PLANT REQUIREMENTS FOR MANUFACTURE OF MECHANICAL SPRINGS

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
COMMUNICATIONS RESOURCES DIVISION
Washington 25, D. C.

FOREWORD

This brochure is one of a series of reports resulting from overseas technical inquiries on factory or commercial establishments, operation, management, and engineering. The report is designed to provide only a general picture of the factors that must be considered in establishing and operating a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice in order to meet specific local conditions.

Mention of the name of any firm, product, or process in this report is not to be considered a recommendation or an endorsement by the Agency for International Development, but merely a citation that is typical in its field.

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For further information and assistance, contact should be made with the local Productivity Center, Industrial Institute, Servicio, or United States Aid Mission.

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Torrington Manufacturing Company
100 Franklin Drive
Torrington, Connecticut

The Torrington Manufacturing Company manufactures all types of spring fabricating machinery, including the Clutch-type and Segment-type Spring Coilers, Torsion Spring Winders, Flexible Casing Coiler, and the Verti-Slide Machine described in this report.

The Coulter and McKenzie Machine Company
36 Union Avenue
Bridgeport 7, Connecticut

The Coulter and McKenzie Company manufactures many types of equipment used by the spring industry, including the Taper Rolling Machines, Hydraulic Spring Coiler, and Cambering Machine described in this report.

The J. H. Elliott Company
2101 New York Avenue, N. E.
Washington 2, D. C.

The Elliott Company is Sales Representative for many manufacturers of machine tool equipment, including the LeBlond Regal Engine Lathe and the U. S. Burke Quartet Milling Machine described in this report.

The Secrest Machine Corporation
2772 South Randolph Street
Arlington 6, Virginia

The Secrest Corporation represents various machine tool manufacturers such as Hendley & Whittemore Company who produce the Alligator Shear and forming rolls described in this report, as well as other machine tool equipment.

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INTRODUCTION

The purpose of this report is to present basic information relative to the establishment of a plant to manufacture mechanical springs in a foreign country.

Springs may be produced in a wide variety of shapes, such as coiled, spiral, flat, leaf, ring, and numerous special shapes. They may be of various types, depending upon their intended use, such as tension, compression, torsion, extension, cantilever, etc. The ends may be formed to most any shape desired, such as tightly coiled, looped, squared, hooked, open, etc. A plant may manufacture only stock type springs for general purpose use, or it may manufacture a wide variety of shapes, types, and sizes to a customer's individual specifications. The plant described herein has been planned and equipped to produce initially the six general groups of spring products listed under "Product Specifications." This production can be varied to suit local conditions.

A plant of this type will require a substantial capital investment and a relatively skilled labor force. Obviously, an economically underdeveloped country could not profitably support a plant of this type, as a market for spring products will not exist until general industrial development is quite advanced. However, in a suitable environment, a plant such as this can realize substantial profits with efficient management, production controls, and sales effort.

GENERAL ASSUMPTIONS

In order to make realistic cost estimates in this report, it is necessary to make the following assumptions:

1. The costs of the building and general facilities are based on the United States prices

2. Material and equipment costs are based on sizes and specifications current in the United States.

3. Labor costs are based on the average for the industry as recently published by the United States Bureau of Labor Statistics.

4. Adequate and suitable water, power, sewerage, and transportation facilities are available at the plant site.

5. This plant operates eight hours a day, five days a week, and fifty weeks a year.

6. The plant manager, foreman, and engineers are capable and experienced men who are able to do all the labor training that is necessary with the aid of the other skilled workmen. It is assumed that learner's rates will be paid in such cases and that the costs can be charged under unforeseen expenses.

7. The following items cannot be estimated realistically:

   a. Land value
   b. Distribution and selling costs
   c. In-freight and out-freight
   d. Administrative costs
   e. Taxes

   Approximate estimates are made for each of these items, with the exception of taxes, for the purpose of completing cost estimates; however, adjustments should be made in accordance with actual local costs.

