grind, 1.4975" x . . . . 4-1/4" portion.	.02190	.01540	-Do-
12. Finish grind, 1.4975" x . . . . 3-3/4" portion.	.01960	.01378	-Do-
13. Mill keyway in extension . . . . end, 2 at 1 time.	.00744	.00523	Browne and Sharpe, milling machine, keyway gage, keyway centering gage, keyway micrometer, and gage for length.

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
SHAFT--Continued			
14. File to remove burrs left . . . by milling keyway in extension end and polish to remove file marks.	0.00715	0.00503	Bench.
15. Inspect.	.01353	.00952	-Do-
Total direct man-hours to . . . fabricate shaft.	.47608	.33482	
SHAFT SLEEVES (2 per motor):			
Material specifications: 2-1/4" x 12' rod, SAE 1113, cold-drawn, free-cutting steel, AISI-B1113.			
1. Cut off, to 2-1/4" x 27/32", . . and drill. 2 operators operate 3 machines.	.01216	.00855	New Britain-Gridley, 6-spindle, automatic chucking machines, micrometer, form tool, 1.809"-1.810", double end limit plug gage, gage for length.
2. Remove burrs left by cutting,. . with scraper.	.01080	.00760	Polishing lathe, stub mandrel.
3. Grind, 2.187" outside diamter. .	.00290	.00204	Cincinnati, No. 2 centerless grinder, and micrometer.
4. Inspect.	.00480	.00338	Bench.
Total direct man-hours to . . . fabricate 2 shaft sleeves.	.03066	.02157	

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
VENTILATING FAN HUB:			
Material specifications: .062" x 30" x 96", hot rolled, deep drawing steel, pickled and oiled, Rockwell hardness, below B 50.			
1. Shear sheets to 7-3/16" x 96", strips.	0.00068	0.00048	10' shears, powered.
2. Pierce, 5/8" center hole, blank disc from piece 7-3/16" x 7-1/16", (13 per strip) and partly draw hub.	.00192	.00135	Niagara, No. A3-1/2-ton punch press, with 3" stroke, die, and gage for depth of first draw.
3. Pierce 6 vent holes and 1-17/32" center hole.	.00389	.00274	Niagara, No. A3-1/2-ton punch press, with 3" stroke, and die.
4. Draw cone around hub and finish draw hub.	.00159	.00112	Niagara, No. A3-1/2-ton punch press, with 3" stroke, die, 1.806"-1.808", progressive limit plug gage.
5. Trim, 6-15/16" outer diameter.	.00150	.00105	Niagara, No. A3-1/2-ton punch press, and die.
6. Inspect.	.00083	.00058	(1/)
Total direct man-hours to fabricate ventilating fan hub.	.01041	.00732	

See footnotes at end of table.

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
VENTILATING FAN BLADE (6 per motor):			
Material specifications: .050" x 30" x 96", steel.			
1. Shear sheets to 4-5/8" x . . . 96", strips.	0.00066	0.00046	10' shears, powered.
2. Blank, 71 pieces per strip. .	.00804	.00565	Niagara, No. A3 punch press, with 3" stroke, and die.
3. Form complete.	.00840	.00591	Niagara, No. A3-1/2-ton punch press, with 3" stroke, die, with locating plates.
4. Inspect.	.00498	.00350	(1/)
Total direct man-hours to . . fabricate ventilating fan blades.	.02208	.01552	
END PLAY WASHERS, 1.510" x 1-15/16" x .010" (2 per motor):			
Material specifications: .010" x 2-1/16" x 72", half hard, cold rolled steel, Rockwell hardness, B 70-80.			
1. Pierce inside and blank . . . outside diameter.	.00167	.00117	Niagara, No. A3-1/2-ton punch press, and compound washer die.

See footnotes at end of table.

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
END PLAY WASHERS, 1.510" x 1-15/16" x 1/64". (2 per motor):			
Material specifications: (2 per motor) 1/64" x 30" x 96", S28B4 steel.			
1. Shear sheets to 2-1/16" x 96", . . strips. 48 pieces per strip.	0.00028	0.00020	10' shears, powered
2. Pierce inside and blank outside diameter. . .	.00167	.00117	Niagara, No. A3-1/2-ton punch press, and compound washer die.
Total direct man-hours to . . . fabricate end play washers.	.00195	.00137	
POLISHED SPRING STEEL END PLAY WASHERS, 1.510" x 1-15/16" x 1/32". (2 per motor):			
Material specifications: 1/32" x 2-1/16", S19B2 steel, in coils.			
1. Pierce inside and blank outside diamter. . .	.00116	.00082	Niagara, No. A3-1/2-ton punch press, with 3" stroke, and compound washer die.
2. Tumble 5 to 8 hours to deburr . . and polish. 5,000 washers, 400 lb. of No. 4a, granite chips, and water per compartment load.	(2/)	(2/)	Crown tumbler.

See footnotes at end of table.

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
POLISHED SPRING STEEL END PLAY WASHERS--Continued			
3. Burnish for 45 minutes with . . . . burnishing soap, hot water, and cyanide. 30 cyanide balls and 5,000 washers per load. Stop tumbler, separate washers from balls with separating riffle. Rinse thoroughly in cold water to remove all soap. Degrease and spray in trichlore ethylene to remove water. Centrifuge dry.	(2/)	(2/)	Crown tumbler.
4. Inspect.	(2/)	(2/)	(1/)
Total direct man-hours to . . . . . fabricate polished spring steel end play washers.	0.00116	0.00082	
END PLAY WASHERS, 1.510" x 1-15/16" x 1/32". (4 per motor):			
Material specifications: .0299" x 36" x 96", S28B4 steel.			
1. Shear sheets to 2-1/16" x 96", . . strips. 48 pieces per strip.	.00057	.00040	10' shears, powered.
2. Pierce inside and blank outside . . diameter.	.00232	.00163	Niagara, No. A3-1/2-ton punch press, with 3" stroke, and washer die.

See footnotes at end of table.

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Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
END PLAY WASHERS--Continued			
3. Inspect.	(2/)	(2/)	(1/)
Total	0.00289	0.00203	
Total direct man-hours to . . fabricate end play washers.	.00767	.00539	
ROTOR CORE KEY, 1/4" x 27/32".			
Material specifications: 1/4" sq. x 12', S34B1 steel.			
1. Cut to size. 1 operator . . . operates 3 automatic screw machines.	.00119	.00084	Brown and Sharpe, No. 00 automatic screw machines. 3/4" gage for length.
2. Remove burrs left by . . . . . cutting off from 4 sides on both ends.	.00405	.00285	Emery wheel.
3. Inspect.	(2/)	(2/)	(1/)
Total direct man-hours for . . rotor core key.	.00524	.00369	

See footnotes at end of table.

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
PULLEY KEY, 1/4" square x 2-19/32":			
Material specifications: 1/4" square x 12', S34B1 steel.			
1. Cut to length. 1 operator . . . . for 3 automatic screw machines.	0.00119	0.00084	Browne and Sharpe, No. 00 automatic screw machines, and 2-1/2" gage for length.
2. Remove burrs left by cutting . . . off from 4 sides on both ends.	.00340	.00239	Emery wheel.
3. Inspect.	(2/)	(2/)	(1/)
Total direct man-hours for . . . . pully key.	.00459	.00323	
ASSEMBLY OF ROTOR:			
1. Weigh and stack armature . . . . . laminations, insert holding nail, and insert 44 conductors.	.13360	.09396	(1/)
2. Twist conductors 2" to 2-1/8" . . pitch. Coin conductors.	.04033	.02836	250-ton hydraulic press, gage for twist, compound head, compound plug, compound ring, compound plate, and base.
3. Preheat for 30 minutes at . . . . 800°F. Remove from furnace 1 at a time and weld conductors to side copper, using 3/32" phosphor copper, welding rod.	.38900	.27358	Electric furnace.

See footnotes at end of table.

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
ASSEMBLY OF ROTOR--Continued			
4. Ream shaft hole, fit key . . . . . into shaft, press in shaft and stamp type and order number.	0.07740	0.05444	Large, single-spindle drill, 25-ton hydraulic press, fixture, gage for diameter of shaft hole.
5. Grind outside diameter, 6.963" . . . plus .001", minus .002".	.17480	.12294	Grinder.
6. Inspect.	.00847	.00596	Bench.
7. Paint outside diameter and both . . ends of rotor with black paint.	.04060	.02855	-Do-
8. Press on balance disc.	.01167	.00821	25-ton, hydraulic press.
9. Press on ventilating fan.	.02013	.01416	25-ton, hydraulic press and punch for ventilating fan.
10. Press on shaft sleeves. Note: . . Apply coat of glyptal sealing compound between shaft and shaft sleeves.	.04580	.03221	25-ton, hydraulic press, punch for pressing on shaft sleeves.
11. Static balance--check location . . . of light point and mark. Clinch balancing weights in holes in ventilating fan. Recheck balance.	.05930	.04171	Bench, balance tracks, and tool.

Table 7. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
ASSEMBLY OF ROTOR--Continued			
12. Dynamic balance--check . . . . . location of light point and mark. Clinch balancing weights in holes in ventilating fan and balancing disc. Allowable limits for out of balance--dial reading, 20 left: 10 right. Recheck balance.	0.16600	0.11675	Globe balancing machine, small, single-spindle drill, and tool.
13. Second inspection.	.00518	.00364	Bench.
Total direct man-hours for . . . . assembly of rotor.	1.17228	.82447	

1/ Not reported.
2/ Indirect labor.

Table 8. Final assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
Total direct man-hours for final assembly . .	1.63213	1.14788	
1. Assemble frame. Place stator on bench. . . . Pry coils to clear stud holes and cut loose string ends. Remove leads and tag from bore of stator frame, sign tag. Check type, voltage, and order number. Scrape bottom of base. Scrape cover fit, and cover fit face on both ends of stator frame. Ream bushing hole. Position bushing and drive into field ring. Start and tighten 4 outlet box screws. Cut and skin 18 field leads. Connect 9 line leads to field. Solder and tape 9 connections. Place connections and make 4 double string ties. Bring 9 leads through bushing. Cut and skin 9 line leads to length. Tag leads, T1 to T9, 4" from bushing. Check field bore for high spot and remove with a file. Clean field bore and both ends of stator frame with air. Prepare 4 field bolts. Unwrap back cover. Retap, (2) 10-32 NF, for oil well cap and (2) 1/4"-18 NPT, for oil well plug and gage. Clean cover with air. Test for opens and grounds. Clean frame and apply decal name plate. Coat decal with clear varnish.	.71730	.50448	Bench and punch for bushing.
2. Frame ground test.	.01300	.00914	Test bench.

Table 8. Final assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
3. Assemble motor. Stamp identification on . . . stator frame. Sign tag and tie to line leads. Trim string ends. Place back cover on bench. Start and tighten oil well plug into back cover. Wipe bearings with towel. Blow out with air. Drive steel retaining washer and felt washer into cover. Apply glyptal around outer edge of steel retaining washer. Blow out field ring with air. Place armature on bench. Remove burrs on both ends of stacking with a file. Straighten ventilating fan. Polish both ends of shaft. Assemble 2 thrust washer assemblies. Clean with air and fit 1 assembly on each end of shaft. Clean and oil shaft. Add necessary end-play washers on both ends of shaft. Oil washers. Position rotor into field. Position back cover onto field and block on. Unwrap front cover. Retap (2) 10-32 NF holes for oil well caps, (4) 10-32 holes, for baffle plate, and (2) 1/4"-18 NPT holes, for oil well plug and gage. Wipe bearing and blow out cover with air. Position baffle plate and start and tighten 4 screws. Position felt and steel, retaining washer into front cover and drive in. Apply glyptal around outer edge of retaining washer. Start and tighten oil well plug. Insert 4 studs into frame. Align front cover and block onto frame. Check and adjust end-play and shaft extension. Start and tighten 4 cover nuts. Ground test at 500 volts. Connect leads and run motor for each voltage.	0.39539	0.27808	Bench, punch for felt and retaining washers, tool and pilot for fitting thrust washers on both ends of shaft, gage for height of shaft. Polishing machine on dolly.

Table 8. Final assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant A, U. S. A., 1951--Continued

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used
4. Stamp name plate.	0.00444	0.00312	Arbor press and fixture.
5. Pack oil wells and fit name plate. Fit . . bearing cap into each cover. Fit oil gage into each cover. Position name plate onto motor and fasten with 4 drive screws. Fit shaft key. Position gasket and oil well caps onto each cover and start and tighten 4 screws.	.09400	.06611	Bench.
6. Stencil voltage and frequency on stator . . frame in case of odd voltage or frequency only.	.00800	.00563	-Do-
7. Test as per testing instructions.	.22400	.15754	Test bench.
8. Ground test.	.02200	.01547	Test room.
9. Make ready to ship. Clean motor. Tape . . shaft key and grease shaft extension.	.02400	.01688	Bench.
10. Pack. Remove tag, check, and write . . . . packing slip. Drill 4 holes in base of packing crate. Place 4 bolts and washers in base. Fit Kraft paper on base. Lift motor from dolly with air hoist and place on base. Place washers on bolts. Start and tighten 4 nuts. Place outlet box by motor. Wrap motor with Kraft paper and tie with string, 2 turns. Form crate around motor and bend 3 wire loops and clinch with hammer. Stencil complete and place on truck. Tack packing slip to crate.	.13000	.09143	(1/)

1/ Not reported.

Table 9. List of parts, 5-horsepower, induction motor, and related data, plant A, U. S. A., 1951

Part name	Number per motor	Made in plant	Purchased
End plates 1/	2	x	x
Bearing caps	2	x	---
Oil well caps	2	x	---
Gaskets for oil well caps	2	---	x
Screws for oil well caps	4	---	x
Oil well plugs	2	---	x
Oil gages	2	---	x
Sleeve bearings 1/	2	x	x
Oil rings	2	x	---
Retainer washers	2	x	---
Felt washers	2	---	x
Back cover thrust washer retainers	2	x	---
Thrust washers	2	---	x
Baffle plate	1	x	---
Baffle plate screws	4	---	x
Outlet box	1	x	---
Outlet box screws	4	---	x
Stator frame	1	x	---
Cover nuts	4	---	x
Field studs	4	---	x
Base pads 1/	2	x	x
Stator punchings	198	x	---
Stator core holding bars	8	x	---
Field slot insulation	36	x	---
Sleeving 1/	36	x	x
Field coil wedges	36	---	x
Main leads	9	x	---
Lead tags 1/	9	x	x
Insulating bushing	1	x	---
Field rivet	1	---	x
Rotor iron punchings	205	x	---
Rotor copper punchings	2	x	---
Rotor conductors	44	x	---
Shaft	1	x	---
Shaft sleeves	2	x	---

1/ Purchased partly finished.

Table 9. List of parts, 5-horsepower, induction motor, and related data, plant A, U. S. A., 1951--Continued

Part name	Number per motor	Made in plant	Purchased
Ventilating fan hub	1	x	---
Ventilating fan blade	1	x	---
End play washers	4	x	---
Rotor core key	1	x	---
Pulley key	1	x	---
Balancing disc	1	x	---
Balancing weights	4	x	---
Name plate	1	---	x
Name plate screws	4	---	x
Direction tags	3	---	x
Packing crate 1/	1	x	x

1/ Purchased partly finished.

Case Study, Plant B

Product Description

5-horsepower, 220-440 volt, 3-phase, 60-cycle, 1,750-r.p.m., squirrel-cage design, induction motor, NEMA, open frame, No. 254.

General Plant Information

Buildings. Manufacture of large motors by this plant is done in a brick and steel column building of about 100,000 square feet on the main floor, with an additional 20,000 square feet in the balconies. The building is over 40 years old, but has been improved for modern manufacturing techniques. Lighting is excellent, floors good, and aisle space is adequate for use of powered, materials-handling equipment. This building is only one of several used by this plant for its varied manufacturing activities.

Machinery. Although this plant reports the use of much heavy duty, automatic machinery - punch presses, turret lathes, automatic screw machines, multispindle drills, boring machines, and conveyorized dip coating of parts - it also reports, more frequently than plant A, the use of machinery without the automatic features usually associated with high speed - such as hand screw machines, single-spindle drills, and a cutoff saw.

The company is well equipped with powered materials-handling equipment. About 10 cranes are available to service the entire area of the main floor and balconies. Powered forklift trucks transfer raw materials between buildings and materials in process, within the building. Parts are stacked on pallets or placed in platform boxes having tiering and lug attachments for handling by lift trucks or cranes and for vertical storage. Roller conveyors are used in subassembly and final assembly. Each operator has a modern materials-handling device at hand for assistance in placing the parts into a machine, onto a bench, or transferring parts to the next operation.

Employment and Wage Practices.

About 2,500 persons work in the several buildings at the location of this plant. Only a portion work in the building devoted to heavy motor manufacture. Ninety-five percent of the direct labor in this plant is paid on a piece rate basis. Time standards, once set, are not changed unless methods change. New employees are trained for 1 day to a week, depending on the job. Apprentice courses are given in tool-and-die making. Supervisors are obtained by promotion of workers.

Operating Practices

Variety of Products. Motors, from 1-horsepower to 300-horsepower, are produced in the building where the reported 5-horsepower motor is manufactured. A wide variety of electrical equipment is produced in other buildings at the same location. This plant will design and produce motors to meet the electrical specifications requested by a customer.

Size of Runs. In this plant, the reported 5-horsepower motor has not been produced in lots larger than 10, and usually a single motor of a particular specification is scheduled through the final assembly line. In the 2 months covered by this report, 74 of these motors were manufactured. Parts are, however, manufactured in lots of 50 to 500. Orders are accepted for a single motor of either standard or special design.

Professional Engineering Services. Design engineers are employed to develop specifications to meet a customer's requirements and to seek improvements in the design of standard products. This plant also employs 20 engineers (9 for heavy motors) to decide plant layout, look for new equipment, study methods, determine how each operation shall be performed, set up operation sheets, and to make time studies. Officials reported these services were very effective and the plant "could not operate without them."

At least 50 percent of the parts used for the reported motor are standard for other models as well. The variation between motors of roughly the same requirements is largely in cores and windings.

Production Scheduling and Control. Production scheduling is done according to orders, rather than by stock. The company uses layout cards, showing all parts required, time standards, specifications, and bills of material.

Manufacturing Process. Manufacture of the reported 5-horsepower motor is highly integrated in plant B. All parts, except bearings, small hardware, and insulation, are manufactured in the plant from castings, sheet metal, and other raw materials. The housing for plant B's 5-horsepower motor is made from 2 cast iron end covers. The raw castings are machined completely in the plant on a 6-station vertical turret lathe. Ends are finished bored and faced, and cap holes are drilled. Front and back, inside and outside bearing caps are iron castings machined within the plant. Two ventilation shields are blanked and formed from sheet steel. From sheet steel a stator frame is cut, rolled, and welded along the seam. Two frame feet are cut from angle steel and machined. The terminal box base and cover are constructed from sheet steel. These parts are formed on a press, annealed, and then reformed, and cover holes are perforated.

The stator core is composed of 120 laminations which have been blanked, slotted, and annealed. These laminations are weighed, assembled, and compressed under hydraulic pressure. Coils are of a double layer, diamond design (36 coils, 21 turns per coil) and are wound on a special winding lathe and form. Windings are inserted in the insulated slots of the stator core, impregnated, and baked until the coatings are completely dried.

The core is also built up of 120 laminations, skewed 6 degrees, and compressed under heavy hydraulic pressure. The squirrel cage of plant B differs from that of other reporting plants, in that it is of aluminum, cast under heavy pressure to fill completely the rotor slots and the molds which form the end rings. Thus, the rotor bars and end rings make complete and intimate contact with the core iron.

The rotor shaft is cut from steel rod, turned on engine lathes, and finished on grinding machines. The shaft is milled for rotor and pulley keyways. The ventilating system consists of cast aluminum blowers, which are subsequently machined and drilled. The rotor, when completely assembled, is then statically and dynamically balanced.

In final assembly, the housing, stator, and rotor are put together. Subassemblies are moved by conveyor. Several inspections and tests are made, name plates attached, information stenciled, and the motor crated. Detailed manufacturing operations are shown in the accompanying tables.

Table 10. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Total direct man-hours to fabricate and assemble housing	2.4410	2.0688	
End covers (2 per motor):			
Material specifications: Iron casting.			
1. Chip and file raw casting	.1111	.0942	Bench.
2. Paint	.0222	.0188	Spray gun.
3. Machine complete, except for finish bore of housing and finish of bead.	.0704	.0597	Bullard, multimatic, 6-station, vertical turret lathe.
Setup divided by 500 (indirect labor)	(.0320)	---	---
4. Finish bore and face bead	.1148	.0973	Engine lathe.
Setup divided by 100 (indirect labor)	(.0200)	---	---
5. Finish bore housing (2 cuts)	.1554	.1317	Excello, boring machine.
Setup divided by 100 (indirect labor)	(.0233)	---	---
6. Drill 4 bearing cap holes	.0370	.0313	Multispindle drill press.
Setup divided by 100 (indirect labor)	(.0122)	---	---
7. Drill 4 through bolt holes	.0167	.0141	Multispindle drill press.
Setup divided by 100 (indirect labor)	(.0122)	---	---
8. Drill and tap (5) 10-32 holes, for vent shield mounting.	.0926	.0785	2-spindle drill press and tapping head.
Setup divided by 100 (indirect labor)	(.0067)	---	---
Total direct man-hours to fabricate end covers.	.6202	.5256	

1/ Standards developed from experience.

Table 10. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Front outside bearing cap:			
Material specifications: Iron casting			
1. Japan dip (in lacquer)	0.0083	0.0070	Oven.
2. Machine complete	.0250	.0212	Bullard, 6-station, vertical lathe.
Setup divided by 250 (indirect labor).	(.0080)	---	---
3. Drill (4) 9/32" diameter holes	.0130	.0110	Multispindle drill press.
Setup divided by 200 (indirect labor).	(.0031)	---	---
4. Drill 2 pipe plug holes	.0241	.0204	Multispindle drill press.
Setup divided by 200 (indirect labor).	(.0008)	---	---
5. Tap 2 pipe plug holes	.0148	.0126	Garvin, tapper.
Setup divided by 200 (indirect labor).	(.0008)	---	---
Total direct man-hours to fabricate. . front outside bearing cap.	.0852	.0722	
Back outside bearing cap:			
Material specifications: Iron casting			
1. Japan dip (in lacquer)	.0083	.0070	Oven.
2. Face mounting surface, turn face . . . and chamfer bead, turn bore and face hub, cut grooves and break edges.	.0269	.0228	Bullard, 6-station, vertical lathe.
Setup divided by 250 (indirect labor).	(.0213)	---	---

1/ Standards developed from experience.

Table 10. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Back outside bearing cap--Continued			
3. Face off back side	0.0139	0.0118	Turret lathe.
Setup divided by 200 (indirect labor).	(.0050)	---	---
4. Drill 4 holes	.0130	.0110	Multispindle drill press.
Setup divided by 200 (indirect labor).	(.0031)	---	---
5. Drill 2 pipe plug holes	.0241	.0204	Single-spindle drill press.
Setup divided by 200 (indirect labor).	(.0008)	---	---
6. Tap 2 pipe plug holes	.0148	.0125	Garvin, tapper.
Setup divided by 200 (indirect labor).	(.0008)	---	---
7. Drill (4) 1/8" diameter holes	.0095	.0081	Single-spindle drill press.
Setup divided by 200 (indirect labor).	(.0008)	---	---
Total direct man-hours to fabricate back outside bearing cap.	.1105	.0936	
Front and back, inside bearing caps (2 per motor):			
Material specifications: Iron casting.			
1. Japan dip (in lacquer)	.0166	.0141	Oven.
2. Face mounting surface, turn face . . . and chamfer bead, turn bore, cut grooves and clearance, and break edges.	.0520	.0441	Bullard, 6-station, vertical turret lathe.

1/ Standards developed from experience.

Table 10. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related date by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Front and back inside bearing caps--Continued			
Setup divided by 250 (indirect labor) .	(0.0426)	---	---
3. Drill 4 holes for 1/4" - 20 tap	.0334	0.0283	Single-spindle drill press.
Setup divided by 200 (indirect labor) .	(.0016)	---	---
4. Tap (4) 1/4" - 20 holes	.0260	.0220	Garvin tapper.
Setup divided by 200 (indirect labor) .	(.0016)	---	---
Total direct man-hours to fabricate . . front and back, inside bearing cap.	.1280	.1085	
Shim (4 per motor): Material: .005" x 3-1/3" sheet steel in roll.			
1. Shear strips	.0025	.0021	Square shear, powered.
2. Blank	.0045	.0038	No. 20 Bliss, punch press.
3. Perforate center hole	.0058	.0049	No. 20 Bliss, punch press.
Total direct man-hours to fabricate . . shims.	.0128	.0108	
Ventilation shields (2 per motor): Material: Sheet steel, .0299" x 9-1/8" x 108"			
1. Shear strips	.0020	.0017	Square shear.
2. Blank	.0027	.0023	No. 6 Toledo, punch press.
3. Perforate center hole with key	.0040	.0034	No. 20 Bliss, punch press.

1/ Standards developed from experience.

Table 10. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Ventilation shields--Continued			
4. Perforate 40 single slots	0.0100	0.0085	No. 018 Bliss, punch press.
5. Perforate(4) 1-1/8" holes, (48 strokes). . . .	.0102	.0086	-Do-
6. Perforate (10) 7/32" holes (10 strokes). . . .	.0178	.0151	-Do-
7. Perforate 4" center hole	.0040	.0034	No. 21 Bliss, punch press.
8. Cut in half to make 2 pieces	.0056	.0047	Square shear, powered.
Total direct man-hours to fabricate ventilation shields. .	.0563	.0477	
Cover screws (4 per motor):			
Material: Round head, machine screws.			
1. Parkerize	.0001	.0001	Tank.
End plate assembly (2 per motor):			
1. Assemble 1 vent shield to end plate, using 5 lock-washers and screws. .	.0889	.0754	Bench.
Stator frame:			
Material: 3/16" x 8-5/16" x 36-3/8", steel.			
1. Cut to length	.0047	.0040	Square shear, powered.
2. Size both ends. (2 strokes)	.0167	.0142	Bliss, punch press.
3. Roll and stack	.0139	.0118	K and R, bender.
4. Weld seam, 8-5/16" length	.0593	.0503	Arc-welder.
5. Form gribs and stack	.0306	.0259	500-volt arc-welder.