8. All cost estimates contained in this report are to be adjusted to conform to local conditions. Columns are provided in the tables included in this report to facilitate conversion of cost figures to those existing locally.

PRODUCT SPECIFICATIONS

The information and costs contained in this report are based on production of the following six general groups of flat and coiled springs. These spring products are manufactured by both hot- and cold-forming methods, and an infinite variety of shapes and sizes is possible within each of the groups. Figure 1 shows some typical spring shapes which might be considered.

1. Cold-formed tension, compression or torsion coil springs (wire outside diameters from 0.003 inch to 0.625 inch oil tempered or 0.750 inch hard drawn)

2. Cold-formed open/closed rings (wire diameters from 0.041 inch to 0.307 inch)

3. Bowden cable casing up to 3/4 inch outside diameter

4. Hot-formed tension, compression or torsion coil springs 1/2 inch to 2 inches

5. Hot- and cold-formed flat springs and torsion bars up to 3/4 inch by 2 inches

6. Special shapes

Spring products are fabricated from a wide variety of carbon or alloy spring steels, depending upon their desired characteristics. Raw stock can be obtained in coil, strip or bar form and the following specifications are available for the better-known grades of spring stock.

American Society for Testing Materials (ASTM)

A 59-49 Silicon-Manganese Steel Bars for Springs

A 60-49 Chromium-Vanadium Steel Bars for Springs

A 68-49 Carbon-Steel Bars for Springs, with Silicon Requirements

A 125-52 Heat-Treated Steel Helical Springs

A 147-51 Heat-Treated Steel Leaf Springs

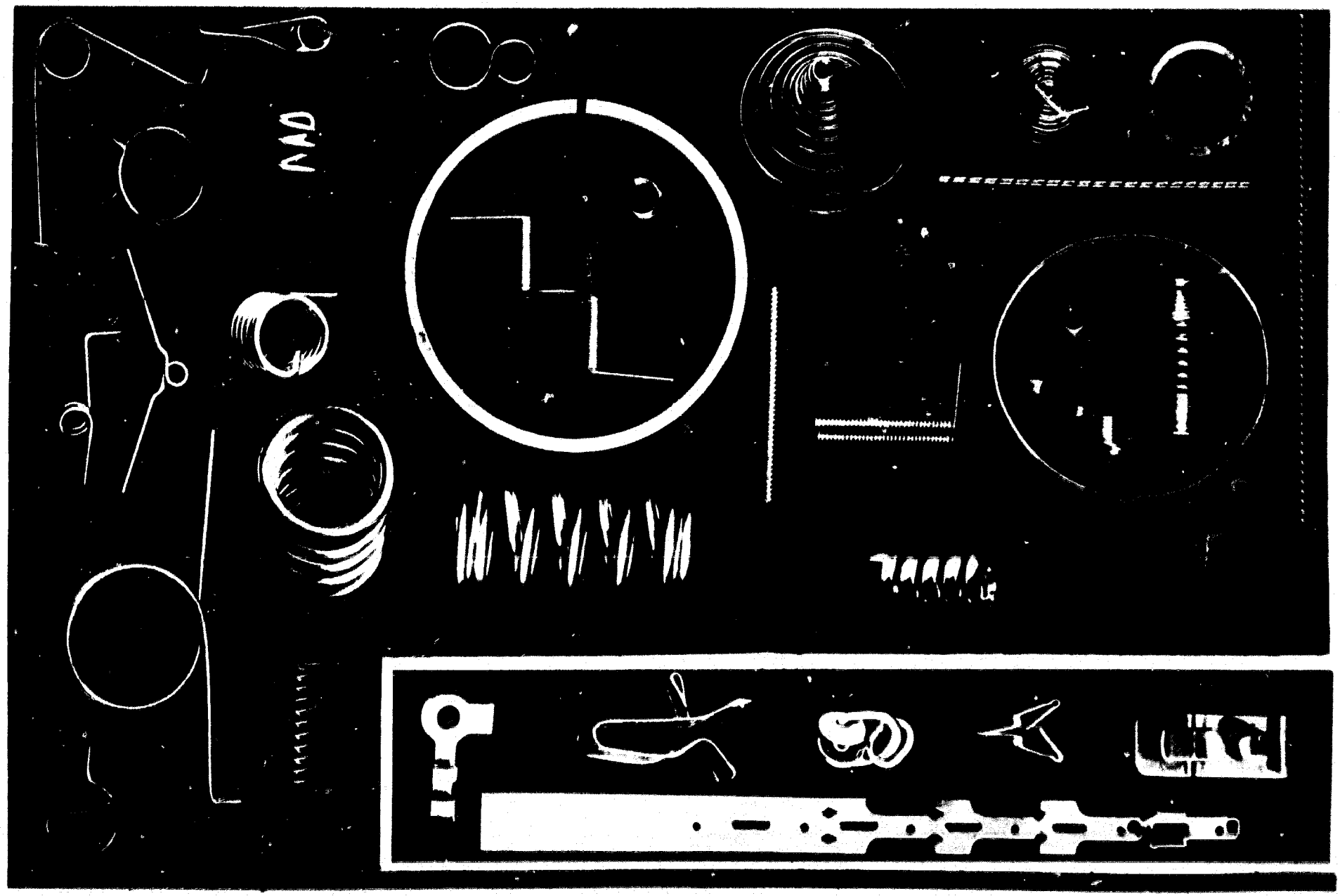

Figure 1. Some Typical Spring Shapes

A 227-47 Hard-Drawn Steel Spring Wire

A 228-51 Steel Music Spring Wire

A 229-56 Oil-Tempered Steel Spring Wire

A 230-47 Carbon-Steel Valve Spring Quality Wire

A 231-41 Chromium-Vanadium Steel Spring Wire

A 232-47 Chromium-Vanadium Steel Valve Spring Quality Wire