1/ Standards developed from experience.

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Table 10. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Stator frame--Continued			
6. Perforate lead hole	0.0072	0.0061	Bliss, punch press (every other stroke is automatic).
7. Round up	.0250	.0211	Bench.
Total direct man-hours to fabricate . . stator frame.	.1574	.1334	
Through bolts (4 per motor):			
Material: Steel rod, 5/16" x 12' for 11 pieces.			
1. Chamfer and cut off	.0213	.0181	Hand screw machine.
2. Thread both ends	.0400	.0339	-Do-
3. Form	.0067	.0057	Toledo punch press.
4. Flatten (3 at a time)	.0007	.0005	Verson No. 500 punch press.
Total direct man-hours to fabricate . . bolts.	.0687	.0582	
Dowel pins (3 per motor):			
Material: Steel rod, 1/4" x 10' for 236 pieces.			
1. Chamfer and cut off	.0051	.0044	Brown and Sharpe No. 00 automatic screw machine.
Frame rib:			
Material: 1/2" x 1" x 16', steel for 37 pieces.			
1. Cut to length	.0022	.0019	Buffalo shear, powered.

1/ Standards developed from experience.

Table 10. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Frame foot (2 per motor):			
Material: Angle steel, 5/16" x 2" x 2-1/2" x 20' for 20 pieces.			
1. Cut to length	0.0056	0.0047	Buffa
2. Form 2 pads, 1 stroke	.0069	.0058	Verso ichpress
3. Perforate 2 mounting holes and trim (automatic 2d stroke).	.0111	.0094	Bliss p. No. 78-1/2.
4. Shear radius and bevel	.0133	.0113	-Do-
5. Notch out bottom	.0078	.0066	Bliss press, No. 308.
6. Straighten	.0278	.0236	Bench.
Total direct man-hours to fabricate frame foot. . .	.0725	.0614	
Foot rib (2 per motor):			
Material: Steel, 3/16" x 2-1/4" x 96" for 15 pieces.			
1. Shear to size	.0053	.0045	Square shear, powered.
Conduit nipple:			
Material: Steel rod, 2-3/4" x 12', for 339 pieces.			
1. Drill through and form, bore center bore, recess, and cut off. . .	.0450	.0381	3-5/8" Acme, automatic screw machine.
2. Burr inner diameter	.0015	.0013	Burring machine.
3. Drill 4 holes, for 1/4" - 20 tap . . .	.0120	.0102	Multispindle drill press.
Setup divided by 200 (indirect labor) .	(.0031)	---	---
4. Burr 4 holes, both sides	.0072	.0061	Single-spindle drill press.

1/ Standards developed from experience.

Table 10. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Conduit nipple--Continued			
Setup divided by 200 (indirect labor) .	(0.0008)	---	---
5. Tap (4) 1/4" - 20 holes	.0195	0.0165	Garvin tapper.
Setup divided by 200 (indirect labor) .	(.0008)	---	---
Total direct man-hours to fabricate . . conduit nipple.	.0852	.0722	
Stator frame assembly:			
1. Assemble and weld conduit nipple, . . . assemble and weld frame rib.	.0833	.0706	Arc-welder.
2. Drill, burr, and tap eye bolt hole . .	.0583	.0494	Radial drill press.
Setup divided by 50 (indirect labor) .	(.0067)	---	---
3. Bore ribs and face inside	.1278	.1083	Potter and Johnson lathe.
Setup divided by 50 (indirect labor) .	(.0333)	---	---
4. Assemble frame in fixture and partly . weld feet. Remove from fixture and weld feet rest of way, assemble and weld foot ribs to the assembly.	.2778	.2354	Electric welder.
5. Wash - dip frame in undercoat	.0167	.0142	Tank.
6. Turn and face bead	.1111	.0942	Gisholt turret lathe
Setup divided by 50 (indirect labor) .	(.0100)	---	---
7. Mill feet	.1278	.1083	Milling machine
Setup divided by 50 (indirect labor) .	(.0133)	---	---
Total direct man-hours to assemble . . stator frame.	.8028	.6804	

1/ Standards developed from experience.

Table 10. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Terminal box base: Material: Sheet steel, .095" x 7-1/8" x 101", for 12 pieces.			
1. Shear square	0.0036	0.0031	Square shear, powered.
2. 1st. form or draw	.0055	.0047	750, HPM, press.
3. Anneal	.0013	.0011	Furnace.
4. 2d form or draw	.0052	.0044	Bliss press, No. 308.
5. Trim outside	.0053	.0045	Verson press, No. 500.
6. Perforate 4 cover holes	.0030	.0025	Toledo, No. 6 punch press.
7. Perforate 4 mounting holes and inlet hole (1 stroke).	.0023	.0019	-Do-
8. Perforate outlet hole	.0023	.0020	-Do-
Total direct man-hours to fabricate terminal box base.	.0285	.0242	
Nipple from terminal box: Material: Steel rod, 2" x 12', for 149 pieces.			
1. Form, drill through, face, chamfer, and cut off.	.0270	.0229	2-1/4" Gridley, automatic screw machine.
2. Chamfer inner diameter of back end . .	.0061	.0052	Porter, cable lathe.
3. Tap, 1" pipe tap, center hole	.0296	.0250	Radial drilling machine.
Setup divided by 200 (indirect labor).	(.0017)	---	---
Total direct man-hours to fabricate nipple.	.0627	.0531	

1/ Standards developed from experience.

Table 10. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Terminal box base assembly:			
1. Assemble nipple to base and weld in . . 4 places.	0.0148	0.0125	Arc-welder.
2. Tap (4) 10-32 holes	.0120	.0102	Garvin tapper.
Setup divided by 200 (indirect labor) .	(.0008)	---	---
Total direct man-hours to assemble . . terminal box base.	.0268	.0227	
Terminal box cover:			
Material: Sheet steel, .095" x 7-1/8" x 101", for 12 pieces.			
1. Shear square	.0036	.0031	Square shear, powered.
2. 1st. form or draw	.0054	.0046	750, HPM press.
3. Anneal	.0013	.0011	Furnace.
4. 2d form or draw	.0052	.0044	Bliss press, No. 308
5. Trim outside	.0033	.0028	Verson punch press, No. 730.
6. Perforate 4 cover holes	.0030	.0025	Toledo, No. 6 punch press.
Total direct man-hours to fabricate . . terminal box cover.	.0218	.0185	

1/ Standards developed from experience.

Table 11. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Total direct man-hours to . . . . fabricate and assemble stator.	5.1713	4.3827	
STATOR LAMINATIONS (120 per motor):			
Material: Sheet steel, .025" x 30-3/4" x 122".			
1. Slit strips	.0340	.0288	Slitter, powered.
2. Blank and separate	.0860	.0729	Toledo, No. 6 punch press.
3. Compound stator slots, shave . . inner diameter, and tie into bundles.	.1400	.1187	Toledo, No. 77 punch press.
4. Flatten	.0120	.0102	Bliss, No. 21 punch press.
5. Anneal	.0280	.0237	Furnace.
Total direct man-hours to . . . . fabricate stator laminations.	.3000	.2543	
STATOR END LAMINATIONS (2 per motor):			
Material: .0598" x 10-1/4" x 108", sheet steel.			
1. Shear strips	.0047	.0040	Square shear, powered.
2. Blank 3 to 5 pieces. Strip . . .	.0060	.0051	Toledo, No. 6 punch press.
3. Perforate center hole and . . . . keyway.	.0053	.0045	Bliss, No. 20 punch press.
4. Perforate 36 slots and separate .	.0083	.0070	Bliss, No. 19 punch press.
Total direct man-hours to . . . fabricate stator ends.	.0243	.0206	

1/ Standards developed from experience.

Table 11. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
SLOT LINING (36 pieces per motor):			
Material: .025" x 4-3/8", roll.			
1. Cuff, form, and cut off	0.0102	0.0086	Plant designed, automatic machine.
CENTER STRIPS (36 per motor):			
Material: Pressed board, .060" x 5" x 120".			
1. Shear strips to length	.0300	.0254	Square shear, powered.
2. Cut off to width	.0798	.0677	Bliss, No. 19 punch press.
Total direct man-hours to . . . fabricate center strips.	.1098	.0931	
TOP CELL LINING (36 per motor):			
Material: Fabric, .020" x 9/16", roll.			
1. Cut off and form	.0798	.0676	Bliss, No. 20 punch press.
STRING (72 pieces per motor):			
Material: Plystring in 1,400' cone			
1. Cut to length, 15"	.0240	.0203	Square shear, powered.
SLEEVING (24 pieces per motor):			
Material: Black tubing in roll.			
1. Cut to length, 5"	.0080	.0068	-Do-

1/ Standards developed from experience.

Table 11. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
CONNECT INSULATION (10 pieces per motor):			
Material: Black tubing in roll.			
1. Cut to length, 3-1/2"	0.0033	0.0028	Square shear, powered.
CONNECT INSULATION (6 per motor):			
Material: Black tubing in rolls.			
1. Cut to length, 6"	.0020	.0017	-Do-
CABLE (3 per motor):			
Material: No. 14, motor cable on reel.			
1. Cut to length, (2') and skin. .	.0014	.0012	Specially built machine.
CABLE (3 per motor):			
Material: No. 14, motor cable on reel.			
1. Cut to length, (1-1/2' and skin	.0014	.0013	-Do-
CABLE (3 per motor):			
Material: No. 14, cable on reel.			
1. Cut to length, (1') and skin. .	.0007	.0006	-Do-

1/ Standards developed from experience.

Table 11. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
LEAD BUSHING:			
Material: Pressboard, .060" x 1-5/8" x 60", for 35 pieces.			
1. Shear strips	0.0002	0.0002	Square shear, powered.
2. Perforate, blank, and stamp complete.	.0006	.0005	Bliss, No. 19 punch press.
Total direct man-hours to fabricate lead bushing.	.0008	.0007	
ASSEMBLE STATOR CORE:			
Materials: Welding rod, No. 14, copper wire and insulating varnish.			
1. Weigh, sort and stack iron, assemble on press, and weld in 6 places.	.3111	.2637	Bench and hydraulic press.
Setup divided by 50 (indirect labor). .	(.0111)	--	--
2. Insulate core	.0556	.0471	Bench.
3. Wind coils: double layer, diamond design, 36 coils, 21 turns per coil. No. 14, Formvar wire, 18.2 lbs. of copper. . . .	.4445	.3767	Special winding lathe and form.
4. Assemble coils to core	3.0000	2.5425	Bench.

1/ Standards developed from experience.

Table 11. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
5. Connect, group connections . . . . 3, 3, 3, 9 leads.	0.4333	0.3672	Bench.
6. Shape and test	.0667	.0565	Test bench.
7. Preheat	.0222	.0188	Oven.
8. Impregnate (2 dips)	.0889	.0753	Tank and oven.
Total direct man-hours to . . . . assemble stator core.	4.4223	3.7478	
STATOR ASSEMBLY:			
1. Press frame over wound stator . . core, stamp number on foot rib, drill for and assemble 3 dowel pins.	.1000	.0848	Single-spindle drilling machine and hydraulic press.
Setup divided by 50 (indirect . . labor).	(.0067)	--	--
2. Brush compound out of stator . . inner diameter.	.0222	.0188	Drill press.
3. Cut leads to length, and skin . .	.0611	.0517	Bench.
Total direct man-hours to . . . . assemble stator.	.1833	.1553	

1/ Standards developed from experience.

Table 12. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Total direct man-hours to fabricate and assemble rotor.	2.3242	1.9697	
ROTOR LAMINATIONS (120 per motor): Material specifications: .025" x 33" x 110", sheet steel.			
1. Slit strips to 6-1/2" width	.0340	[illegible]88	Slitter, powered.
2. Blank and separate	.0860	[illegible]29	Toledo No. 6 punch press.
3. Compound slots 44, center hole and tie . .	.1060	.0898	-Do-
4. Anneal	.0220	.0186	Furnace.
Total direct man-hours to fabricate . . . . rotor laminations.	.2480	.2101	
SHAFT: Material specifications: 1-9/16" x 18', . . . steel rod, for 10 pieces.			
1. Cut to length, and center both ends	.0958	.0812	Cut-off saw and centering machine.
2. Turn 4 shaft faces and radii, 1 end	.0704	.0597	Monarch engine lathe.
Setup divided by 200 (indirect labor) . . .	(.0047)		
3. Turn 3 shaft faces and radii, 1 end	.0741	.0628	Monarch engine lathe.
Setup divided by 200 (indirect labor) . . .	(.0025)		
4. Rough grind 3 shaft diameters and . . . . . grind 4 shaft diameters to size.	.1583	.1342	Grinding machine.

1/ Standards developed from experience.

Table 12. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
Setup divided by 200 (indirect labor) . . .	(0.0017)		
5. Cut 7 radii, knurl 2 shaft diameters, and burr corners.	.2556	0.2166	Engine lathe.
Setup divided by 200 (indirect labor) . . .	(.0017)		
6. Cut 1 thread	.0306	.0259	Gridan threader.
Setup divided by 200 (indirect labor) . . .	(.0017)		
7. Mill pulley and rotor keyways, (3 at a time) and burr keyways	.0528	.0447	Cincinnati milling machine.
Setup divided by 200 (indirect labor) . . .	(.0033)		
8. Mill 1 woodruff keyway and file burrs . . .	.0195	.0165	Whitney hand mill.
Setup divided by 200 (indirect labor) . . .	(.0025)		
Total direct man-hours to fabricate . . . . shaft.	.7571	.6416	
BLOWER (2 per motor):			
Material specifications: Cast aluminum.			
1. Drill 2,11/32" holes	.0445	.0377	Single-spindle drill press.
Setup divided by 100 (indirect labor) . . .	(.0017)		
2. Assemble 2 bolts, lockwashers, and tighten.	.0250	.0212	Bench.
Setup divided by 100 (indirect labor) . . .	(.0017)		
3. Bore, chamfer, and ream center hole . . .	.0639	.0542	Warner and Swasey turret lathe.
Setup divided by 100 (indirect labor) . . .	(.0133)		
4. Static Balance.	.0704	.0596	Bench and drill press.

1/ Standards developed from experience.

Table 12. Rotor fabrication and assembly, 5-horsepower induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
5. Saw blower in 2 pieces	0.0222	0.0188	
Total direct man-hours to fabricate . . . . blowers.	.2260	.1915	
BAFFLE SPACERS (2 per motor): Material specifications: 2-7/16" x 12', steel rod for 186 pieces.			
1. Feed out and rough form, spot drill, . . . drill, and turn to size and face, radius and cut off.	.0498	.0422	2-5/8", No. 6 Gridley, automatic screw machine.
2. Burr 1 side	.0027	.0023	Burring machine.
3. Face 1 side, cut off	.0389	.0330	Turret lathe.
Setup divided by 200 (indirect labor) . . .	(.0100)		
4. Copper plate	.0007	.0006	Tank.
Total direct man-hours to fabricate . . . . bottle spacers.	.0921	.0781	
BAFFLE NUT: Material: 2-1/4" x 16', steel rod, ... for 214 pieces.			
1. Rough form and spot drill, drill thru, . . form and bore recess, tap and cut off.	.0130	.0110	2-5/8" Acme, automatic screw machine.

1/ Standards developed from experience.

Table 12. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
2. Chamfer inner diameter	0.0056	0.0047	Porter, cable lathe.
3. Mill 8 slots (1 at a time).	.0611	.0518	Milling machine.
Setup divided by 200 (indirect labor) . . .	(.0025)		
4. Burr 8 slots	.0361	.0306	Bench.
5. Copper plate	.0003	.0003	Tank.
Total direct man-hours to fabricate . . . . baffle nut.	.1161	.0984	
BALANCE WEIGHTS (6 per motor):			
Material: 3/8" x 12', steel rod for 347 pieces.			
1. Form and cutoff	.0162	.0137	No. 0, Brown and Sharpe, automatic screw machine.
CORE KEY:			
Material: 1/4" x 1/4" x 12', square steel for 43 pieces			
1. Chamfer and cutoff	.0027	.0023	-Do-
PULLEY KEY:			
Material; 1/4" x 1/4" x 12', square steel for 59 pieces.			
1. Cut to length and bevel	.0021	.0018	-Do-

1/ Standards developed from experience.

Table 12. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951--Continued

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery, tools, and gages used
ROTOR CORE ASSEMBLY:			
1. Stack iron, build core, skew 6°, mold bars. and rings of aluminum.	0.3000	0.2543	(2/)
2. Size center hole	.0250	.0212	Hydraulic press.
Setup divided by 50 (indirect labor). . . .	(.0011)		
3. Broach keyway (1 stroke) knock burr . . . . from slot, stamp number on end of core.	.0306	.0259	Oilgear broaching machine.
Setup divided by 50 (indirect labor) . . .	(.0040)		
4. Stamp number in keyway, assemble key, . . . broach and press shaft into core, clean and oil centers.	.0583	.0494	Lucas press.
Setup divided by 50 (indirect labor) . . .	(.0033)		
5. Turn outer diameter of core	.0583	.0494	No. 2 engine lathe.
Setup divided by 50 (indirect labor) . . .	(.0133)		
6. Finish grind 2 bearings and pulley shoulder	.2222	.1883	Grinder.
Setup divided by 50 (indirect labor) . . .	(.0067)		
7. Balance and paint	.1695	.1437	Balancing machine.
Total direct man-hours to assemble rotor core.	.8639	.7322	

1/ Standards developed from experience.
2/ Not reported.

Table 13. Final assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant B, U. S. A., 1951

Operation	Planned man-hours per motor 1/	Adjusted man-hours per motor	Machinery and tools used
Total man-hours for final assembly of 5-horsepower, induction motor	1.0139	0.8593	
1. Blow out all parts and assemble complete, stencil serial number, check rotor freeness, and make minor repairs	.5333	.4520	Bench.
2. Test (indirect)	--	--	--
3. Inspect (indirect)	--	--	--
4. Drill name plate holes	.0417	.0353	Bench.
5. Assemble base, gasket, and cover	.1167	.0989	-Do-
6. Paint, prime, and finish coats	.0333	.0282	Conveyor.
7. Stencil and assemble name plate and pulley key .	.1111	.0942	-Do-
8. Crate	.1778	.1507	-Do-

1/ Standards developed from experience.

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Table 14. List of parts, 5-horsepower, induction motor, and related data, plant B, U. S. A., 1951

Part name	Number per motor	Made in plant	Purchased
End plate 1/	2	x	x
Front outside bearing cap	1	x	---
Back outside bearing cap	1	x	---
Inside bearing caps	2	x	---
Bearing cap screws	8	---	x
Ball bearing	2	---	x
Bearing lockwasher	1	---	x
Gaskets	4	---	x
Vent shields	2	x	---
Conduit box base	1	x	---
Conduit box cover	1	x	---
Conduit box screws	4	---	x
Nipple	1	x	---
Frame	1	x	---
Frame rib	1	x	---
Frame foot	2	x	---
Foot rib	2	x	---
Conduit nipple	1	x	---
Base gasket	1	---	x
End plate nuts	8	---	x
Thru bolts	4	x	---
Cover gasket	1	---	x
Cover screws 1/	4	x	x
Stator punchings	120	x	---
Stator end punchings	2	x	---
Dowel pins	3	x	---
Slot lining	36	x	---
Sleeving	24	x	---
Center strips	36	x	---
Wedges	36	---	x
Top cell insulation	36	x	---
String	72	x	---
Phase insulation	24	---	x
Connect insulation, 3-1/2"	10	x	---
Connect insulation, 6"	6	x	---

1/ Purchased semifinished.

Table 14. List of parts, 5-horsepower, induction motor, and related data, plant B, U. S. A., 1951--Continued

Part name	Number per motor	Made in plant	Purchased
Cable, 2', ...	3	x	---
Cable, 1-1/2'	3	x	---
Cable, 1'	3	x	---
Terminals	---	---	x
Lead bushing	1	x	---
Rotor punchings	120	x	---
Rotor core	1	x	---
Shaft	1	x	---
Blower	2	x	---
Baffle spacers	2	x	---
Baffle nut	1	x	---
Core key	1	x	---
Pulley key	1	x	---
Balance weights	6	x	---
Shim	4	x	---
Name plate	1	---	x
Drive screws	2	---	x
Eye bolt	1	---	x
Pipe plugs	4	---	x
Screws	10	---	x
Lockwashers	14	---	x
Nuts	2	---	x
Screw bolt	2	---	x
Crate	1	---	x
Skid	1	---	x
Carriage bolt	4	---	x
Wrapping paper	1	---	x
Nails	12	---	x

Case Study, Plant C

Product Description.

5-horsepower, induction motor, 220-440 volt, 3-phase, 60-cycle, 1,750 r.p.m., horizontal, ball bearing motor. Protected, open-type frame, NEMA, size Number 254.

General Plant Information

Buildings. The reported product is manufactured in a concrete and steel frame building of 80,000 square feet, with storage facilities of about 4,000 square feet constructed of steel. The original portion of the plant was built over 35 years ago, but since that time several additions have been made, including the recent construction of the storage building. These buildings were designed for manufacture of electric motors with each addition planned so as to incorporate changes in modern production techniques. All manufacturing operations are performed on one floor.

Machinery. In the production of this product, the plant uses much heavy duty, automatic machinery, such as turret lathes, engine lathes, boring machines, punch presses, grinders, both large and small multispindle and radial drill presses. Conveyors are extensively used for transporting parts to insulating varnish vats and through the baking oven. Throughout the plant, 24-inch roller conveyors are in operation. Other equipment includes arc-welders, spray booths, powered handtools, static and dynamic balancing machines, and test benches.

Jigs and fixtures are extensively used in the various operations. Materials movement is by mechanical and electric hoists, hand trucks, and roller conveyors at assembly benches. Overhead monorail conveyor is used at unloading dock.

Employment and Wage Practices.

More than 500 employees, including nonproduction employees, work in this plant. Production employees are entirely on piecework basis, except for certain day workers. New employees receive on-the-job instruction from their respective supervisors. From time to time, supervisory meetings are held for the purpose of discussing production and safety problems.

Operating Practices

Variety of Products. Motors ranging in size from fractional-horsepower to 2,000-horsepower are produced in the same building where the reported 5-horsepower motor is manufactured. One- to five-horsepower, polyphase motors constitute roughly, one-third of the value of sales. Variations from the standard model will be made on request for orders as small as for a single motor. Special orders seldom require changes in more than one or a few parts, with the remainder of the motor assembled from standard components.

In addition, the repair and service department of this plant repairs used motors, from fractional- to 200-horsepower sizes, returned to the plant, and ships parts for worn or broken motors. All standard housings produced by this plant conform to NEMA standards.

Major categories of all items produced within the plant, by percent of their total value of shipment, during 1950:

Fractional-horsepower motors	22 percent
1- to 5-horsepower motors, polyphase	34 percent
7-1/2- to 20-horsepower motors	23 percent
25- to 200-horsepower motors	19 percent
Integral, single-phase motors	2 percent

Size of Runs. Final assembly of 5-horsepower motors varies from 1 to 25 per day, with the usual lot size being 3 or 4. In the 6-days covered by this report, 14 of these motors were manufactured.

Professional Engineering Services. This plant has an engineering department which is responsible for motor and tool designs, time studies, time standards, processing of parts, plant layout, and materials handling. The tool engineering department develops tools used in research and experimentation. Management reports that one of the primary functions of this department is to reduce man-hour requirements.

Production Scheduling and Control. Production scheduling, and control of special orders begin in the sales department. This department screens all orders for electric motors and classifies them with respect to price and specifications. From the sales department, these orders are sent to the engineering department, where the order is screened for electrical and mechanical specifications, and a design drawing is recorded on the production order. After the engineering department has passed upon the order, it is sent back to the sales department, then routed to the production control department where it is screened for special instructions. From the production control department, the orders are passed to the materials-control department, where the order is screened to determine whether or not the material required is on hand or on order. If material required is not on hand or order, a purchase requisition is written at this time and attached to the order folders. These folders are returned to the scheduling clerk who then schedules the orders for production to the master schedule.

Orders by due date are entered in a schedule book from which factory production schedules are made. From the schedule book, the mechanical department can ascertain what materials have to be allocated to the quantities of motors to be scheduled that day. Work orders are issued for any special part. After machine allocation, orders go back to the scheduling department where job tickets are run for the stator, rotor, and housing. Stubs of the tickets are removed when inspection takes place, providing a means of reporting the movement of motors through the plant. Standard orders are run from stock on a maximum and minimum basis.

Manufacturing Process. Unlike plants A and B, plant C purchases most of its housing parts partly finished. The parts bought include the end-plate castings, grease and oil caps, terminal boxes and covers, and the stator frame, which comes precut and preformed.

Stator laminations are blanked and slotted, and made into a core. Slots are insulated. The stator windings are coiled on a form and then inserted into the stator core. The wound stator is then impregnated with insulating varnish and baked to protect the stator windings.

Rotor laminations are blanked and slotted. Forty-eight copper rotor bars and 2 end rings are cut, formed, pressed to shape in the core, and welded. Rotor ventilating fans, which are purchased partly finished, are bored and reamed in the plant.

Final assembly, which consists of putting the three major subassemblies together, is highly conveyorized.

Table 15. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant C, U. S. A., 1951

Part and operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used	Materials-moving device
Total direct man-hours, to fabricate housing	0.813	0.750		
1. End plates (2 per motor): Material: Iron casting. Turn, drill, and . . . . diamond bore, end plates.	.244	.225	Small, multiplespindle drill, Potter and Johnson lathe, and Excello boring machine.	Hand truck.
2. Grease caps (2 per motor): Material: Iron castings. Bore, turn, face, ... groove, and ream, grease caps.	.048	.044	4-spindle drilling machine and Potter and Johnson turret lathe.	-Do-
3. Dust caps (2 per motor): Material: Sheet steel. Blank out	1/ .016	.015	Punch press	-Do-
4. Bearing lock washers: Blank out	1/ .012	.011	-do-	-Do-
5. Stator frame	--	---	Purchased precut and preformed	--
6. Base angles (2 per motor): Material: Sheet steel. Cut off and form	.012	.011	Minster and Toledo press	-Do-
7. Base blocks (2 per motor): Cut off	.016	.015	No. 2 or No. 3 press	-Do-

1/ See footnote at end of table.