B 260-56T Brazing Filler Metal, Tentative Specification for (American Welding Society (AWS) A 5.8-56T)

A 313-55 Chromium-Nickel Corrosion-Resisting Steel Spring Wire

A 332-56 Nickel-Chromium-Molybdenum Steel Bars for Springs

A 401-58 Chromium-Silicon Steel Spring Wire

United States Federal Specifications

QQ-W-412 Wire, Steel Alloy (general purpose quality) for Mechanical Springs

QQ-W-423 Wire, Steel, Corrosion-Resisting

QQ-W-428 Wire, Steel, High Carbon, Round, Uncoated for Mechanical Springs (general purpose)

QQ-W-470 Wire, Steel, High Carbon, Spring, Bright, Music

Society of Automotive Engineers (SAE)

1956 SAE Handbook

Recommended Practice:

Helical Compression and Extension Springs Cold-Coiled for Automotive Use

Helical Springs for Motor-Vehicle Suspension

Standard

Leaf Springs for Motor-Vehicle Suspension

DEFINITIONS

Flat Spring - Essentially any spring made of flat strip or bar stock which deflects as a cantilever, or a simple, beam. Flat springs may be of the following types: single or laminated leaf, semi- or double-eliptic, spiral-coiled, and many others.

Helical Compression Spring - An open-coil spring that offers resistance to a compressive force applied axially. Generally, compression springs are cylindrical in form, however, they may be conical, tapered, concave, convex, etc.

Helical Extension Spring - A close-wound or open-wound spring that offers resistance to an axial force tending to extend its length. Springs of this type are fitted with ends suitable for attaching the spring to the assembly.

Helical Torsion Spring - A spring that offers resistance to or exerts a turning force in a plane at right angles to the coil axis. Helical springs are generally fabricated from circular wire. However, wire with a square or rectangular cross-section may be employed for certain applications.

Spiral Torsion Spring - Generally made by winding flat material on itself in the form of a spiral. These springs are designed to wind up and exert pressure in a rotating direction around the spring axis.