Table 15. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant C, U. S. A., 1951--Continued

Part and operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used	Materials-moving device
8. Stator core holding bars (8 per motor):				
Blank out	0.010	0.009	Toledo press	24"-roller conveyor.
9. Weigh stack, and rivet . . stator punchings, press stator core into frame, stamp style number, weld assembly, and weld base to frame.	.204	.188	Bench, press, arc-welders, welding generator, jigs to hold frame and feet.	-Do-
10. Drill and tap stator frame.. for terminal and drill drain.	.109	.101	Hand feed drill	Conveyor.
11. Turn and face shoulder of frame.	.072	.066	Gisholt Fastermatic lathe	Hand truck.
12. Drill and grind feet . . .	.041	.038	Hand feed drill and Gardner disc grinder.	(2/)
13. Terminal box: Material: Iron castings.				
Drilling operations . . .	.023	.021	Small, hand feed, multi-spindle, and radial drills.	Hand truck.
14. Terminal box cover: Material: Casting.				
Drilling operations . . .	.006	.006	-do-	-Do-

1/ Estimated.
2/ Not reported.

Table 16. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant C, U. S. A., 1951

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used	Materials-moving device
Total direct man-hours to fabricate and assemble stator..	3.156	2.914		
1. Blank stator punchings . .	.085	.079	V and O press	24" roller conveyor.
2. Notch	.294	.272	-Do-	-Do-
3. Assemble stator core . . .	(1/)		(1/)	
4. Cut insulation	.100	.092	Insulation shear	-Do-
5. Insulate stator	.088	.081	Bench	-Do-
6. Wind coils on form	.325	.300		-Do-
7. Tape coils (sleeving) . . .	.414	.382	Taping machine	-Do-
8. Place coils in stator core.	.960	.886	Bench	-Do-
9. Connect stator	.212	.196	-Do-	-Do-
10. Tie and test	.148	.137	-Do-	-Do-
11. Dip and bake, brush paint-insulation, clean and trim.	.530	.489	Dip tank, oven, spray stand, and baking conveyor.	Conveyors.

1/ Time included with assembly of core to frame. See operation 9 of housing fabrication.

Table 17. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant C, U. S. A., 1951

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used	Materials-moving device
Total direct man-hours to fabricate and assemble rotor.	1.665	1.537		
1. Blank rotor punchings . . .	.085	.079	V and O press	Hand truck.
2. Notch rotor punchings . . .	.237	.219	-Do-	-Do-
3. Rotor bars (48 per motor) . Cut off copper.	.019	.018	Small punch press	-Do-
4. End rings (2 per motor) . . cut off, form, weld, and press to shape.	.065	.060	--	-Do-
5. Shaft, cut off, turn, mill, cut threads, and grind.	.596	.550	DoAll saw, Monarch lathe, threading machine and Norton grinder.	Conveyor from storage to saw.
6. Fans - bore and ream . . .	.050	.046	Warner and Swasey turret lathe.	Truck.
7. Weigh and stack punchings . and assemble rotor bars and end rings.	.205	.189	End-ring roller, welding machine and generator jig, bench, and vise.	Conveyor and chute to welding.
8. Weld rotor core	.092	.085	Automatic welder	Chute.
9. Rotor key, cut off from bar stock.	1/ .010	.009	Saw, powered	Truck.
10. Pulley key, cut off	.010	.009	-Do-	-Do-
11. Assemble rotor core, shaft, and fan and grind core.	.131	.121	Bench hydraulic press and Norton grinder.	Chute to balancing machines.
12. Balance	.165	.152	Gisholt, dynetric balancer	

1/ Estimated.

Table 18. Final assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant C, U. S. A., 1951

Operation	Standard man-hours per motor	Adjusted man-hours per motor	Machinery, tools, and gages used	Materials-moving device
Total direct man-hours for . . . final assembly.	0.377	0.348		
1. Assemble end plates, rotor. and stator.	.267	.246	Handtools, and bench	Conveyor.
2. Assemble terminal box to . . motor.	.030	.028	-Do-	-Do-
3. Paint, and clean	.080	.074		-Do-

Table 19. List of parts, 5-horsepower, induction motor, and related data, plant C, U. S. A., 1951

Part name	Number per motor	Made in plant	Purchased
End plates 1/	2	x	x
Grease caps 1/	2	x	x
Grease cap bolts	4		x
Oil well caps	2		x
Dust caps	2	x	
Ball bearings	2		x
Bearing lock nuts	(2/)		x
Bearing lock washers	(2/)		x
Terminal box 1/	1	x	x
Terminal box cover	1	x	x
Terminal box gasket	1		x
Terminal screws	(2/)		x
Terminal cover screws	(2/)		x
Stator frame	1		x
Base angles	2	x	
Base blocks	(2/)	x	
Cover bolts	(2/)		x
Stator laminations	(2/)	x	
Stator core holding bars	8	x	
Slot insulation 1/	(2/)	x	x
Sleeving	(2/)		x
Oil muslin	(2/)		x
Pressed board	(2/)		x
Slot sticks	(2/)		x
Tape	(2/)		x
Rivets	(2/)		x
Rotor laminations	(2/)	x	
Copper bars	48	x	
End rings	2	x	
Shaft	1	x	
Fan 1/	1	x	x
Rotor core key	1	x	
Pulley key	1	x	
Name plate	1	x	
Name plate screws	(2/)		x
Wire, No. 16	(2/)		x
Paint			

1/ Purchased partly finished.
2/ Not reported.

Case Study, Plant D

Product Description

5-horsepower, 60-cycle, 3-phase, 1,725-r.p.m., 220-440 volt, ball-bearing, induction motor, NEMA, frame No. 254.

General Plant Information

Buildings. Manufacturing operations in plant D are performed in a small number of separate buildings with a total working area of about 114,000 square feet. These structures range from about 5 to 50 years in age and are constructed of brick, timber, steel, and concrete. The older buildings were not originally designed for modern techniques, but recently have been modified to permit better materials handling, lighting, and ventilation, by the installation of overhead monorails, electric hoists, fluorescent lighting, and forced ventilation.

Buildings and departments have been added as needed, with the result that the various operating departments are scattered throughout the separate buildings. A formidable materials-handling problem has resulted. Materials must be moved by hand trucks from building to building through the narrow ramps which connect them.

Machinery. This plant uses both light-and heavy-duty, automatic machinery - hydraulic and mechanical punch presses, turret lathes, milling machines, drill presses, boring machines, and grinders.

Jigs and fixtures are used in key operations. These jigs and fixtures include special chucks for machining end covers and stator frames, jigs for drilling and multiple tapping heads, fixtures for assembling stator laminations into the stator shell, special fixtures for hydraulic presses, turntable fixtures, face plate adapters, and fixtures for pressing the rotor core onto the shaft. A great number of gages of the snap-, plug-, and length-type are used by the plant.

Employment and Wage Practices

About 408 employees work in this plant, of this number 17 percent are women. This firm uses a considerable amount of handicapped labor. Wage payment systems are mixed. In many of the departments, direct labor is paid by piecework and hourly rates, whereas, in others only the piecework rate is employed. Indirect employees are paid hourly rates. At the time of this report, the firm was trying to work out a bonus system for direct workers and a profit-sharing plan for the indirect and administrative workers.

New employees receive on-the-job training from their respective foremen and group leaders. Supervisors do not receive formal training, but are promoted from the ranks on a merit basis.

Operating Practices

Variety of Products. This plant manufacturers fractional and integral motors of various sizes (direct current and alternating current, single and

polyphase types) as well as a few additional products using motors as a major component. Integral horsepower motors constitute over 50 percent of total production. Besides standard products, the plant designs motors to meet purchasers' specifications in lots as small as a single item.

Size of Runs. The minimum number of 5-horsepower motors reported in 1 continuous run was 5, with a maximum of 40 and an average of 25 for the period. Usually, a production run is made for custom built models or for variations of the standard model. During the 1-month reported, 141 of the specified motors were produced.

Professional Engineering Services. This plant maintains both design and engineering departments. The 14 design engineers develop designs to meet purchasers' specifications, and constantly seek ways to improve the design of standard products. All incoming orders received by the company pass through this department, and any drawings needed are made before the order is sent to the production department.

In the engineering department, 4 engineers make time studies, determine incentive rates, and study shop methods. They also collaborate with the tool designer in working out new jigs and fixtures. Management feels that significant reductions in man-hours have resulted because of this department's scientific analysis of each operation and the proper setting of incentive rates.

Production Scheduling and Control. Scheduling control for the reported product is undertaken by the sales and production departments. The production department reports to the sales department the number of motors which can be built 6 weeks in advance of shipping date. In turn, the sales department reports back daily which types and models are required to fill schedule. Scheduling in all departments rests upon this master schedule, which allows enough advance time to meet final shipping dates.

Manufacturing Process. Housing parts, which are purchased partly finished, are the end bells and stator frame. The plant machines these cast iron end bells to fit stator frame, drills for cover bolts, and diamond bores for bearings. The stator frame, received as a rough casting, is machined for end cover fit, eye bolt, stator core fit, and cover bolts. The terminal box and cover are manufactured in the plant.

Stator and rotor laminations are blanked simultaneously on punch presses with a compound die. Stator coils are form wound, slots of the stator core are insulated, windings are inserted in slots, and slot wedges are put into place. The completed winding is heated thoroughly, saturated with insulating varnish, baked, redipped, and rebaked. Extensive use is made of special fixtures and handtools in this phase, as well as hand trucks for moving the assemblies.

The blanked rotor laminations are assembled, and the core is welded. Rotor bars and end rings are blanked out and welded together in the core. Special fixtures for coining rotor bars and a turntable fixture for welding

these bars are attached to a hydraulic press. Rotor shafts are machined on grinders. Fans are purchased partly finished, but machined in the plant. Materials moving is accomplished by means of hand trucks. Handtools and a test panel are used in final assembly.

Table 20. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant D, U. S. A., 1951

Part and operation	Average man-hours per motor 1/	Machinery, tools, and gages used	Materials-moving device
Total direct man-hours to fabricate housing	1.363		
1. End bells (2 per motor): Material: Iron casting. Machine to fit stator frame, drill for cover bolts, and diamond bore for bearings.	.495	No. 4, turret lathe, drill press, Excello boring machine, special chuck, drill jig for holes, face plate adapter for diamond boring.	Hand truck.
2. Punch dust cap	.003	15-ton punch press	-Do-
3. Punch terminal box	.017	30-ton punch press	-Do-
4. Stator frame: Material: 1 piece casting with internal ribs to support stator. Machine for end cover fit, eye bolt, stator core fit, and cover bolts.	.848	No. 5 turret lathe, drill press, milling machine, special chuck and gages.	-Do-

1/ Average is for production during the first half of 1951.

Table 21. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant D, U. S. A., 1951

Operation	Average man-hours per motor 1/	Machinery, tools, and gages used	Materials-moving device
Total direct man-hours to fabricate and assemble stator	2.950		
1. Blank stator laminations, 2 . . hits to make 1 complete stator and 1 complete rotor lamination	2/ .155	Punch press, with compound die	Hand truck.
2. Assemble and wind stator. . . . Wind coils on forms. Assemble laminations in stator frame and press together. Insulate slots, place coils in slots, place slot wedges, dip in insulating varnish, and bake.	2.795	Special fixture and handtools	-Do-

1/ Average is for production during the first half of 1951.
2/ Half of operation time is charged to stator and half to rotor fabrication.

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Table 22. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant D, U. S. A., 1951

Operation	Average man-hours per motor 1/	Machinery, tools, and gages used	Materials-moving device
Total direct man-hours to fabricate and assemble rotor. . . .	1.306		
1. Blank rotor laminations. . . . . 2 hits to make 1 complete stator and 1 complete rotor lamination. Rotor and stator laminations are blanked on first hit, rotor lamination pierced on second hit.	2/ .156	Punch press, with compound die	Hand truck.
2. Assemble laminations, copper. . . bars, and end rings and weld rotor core.	.595	80-ton hydraulic press, with special fixture for coining rotor bars, and turntable fixture for welding bars.	-Do-
3. Machine rotor shaft	.487	36" Landis grinder and 1-1/2" hand screw machine	-Do-
4. Machine fan	.068	No. 3 turret lathe, and drill press.	-Do-

1/ Average is for production during the first half of 1951.
2/ Half of time is charged to stator and half to rotor fabrication.

Table 23. Final assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant D, U. S. A., 1951

Operation	Average man-hours per motor 1/	Machinery, tools, and gages used	Materials-moving device
1. Assemble, test, and finish	0.835	Test panel, handtools	Hand truck

1/ Average is for production during the first half of 1951.

Table 24. List of parts, 5-horsepower, induction motor, and related data, plant D, U. S. A., 1951

Part name	Number per motor	Made in plant	Purchased
End bells 1/	2	x	x
Ball bearings	2	---	x
Bearing cap	1	x	---
Grease fittings	2	---	x
Terminal box	1	x	---
Stator frame 1/	1	x	x
Stator laminations	---	x	---
Stator coils	---	x	---
Insulation	---	---	x
Rotor laminations	---	x	---
Shaft	1	x	---
Fan 1/	1	x	x
Miscellaneous small parts	---	---	x

1/ Purchased semifinished.

Case Study, Plant E

Product Description

5-horsepower, 220-440 volt, 3-phase, 60-cycle, 1,750-r.p.m., squirrel-cage design, induction motor in a rolled steel, welded construction frame, NEMA frame No. 254.

General Plant Information

Buildings. The company performs its entire production and clerical functions on the top floor of a 30-year-old brick and concrete multistory building. The working area totals about 3,000 square feet, which covers roughly one-half of the floor space. Storage facilities are maintained in the basement of the building and material hauling to and from the production area is accomplished by means of a single freight elevator.

Machinery. The machinery used consists of punch presses, light lathes, dynamic balancers, grinders, and drill presses. Handtools of various types are used on the assembly benches. In general, only a few jigs and fixtures are used. The two main uses for these jigs are: (1) to hold the motor level while braces are welded to the frame, and (2) to grip the frame around the stator core firmly so that it can be welded. Materials moving is by hand or by using 2- and 4-wheel hand trucks.

Employment and Wage Practices

Ten employees work in this plant. About 10 percent of their time is considered indirect labor and the remaining 90 percent is direct labor. Pay for direct and indirect labor is on an hourly rate basis. A new employee receives little formal instruction, but usually receives on-the-job training, which takes about 2 weeks in order for him to become productive. A training program for supervisors is not necessary, since the owner is the sole supervisor.

Operating Practices

Variety of Products. Besides the reported product, this plant manufactures other integral horsepower motors, as well as direct current and alternating current converters and generators. Since this company operates as a job shop, changes are readily made in the normal production sequence to meet the particular specifications of the customer. NEMA standards are followed in the design of reported item.

Size of Runs. Since plant E is geared to small job lot manufacture, it is impossible to obtain any realistic average size of run for the reported item. In the 1 month covered by this report, 20 of these motors were manufactured. Orders are accepted for a single motor, whether standard, or of special design.

Professional Engineering Services. In this plant, the owner-manager devotes part of his time to design and production engineering. Since the company operates primarily as a job-shop, filling special requests, design engineering is of major importance. The owner-manager makes all drawings necessary for changes in product specifications. He is also responsible for plant layout and any changes necessary in manufacturing methods.

Production Scheduling and Control. Since this plant is primarily a job shop, customer specifications must be examined and certain blueprints drawn before production scheduling can take place. After this step has been accomplished, shop orders are issued by the company president, who is its chief engineer, to the machine, winding, and assembly departments, to construct the specific motor or motors.

Manufacturing Process. Manufacturing operations are not as highly integrated as in the other plants studied. The two rough iron casting end covers of the housing are machined to fit the stator frame, and holes are drilled for housing bolts and bearings. For the latter operation, single-spindle drills, with jigs attached for locating holes, are used. The stator frame is purchased precut and rolled. It is machined to fit the end covers, cleaned, and polished, and the purchased feet and braces are welded to the frame.

Stator and rotor laminations are blanked on open back inclinable punch presses at the rate of 300 per hour. They are notched at the rate of 150 per hour. Stator coils are wound, slots insulated, coils inserted into slots, and connections made. The wound stator is dipped in impregnating material and baked. All insulating materials are purchased.

Rotor bars and end rings are cut and formed in the plant. Bars are inserted into rotor slots and brazed to the end rings. The assembled rotor is then turned to proper diameter and smoothness, and dynamically balanced.

The plant cuts and machines its own shaft which takes 2 hours of direct labor per shaft. The ventilating fan and small hardware are purchased completely finished. Final assembly is reported to require 2 hours of direct labor per motor. Handtools are used in assembly.

The chief variations in manufacture occur in the winding department, where the machines are set to the required number of turns and shape of the coil head. The stamping dies may have to be changed. All of these changes are common and are charged as setup and handling, and amount to about 10 percent of the cost of manufacture.

Table 25. Housing fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant E, U. S. A., 1951

Operation	Direct man-hours per motor 1/	Machinery, tools, and gages used	Materials-moving device
Total direct man-hours to fabricate housing. . . .	3.75		
1. End covers (2 per motor).	1.50	Single-spindle drill press, locating jig for holes, lathe for turning.	Hand truck.
2. Assemble and machine stator . . . frame which is purchased precut and preformed. Stack stator laminations, insert in frame, weld frame seam, tack-weld laminations to frame and weld feet and braces to frame. Turn to fit end covers.	2.25	Handtools, special vise to squeeze frame, milling machine, lathe, jig to hold frame and stator core assembly while base is welded to frame, welder.	- Do -

1/ Derived by dividing costs from cost records, by the hourly wage for the particular operation.

Table 26. Stator fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant E, U. S. A., 1951

Operation	Direct man-hours per motor 1/	Machinery, tools, and gages used	Materials-moving device
Total direct man-hours to fabricate and assemble stator. . .	5.12		
1. Blank laminations at a rate . . . of 300 per hour.	2/ .25	Open back, inclinable punch press.	Hand truck.
2. Notch laminations at a rate of. . 150 per hour.	2/ .62	Open back, inclinable notching press.	-Do-
3. Wind stator - wind coils, ... insulate slots, put paper between wire and iron core, insert stator coils, and make connections.	4.00	(3/)	(3/)
4. Dip and bake stator	.25	(3/)	(3/)

1/ Derived by dividing costs from cost records by the hourly wage for the particular operation.

2/ This is one-half actual time. Remaining half has been charged to rotor fabrication.

3/ Not reported.

Table 27. Rotor fabrication and assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant E, U. S. A., 1951

Operation	Direct man-hours per motor 1/	Machinery, tools, and gages used	Materials-moving device
Total direct man-hours to fabricate and assemble rotor. . . .	6.13		
1. Blank laminations	.25	Open back, inclinable punch press.	Hand truck.
2. Notch laminations	.63	Open back, inclinable notching press.	-Do-
3. Turn shaft to specified . . . . . diameters.	2.00	Lathe	-Do-
4. Stack rotor laminations, ... insert copper bars, assemble end rings, braze bars to end rings, and assemble to shaft.	1.50	Handtools	-Do-
5. Turn rotor to specified . . . . . diameter and smooth surface.	.75	Lathe	-Do-
6. Balance rotor	1.00	Dynamic balancer	-Do-

1/ Derived by dividing costs from cost records by the hourly wage for the particular operation.

Table 28. Final assembly, 5-horsepower, induction motor: Direct man-hours required per unit, and related data, by operation, plant E, U. S. A., 1951

Operation	Direct man-hours per motor 1/	Machinery, tools, and gages used	Material-moving device
Total direct man-hours for final . . . assembly.	2.00		
1. Put bearings on rotor shaft, . . . block 1 end bell onto stator frame, put fan on shaft, and assemble rotor to frame, block on 2d-end bell, insert cover bolts and tighten nuts.	2.00	Handtools	Hand truck.
2. Test voltage, frequency, and current - 3 phases. Check torque at rated current.			

1/ Derived by dividing costs from cost records, by the hourly wage for the particular operation.

Table 29. List of parts, 5-horsepower, induction motor, and related data, plant E, U. S. A., 1951

Name of part	Manufactured in plant	Purchased
Rotor laminations	x	
Stator laminations	x	
Motor frame		x
Shaft	Machine finished	Purchase steel.
End bell castings		Cast from company's patterns.
Ball bearings		x
Fan		x
Wire		x
Insulation		x
Varnish		x
Sleeving		x
Friction tape		x
Rag paper		x
Feet on frame and braces		x
Tie rods		x
Nuts, miscellaneous		x

Case Study Data on
Productivity and Factory Performance

5-HORSEPOWER, INDUCTION MOTORS

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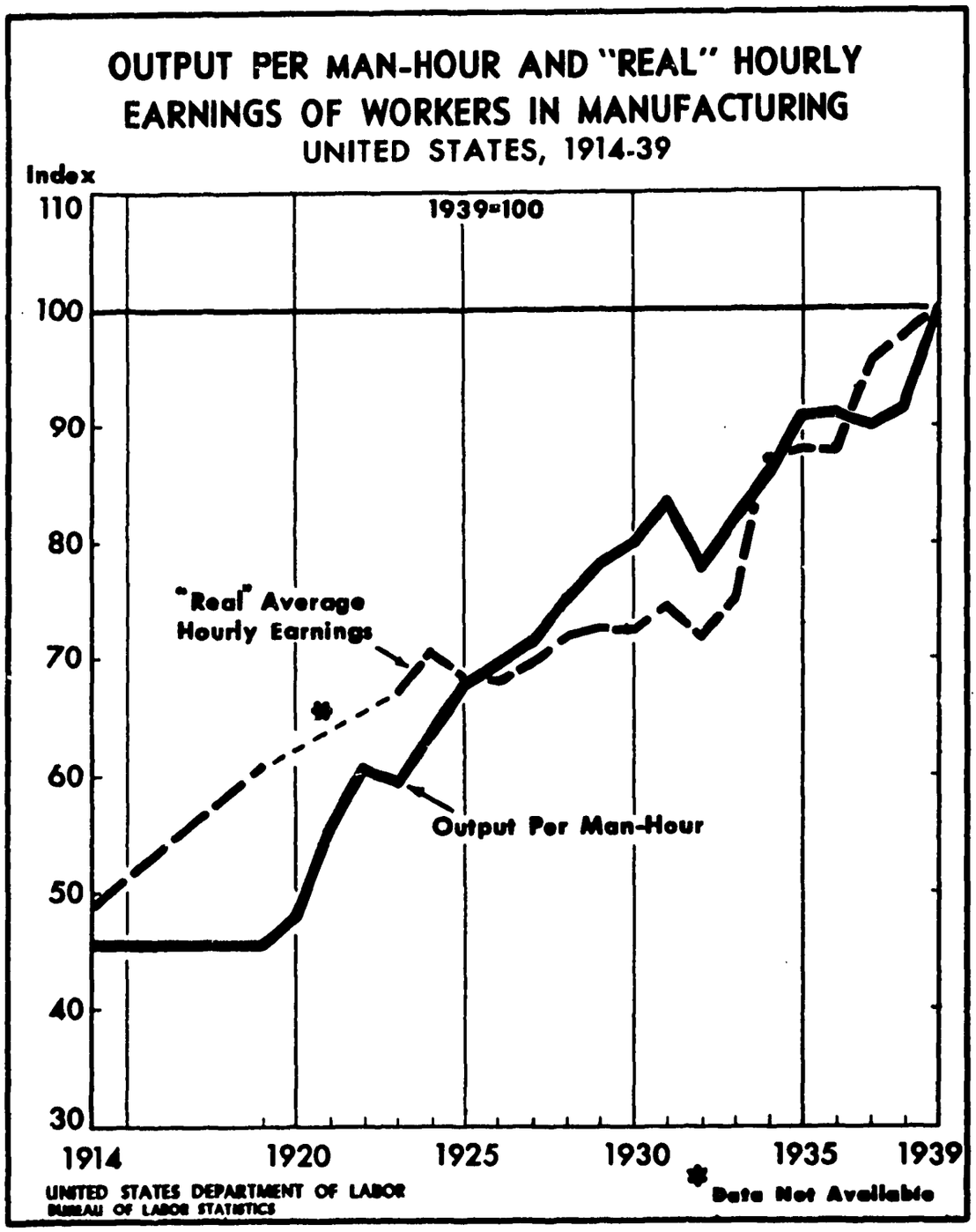

Figure 6 Output per man-hour and "real" hourly earnings in manufacturing, United States, 1914-39.

CHAPTER III: LABOR IN THE ELECTRICAL INDUSTRIAL APPARATUS INDUSTRY

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

Labor Background

Workers' earnings, as well as the earnings of other groups in the United States, have increased in real as well as in monetary terms along with almost continuous improvements in productivity. The Bureau of Labor Statistics estimated that from 1909 to 1947, the average real weekly earnings of factory workers doubled, whereas hours worked per week declined a fifth. 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. The mass market created by the purchasing power of the workers in turn encouraged advances in production techniques. 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. Besides greater weekly pay and shorter hours per week, workers have also chosen to take some of the returns from greater productivity in the form of "fringe benefits" -- paid holidays, vacations, pensions, and rest periods.

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

The average earnings of workers in United States factories and in the electrical industrial apparatus industry since 1947, are shown in table 30. In table 31, an attempt is made to eliminate confusion arising from different currencies by showing the cost of common commodities in terms of minutes of work required of the average factory worker for their purchase.

Average hourly earnings including overtime earnings, in the electrical industrial apparatus industry, rose from $1.33 in 1947 to $1.77 in 1952, an increase of 33.3 percent, and the average workweek increased 1.2 hours raising weekly earnings from $53.92 in 1947 to $73.99 in 1952, an increase of 37 percent. During the same period, the Consumers' Price Index of the United States Bureau of Labor Statistics rose approximately 18.7 percent.

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Table 30. Average hours and gross earnings of production workers, in all manufacturing industries and in the electrical industrial apparatus industry 1/, U. S.A., selected years, 1947-52

Year	Consumers' Price Index	All manufacturing industries			Electrical industrial apparatus industry		
		Average weekly earnings	Average weekly hours	Average hourly earnings	Average weekly earnings	Average weekly hours	Average hourly earnings
1947..	95.5	$49.97	40.4	$1.24	$53.92	40.6	$1.33
1950..	102.8	59.33	40.5	1.46	63.75	41.1	1.55
1951..	111.0	64.71	40.7	1.59	70.31	42.1	1.67
1952..	113.4	67.97	40.7	1.67	73.99	41.8	1.77

1/ The full title of this industry is "electrical generating, transmission, distribution and industrial apparatus."

Wage and Occupational Practices

Interplant variations in wage rates in this industry are influenced by the size of establishment, geographic location, method of wage payment, and extent of unionization.

According to a wage survey made by the Bureau of Labor Statistics in 1945, workers in large plants (over 100 employees) generally showed higher average earnings than workers in small plants. Geographic location also had an influence on the wage scale. Earnings of all plant workers in the Pacific region, were 9 percent higher than in the next highest region, the Great Lakes region.

Incentive pay methods that directly relate earnings to workers output have a considerable effect in this industry on average wage rates. In the 1945 survey, 2 of every 7 plants studied had an incentive system covering at least one-fourth of their plant workers. 3/ These incentive plans were about equally divided between piece rate and bonus systems, and in the majority of cases, pay was related to the efforts of individuals rather than to groups of workers. Although incentive wage payments are certainly not a requisite for high earnings, the fact that many workers in this industry are paid incentive wages is one influence toward higher average earnings.

Average earnings in union plants in comparable key jobs were higher than in nonunion establishments. In 1945, union plant earnings in the Great Lakes region were, on the average, about 13 percent higher than those in nonunion plants. In the Pacific region, the differential amounted to about 10 percent.

3/ Wage Structure, Electrical Generating and Distribution Equipment, Bureau of Labor Statistics, 1945.

Table 31. Amount of worktime required of average American factory worker and of average electrical industrial apparatus factory worker, to buy selected food and clothing items, 1947

Item	Unit of measure	Average factory worker		Average electrical apparatus factory worker 1/	
		Hours	Minutes	Hours	Minutes
Food:					
Milk	1 liter		9		8
Eggs	1 dozen		34		31
Oranges	1 dozen		21		19
White flour	1 kilogram		11		10
White wheat bread	1 kilogram		13		12
Butter	1 kilogram	1	28	1	21
Salt pork	1 kilogram		49		45
Potatoes	1 kilogram		7		6
Coffee	1 kilogram		51		47
Clothing:					
Men:					
Heavy wool suit	1	36	43	33	45
Work shirt	1	1	19	1	12
Socks	1 pair		16		15
Street shoes	1 pair	6	32	6	0
Work shoes	1 pair	5	56	5	27
Women:					
Wool coat	1	17	53	16	27
Street dress	1	8	20	7	40
Housedress	1	2	31	2	19
Rayon and nylon stockings	1 pair		53		49
Street shoes	1 pair	5	26	5	0

Source: The Gift of Freedom, U. S. Department of Labor, 1947, p. 23, et seq.

1/ Time data in this column obtained by multiplying time data in previous column by the ratio of average hourly earnings, all manufacturing, ($1.221), to average hourly earnings, electrical apparatus manufacturing ($1.328) for the year 1947. Earnings data obtained from Handbook of Labor Statistics, U. S. Department of Labor, 1947 and 1950 editions.

A written or otherwise generally recognized rate or scale of rates for each occupational group is the pattern for unionized plants. Man-power management is aided by the use of these formalized rate structures, since all employees know the paths of advancement. Promotion to a higher rated job is usually governed by seniority and merit. In contrast, a minority of small non-union plants determine wage rates informally on an individual basis.

The major occupations in the production of motors and generators are those of assemblers, punch press operators, drill press operators, inspectors, testers, painters, platers, lathe operators, and milling and grinding machine operators. Occupations peculiar to the electrical motor industry are wiring, armature winding, and coil winding. In 1945, the Bureau of Labor Statistics also found that almost one-fifth of all plant workers were assemblers, about one-ninth were engaged in the machinery operation classification, and one-twelfth were inspectors and testers. Five percent of all plant workers were classified as winders and wirers.

In this industry, layout men, tool-and-diemakers, machinists, mechanics, and setup men receive the highest pay. Skilled operators of specialized machines are the next highest paid group. Automatic lathe operators rate the highest average wage followed by operators of engine lathes, grinding machines, milling machines, screw machines, turret lathes, and welders. The largest group of workers are a semiskilled group, including assemblers, painters, inspectors, solderers, testers, wirers and winders, who receive less pay than the skilled operators. The unskilled, such as janitors, helpers, and apprentices, are employed at still lower wage rates. Table 32 gives a comparative analysis of the earnings of four classes of workers in the electrical industrial apparatus industry in Bridgeport, Conn.

Table 32. Average hourly earnings in electrical industrial apparatus industry, by occupational groups, in Bridgeport, Conn., U. S. A., 1951

Occupation	Skill	Straight-time average hourly earnings
Tool-and-diemakers	Highly skilled	2.01
Machine-tool operators . . .	Skilled	1.76
Inspectors	Semiskilled	1.56
Janitors	Unskilled	1.31

Fringe Benefits. American workers receive supplemental income in the form of paid vacations, bonuses, paid lunch periods, paid sick leave, company-paid insurance, pensions, and other services not mentioned here. Inasmuch as this industry is highly unionized, it has developed a strong program of welfare benefits.

Extra compensation, usually 1-1/2 times the base rate, is paid for all hours worked per week over 40. In 1951, motor and generator workers averaged 42.1 hours per week. Plants in this industry pay a shift differential ranging from 1 to 15 percent for second and third shifts, covering late evening and night hours. Bonuses not directly related to output, are numerous in this industry and are paid in the form of Christmas bonuses and profit sharing plans.

Paid lunch periods are uncommon, but a few plants include the lunch hour as part of the working time. A majority of plants have formal vacation provisions, including a vacation of 1 week for workers with 1 year of service, and longer vacations for longer service. Paid sick leave is a new development and exists in relatively few plants.

Pension Plans. As required by Federal law, virtually every worker in the United States employed by business or industrial firms, receives a pension at the age of 65. To finance this pension plan, (known as Federal Old Age and Survivors' Insurance) employers are required to contribute periodically an amount equal to 1-1/2 percent of each wage payment, and the employee contributes an equal amount. 4/ In addition, some States make extensive payments to aged workers to supplement for Federal payments.

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. If all the cost is not paid by the employer, the employees contribute the remainder. A recent survey revealed that more than half of the establishments in this industry contribute to the maintenance of such pension plans for plant workers.

Unions in the Industry

It is estimated that four-fifths of the electric motor and generator manufacturing plants are unionized and that this is one of the important influences resulting in the high industry wage level.5/

The workers in the electrical machinery industry were represented, until 1949, by three major unions. These were the United Electrical, Radio and Machine Workers of America (UE), which was affiliated with the Congress of Industrial Organizations(CIO); the International Brotherhood of Electrical Workers (IBEW) and the International Association of Machinists (IAM). The latter two unions are affiliated with the American Federation of Labor.

4/ The contributions will be progressively higher starting in 1954. For years 1954 to 1959, the contribution will be 2 percent and will eventually reach a maximum of 3-1/4 percent by 1970. Your Social Security, a pamphlet describing Federal Old Age and Survivors' Insurance, U. S. Government Printing Office, Washington, D. C.

5/ Wage Structure, Electrical Generating and Distribution Equipment, Bureau of Labor Statistics, 1945.

In November 1949, the national convention of the CIO expelled the UE and chartered the International Union of Electrical, Radio, and Machine Workers, known as the IUE-CIO, to represent the workers in the electrical products industries. The UE has since been an unaffiliated union. A substantial portion of the former UE membership is now part of the IUE-CIO.

Adjustments to Technological Change

Labor and management in the United States have always been faced with problems arising from changes in processes and the introduction of new machinery. The problems generally include determination of earnings, workload, 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 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 from a case in one industry is applicable to problems of change in other industries. Consequently, the methods and ideas developed in negotiations over technological change are used in many industries 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.

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

APPENDIX I: CASE STUDIES OF ADJUSTMENTS TO TECHNOLOGICAL CHANGE

NOTE: THE CASE STUDIES USED TO ILLUSTRATE ADJUSTMENTS TO TECHNOLOGICAL CHANGE WERE NOT MADE IN THE 5-HORSEPOWER MOTOR INDUSTRY. THESE EXAMPLES WERE SELECTED BECAUSE OF THE TECHNIQUES AND PROCEDURES THEY DEMONSTRATE, WITHOUT REGARD TO THE INDUSTRY IN WHICH THEY OCCUR.

Example A.6/ "1. The company discusses with the union proposed changes in process and introduction of new machinery. The company must keep pace with, and if possible, lead the way in making changes in technology and processes which turn out cheaper and better glass. Accordingly, Libbey-Owens-Ford wants freedom to introduce new machines and processes, to shift work from less efficient to more efficient plants, and to make more products with less manpower. If it is unable to achieve these objectives at least in part, its very survival as a business is in jeopardy; the automobile manufacturers, which use a large amount of the glass produced by LOF, are 'tough customers.' The following case is an illustration of the union-management consultation which usually precedes any technological change.

"A conveyor system was to be installed in the laminated plant in Toledo. The local president was called in and told the company's plans. At first he hit the ceiling. After he had calmed down he gave a dozen and one reasons why the plan would not work. By the time a second meeting was held with full union committee, management had altered its plans to meet several of the objections raised by the local president and had answers ready for the others. Again the union representatives told management why their plans would never work, and again the company adopted some suggestions and set forth its reasons for insisting that the conveyor system be used. The conveyor system was then installed, but in a way which met many of the union's objections. The union's biggest fear was that earnings would be reduced, and in this respect the company was able to assure the men that they could keep up their bonus earnings on the new jobs. In this case the information-sharing process was used successfully as a means of implementing a management decision.

"2. Another time the company laid a scheduling problem out on the table for the union's consideration. Since the auto manufacturers were short of steel they could not use the glass they had ordered for the next nine-month

---

6/ The Libbey-Owens-Ford Glass Company and the Federation of Glass, Ceramic and Silica Sand Workers of America, Causes of Industrial Peace Under Collective Bargaining, Case Study No. 2, National Planning Association, Washington, D. C., November 1, 1948.

period. The company had two alternatives. They could cut production drastically at once, lay off a large number of men, and then rehire later to bring production back up when the glass could be used at a faster rate. Or they could gamble on the total amount that would be needed for the entire nine months and schedule the glass at a constant rate, laying off a few workers at once but keeping all the remaining men at work over the entire nine-month period. The company told the union to make the decision, since it felt that the laying off and rehiring of men was the most important consideration involved. As one might expect, the union decided to cut down as much as necessary for the entire period. Probably the company wanted the same thing but recognized the advantage of having the union make the decision in a case of this kind."

Example B. 7/ "Technological changes involving displacement of workers have been handled with real care and with genuine concern for employee welfare. In 1945, a division of the company employing 76 people was moved from Cambridge to a new plant in another area in order to locate the manufacturing operation near the source of supply of raw materials. For 6 to 8 months prior to the move, consideration was given to the placement of the employees affected. Some were transferred to other jobs as normal turnover created openings. A crew of 35 operators was required right up to the last moment in order to build up an inventory to supply customers during the transfer of heavy equipment to the new plant. These workers were given a guarantee of their regular hourly rates regardless of the job to which they might be transferred. The guarantee was based on length of service: 1 month for each year up to 12 months' guarantee. The length of service of these employees ranged from 1 year for 2 people to 10 years or more for 8 people. Practically all these employees were placed before their guarantees expired, on jobs carrying rates at least as high as their former ones. None of the 76 was laid off, but 2 men and 8 women resigned rather than accept transfer."

7/ The Dewey and Almy Chemical Company and the International Chemical Workers Union, Causes of Industrial Peace Under Collective Bargaining, Case Study No. 3, National Planning Association, Washington, D. C., December 17, 1948.

APPENDIX II: INDUSTRY STATISTICS

Table IIa. General statistics for the electrical industrial apparatus industry, and its major divisions, U. S. A., 1947

Industry	Number of establishments	Number of employees	Value of products (000 omitted)	Percent of total industry products
Electrical industrial apparatus, total	1,567	321,352	$2,771,019	100.0
Motors and generators	256	127,012	1,007,186	36.3
Electrical control apparatus .	324	72,330	628,108	22.7
Wiring devices and supplies .	342	38,367	378,099	13.6
Transformers	144	36,635	356,968	12.9
Electrical measuring instruments	154	20,926	153,380	5.5
Electrical welding apparatus .	108	7,265	103,712	3.7
Carbon and graphite products .	44	7,818	68,745	2.5
Electrical industrial apparatus (not elsewhere classified).	195	10,999	74,821	2.8

Source: U. S. Census of Manufactures, 1947

Table IIb. Number of establishments, number of wage earners, wages paid, and value of products, in electrical motors and generators industry, U. S. A., selected years, 1939-51

Year	Number of establishments	Number of production workers (average for year)	Total wages paid	Value of products	Percent wages to value of products
1939..	132	1/ 44,423	$ 67,376,000	$ 264,196,000	25.50
1947..	256	1/ 101,852	282,252,000	1,007,186,000	28.02
1950..	(2/)	3/ 72,405	235,657,000	1,000,059,000	23.56
1951..	(2/)	4/ 90,740	338,050,000	1,386,754,000	24.38

1/ U. S. Census of Manufactures, 1947.
2/ Information not available.
3/ Annual Survey of Manufactures, 1949-50, U. S. Bureau of Census.
4/ Annual Survey of Manufactures, Advance Report, March 11, 1953.

APPENDIX III: COLLECTION OF DATA

Introduction

The preparation of data for this study required five steps: (1) library research and personal contacts in Washington to learn the background of the industry and the general manufacturing process; (2) preparation of a questionnaire with the advice and counsel of management, labor, and trade associations; (3) testing of the questionnaire in a few cooperative companies and later revision to conform to actual conditions found during these pilot visits; (4) assignments of the study to the field offices of the Bureau of Labor Statistics and gathering of data by personal conferences with top officials and from company records; (5) finally, evaluation, selection, and arrangement of the data as presented in this report.

Derivation of Man-Hour Data

Plant A. Total direct man-hours per motor were derived by dividing cost per motor for production of 102 of the reported motors in 1 month by the average hourly rate of pay per worker. Total indirect labor per motor was computed by applying the ratio of indirect payroll to direct payroll to the man-hours of direct labor as derived above. Both standard man-hours, as developed by plant time study engineers, and adjusted man-hours are shown for individual operations. The adjusted hours are in all cases 70 percent of reported standard hours for the operation. The adjustment factor is simply the ratio of total direct man-hours per motor derived from cost records to total standard man-hours per motor.

Plant B. Total direct labor per motor was computed by dividing the average direct labor cost estimate per motor in the 2-month reporting period by the average hourly wage of direct labor. The cost estimate was based on standard labor time in the heavy motor department adjusted for variance. Total indirect labor was taken as 30 percent of direct labor. This was the ratio the company was using at the time of the report to compute its costs. "Planned" direct labor times for individual operations were taken from the plant's records; "planned" direct hours are standards developed from previous experience. The ratio derived by dividing the sum of the "planned" man-hours at all operations by total direct hours per motor secured from costs as described above, was applied to the "planned" times to compute adjusted man-hours at each operation. The total of adjusted man-hours per motor then is equal to the total direct labor per motor computed from labor costs.

This plant included as direct labor costs - machining, winding, assembling, testing, painting, inspecting, and packaging. Indirect labor costs include setup, some testing, repairing, instruction on job, overtime bonus and shift bonus, maintenance, tool room, and engineers' pay.

The total direct and indirect man-hours per motor are averages for the 74 motors included. Adjusted man-hours at individual operations depend on an average adjustment factor. Therefore, actual labor time for any particular motor, or at any particular operation may have been either higher or lower than the times shown.

Plant C. Total direct labor per motor was computed by dividing the average direct labor cost estimate per motor in the reporting period by the average hourly wage of direct labor. Total indirect labor was derived by applying the plantwide ratio of indirect to direct labor to total direct labor per unit.

Both standard times and adjusted man-hours are shown for individual operations. The adjusted hours for all operations are derived by taking 92.4 percent of reported standard hours for the operation. This adjusting factor is simply the ratio of total direct man-hours per motor derived from costs records to total standard man-hours per motor.

Plant D. Total direct man-hours per motor and man-hours at individual operations are actual average performance for the first 6 months of 1951 developed from records. The month-to-month variations which naturally occur are smoothed out by these averages. Indirect man-hours were derived by prorating a fixed percentage of total man-hours for the period.

Included under the category of direct labor are the operations of machining, winding, assembling, testing, welding, inspecting, and packing. Indirect labor includes truckers, watchmen, elevator operators, building maintenance, and toolroom employees.

Plant E. This plant maintains no time standards, and direct man-hour figures charged to each operation were obtained from the cost records. This was done by taking the labor cost per operation and dividing it by the wage rate for that operation.

Indirect labor was estimated by the company to be 10 percent of the direct hours per operation.

This plant includes as direct labor all winding, machining, sheet-metal work, and assembly operations. Indirect labor is composed of setup, materials moving, and supervision.

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

CONFIDENTIAL

PRODUCTIVITY AND FACTORY PERFORMANCE

5-HORSEPOWER, INDUCTION MOTORS

Name of company _____ Address _____

Plant name _____ Address _____

Officials interviewed: Cross out word not applicable:

Name _____ Title _____ (Co.) (Plant)

Name _____ Title _____ (Co.) (Plant)

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

Survey made by _____ Date _____

A. SPECIFICATIONS

List specifications of reported product: _____

B. PRODUCTION: MAN-HOURS

1. Man-hours per reported item:

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

      Period begins _____ and ends _____

   b. Total production of reported product during this period _____
   c. Total factory man-hours on reported product during this period _____
   d. Total direct man-hours on reported product during this period _____
   e. Total indirect man-hours on reported product during this period _____
   f. List the labor classifications included in the indirect man-hour figures given in (e) above: _____

g. Describe exactly the procedure used to derive direct and indirect man-hours in (d) and (e) above: _____

_____

_____

_____

_____

C. PRODUCTION SCHEDULING AND INSPECTION

1. Production run per reported product:

a. Average continuous run of reported product _____
b. Smallest number in one continuous run _____
c. Largest number in one continuous run _____
d. Production method, line _____, job lot _____, other (describe) __

_____

_____

_____

e. Average actual production during reported period by shift:
(1) Day shift _____ (2) 2d shift _____ (3) 3d shift _____

2. Scheduling

a. Describe fully the methods used in production scheduling and control for the reported product, paying particular attention to factors such as planning for chargeover to this model, organization of flow of materials or components, relative to product design, etc. _____

b. Custom production:
(1) Are variations of the reported product made to purchasers' specification: Yes _____ No _____.
(2) If output of such variations were included in B (1) b, give the number of such units produced _____.
(3) What is the smallest order (in units) acceptable: For standard models of the reported product _____; for variations of standard models _____; for special or custom made models _____.

c. Describe the changes made in normal production arrangements upon the introduction of a run of a variation of a standard model, or of a special or custom made model, in terms of actual examples _____.

3. Design and methods improvement

a. Does this plant have a design department? (Check) Yes __ No __. If "no," does it contract for the services usually performed by such a department? (Check) Yes __ No __.
Describe department or services: _____

b. How many are employed in design department? _____

c. Does this plant maintain an engineering (methods analysis, etc.) department to improve plant layout, manufacturing methods, etc., or make provisions for such activity? Yes___ No___ Describe_____

d. How many are employed in this engineering department?_____

e. Describe management's view of the effectiveness of this department in reducing man-hour requirements for the reported model or related models _____

f. How frequently are operations analyzed to evaluate standard time, etc. Describe methods used._____

Standardization and Simplification

a. During the year prior to the reporting period, how many changes were made in the design of the reported product in the interest of standardization (interchangeability of parts)_____

b. Describe fully a typical example of such change_____

c. During the year prior to the reporting period, how many changes were made in the design of the reported product in the interest of simplification of production operations_____

d. Describe fully a typical example of such change:_____

Inspection

a. Are any statistical quality control methods used in any of the manufacturing operations? Yes_____ No_____. If yes, describe_____

b. Other systems used: (Describe)_____

Jigs and Fixtures

Describe the extent to which jigs and fixtures are used in key operations, furnishing descriptions (and drawings) of several examples, if possible._____

D. GENERAL PLANT INFORMATION

List major categories of plant production and value of shipments during 1951: _____

Employment:

a. Number employed in plant during reported period:

Total - all plant employees	_____
Total - production and related employees	_____
Total - direct production employees	_____
Total - indirect production employees	_____
Nonproduction employees	_____

b. Average length of scheduled workweek (excluding overtime) during reported period _____hours.

Plant employment by department, occupations, sex, and payment method during reported period.

Department	Number of Workers		List Key Occupations	Method of Payment (Check)	
	Total	Female		Piece Rate	Hourly
All Departments			XXXXXXXXXX	XXXXXXXXXX	XXXXXX

Training programs:

a. Describe training program for production workers (1) on in-plant basis; (2) using outside resources (schools, etc.)_____

b. Describe training program for supervisors_____

Plant buildings:

Use	Sq. Ft.	No. of Floors	Age	Type of Construction and Special Features

a. Were buildings designed originally for modern production techniques as applied to this product?
Yes_____No_____

b. Were buildings modified for use of modern production techniques as applied to this product?
Yes_____No_____. If yes, describe:_____

Secure the following, if available:

a. Sales literature, catalogs, etc.
b. Pictures of products reported.
c. Floor plans and work-flow charts of plant if readily available.
d. Forms used in scheduling work, controlling inventory, etc.

Productivity Factors:

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

_____

_____

E. ANALYSIS OF PARTS AND ASSEMBLY OPERATIONS

List of parts, materials and components for reported product

Part Name	Manufactured (Check)		Used in Operation Sequence No. 2/
	In Plant	Purchased 1/	

1/ Check as purchased, items made in other plants of same company.
2/ Enter operation sequence No. of sheet in which the part, material or component is used in E. 2.

Analysis of manufacturing process

On the attached sheets, indicate operations performed in order of their actual sequence in the plant. Indicate unit man-hours per operation in every case: Actual man-hours wherever possible, and standard or estimated hours otherwise. Attach time standards if available. In the space below describe the method of deriving these man-hours and time standards and the time period to which they relate.

F. ANALYSIS OF MANUFACTURING PROCESS

Name of Plant _____ Parts, materials and components used 1/ _____

Operation sequence number _____

Part or product produced _____

Step number	Operations performed (nature of work done in each shop)	Machinery used 2/		Materials-moving device and destination	Unit man-hours 4/ per operation or part
		Name, make, model, type drive 3/	Capacity per unit time		

1/ If subassembly of previous operation is used, identify by operation number.
2/ If possible, secure blueprints or drawings of specially designed machines, special jigs and fixtures and attach to operational sheet.
3/ Note "L" if line drive, "U" if unit drive, "G" if group drive.
4/ Actual man-hours preferably, standard time otherwise.

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GLOSSARY

a. c.:	Alternating current.
ASA:	American Standards Association.
Blanking:	Stamping sheet metal to dimensions by use of a cutting die in a press.
Block:	To press wire coils into core slots.
Brite:	Bright.
C:	Frequently used as an abbreviation for center as in C bore.
Center band or stator frame:	A cylinder of steel which supports the stator parts. The center band also forms a part of the housing and is fitted to the end bells.
Coil:	An arrangement of one or more turns of wire.
Core:	Stacked and bound laminations which become part of a magnetic circuit when wire wound around the core is energized with electricity.
d. c.:	Direct current.
Direct labor:	Workers whose efforts can be identified as applying to a particular product at a particular time. For example, a machine operator or an assembler. See Indirect Labor.
Drawing:	A cold-pressing operation to change the form of a piece of metal from a flat blank to a circular or cylindrical shape.
End bell, end cover, or end shield:	The end cover of an electric motor, particularly one with a center band.
End ring:	On a squirrel-cage, induction motor, an end ring is a ring of conducting metal used to connect the rotor bars at their ends.
Forming:	A cold-pressing operation to change the shape or thickness of a piece of metal.

Frame:	A frame is the supporting structure for the stator parts. In a direct-current machine the frame usually forms a part of the magnetic circuit; it includes the poles only when they form an integral part of it. From ASA. Also called the center band, stator band, or stator shell.
Indirect labor:	Labor which is auxiliary to the direct production operations, e.g., shipping and receiving, plant maintenance, materials moving, supervision, production planning and control.
Induction motor:	An induction motor is an induction machine which converts electric power delivered to the primary circuit into mechanical power. The secondary circuit is short circuited or closed through a suitable circuit. --From ASA.
Lamination:	A stamping of sheet steel shaped so that a number of them can be stacked and bound to form a core which can be magnetized.
NEMA:	National Electrical Manufacturers Association.
Rating, continuous:	Continuous rating is the rating that defines the load which can be carried for an indefinitely long time.--From ASA.
Rotor:	A rotor is the rotating member of a machine.--From ASA.
Rotor core:	The assembled laminations which form the magnetic circuit of the rotor.
Sleeving:	Insulation.
Slots:	Trenches cut into the inner faces of stator laminations and outer periphery of rotor laminations in which the current carrying windings are imbedded when several laminations have been riveted together to form a core.
Squirrel-cage winding:	A squirrel-cage winding is a permanently short-circuited winding, usually uninsulated (chiefly used in induction machines), having its conductors uniformly distributed around the periphery of the machine and joined by continuous end rings. From ASA.

Stator:	The stationary part of an electrical machine.
Stator band, stator frame, or stator shell:	See center band.
Stator core:	The assembled laminations which form the magnetic circuit of a stator.
Tumbling:	To polish by placing pieces in a closed turning container together with a suitable abrasive or wax.
Windings:	The conductors, which when assembled into a core, carry the electric current which sets up a magnetic circuit.