Torsion Bar Spring - A straight bar or rod of definite cross-section that offers resistance to a twisting moment about its longitudinal axis. The cross-section may be round, square, rectangular, or hexagonal, as required. The ends usually are upset to diameters larger than the body diameters, with a transition section between the body and ends to keep stress concentrations low. Couplings such as splines and serrations are cut on the upset ends to provide anchorage.

Bowden Cable Casing - Consists of flat or round wire coiled continuously in long lengths in the form of a casing. It is generally supplied in standard lengths and, when fitted with an interior wire or rod and suitable end connections, is used for flexible shafting and control cables.

Load - The force exerted upon or by a spring to reproduce or modify motion, or to maintain a force system in equilibrium. The load may be either static or dynamic in nature.

Initial Tension - The load wound into springs during the coiling operation. This keeps the coils tightly closed until it is exceeded by an applied load.

Total Deflection - The movement of a spring from its free position to its maximum operating position.

Deflection Per Coil - The total deflection of the spring divided by the number of active coils.

Set - The permanent distortion from the manufactured dimensions which occurs when a spring is stressed beyond the elastic limit of the material.

Solid Length - The over-all length of a compression spring when all coils are fully compressed.

Free Length - The over-all length of a spring in an unloaded condition.

Spring Index - The ratio of the mean spring diameter to the diameter of the wire.

Spring Rate - The load required to deflect a compression or extension spring one inch, or the load required to deflect a torsion spring one degree or one revolution.

Torque - The turning force about an axis multiplied by its distance from the axis, usually expressed in pound - inches or ounce - inches.

Spring Tolerance - The allowable deviations from a given dimension, such as the outside diameter or number of coils of helical springs, position of arms for torsion springs, free length for compression and extension springs, alignment of ends and loops, and load deflections.

Direction of Helix - When viewing a spring from one end, the direction of helix is considered to be right-hand when the coil recedes in a clockwise direction and left-hand when it recedes in a counterclockwise direction.

Tempering - A low temperature heat treatment, after coiling or bending, to remove residual stresses caused by the forming method.

Hardening - Heat treating above the critical temperature and quenching in oil to harden the steel.

Keystone Effect - The change in shape that occurs when square or rectangular wire is coiled. A trapezoidal section results because some of the material on the outside diameter is drawn into the wire while the material on the inside diameter is upset. The original thickness of the wire is preserved at or near the pitch diameter of the coil.

Heat Treatment - An operation or combination of operations, involving the heating and cooling of a metal or an alloy in the solid state, for the purpose of obtaining certain desirable conditions or properties.

Quenching - Rapid cooling by immersion in liquid such as oil, water, brine, etc.

PRODUCTION CAPACITY

This plant can produce about 800 pounds of mechanical springs in an eight hour day or about 100 tons in a year. Approximately 120 tons of raw stock per year will be required to meet this production rate.

The plant should reach full production in about two months, with all labor training being accomplished by the manager, foreman, and engineers assisted by the skilled machinists.

This estimated production rate of 200,000 pounds of mechanical springs per year is based on the manufacture of a variety of spring sizes and shapes limited to the six general groups previously discussed. However, many other types can be fabricated. Not only are springs almost infinite in sizes, weights, shapes, styles, ends, treatments, finishes, etc., but there is also a great difference in manufacturing cost between mass produced, standard or stock designs and those custom-made to conform to certain specifications. Thus, production rate and manufacturing cost can vary greatly

depending on the specific types being fabricated. Properly controlled production line labor skills, efficient plant management, quality engineering of spring designs, and an active sales force can combine into a profitable high capacity operation.

MANUFACTURING UNIT

The manufacturing unit for the production of mechanical springs is the pound.

MANUFACTURING OPERATIONS

Springs may be either cold- or hot-formed, depending upon the raw stock size. Stock sizes up to about 1/2 inch may be formed cold, while larger sizes should be formed hot. These two processes, and details of the operations involved in fabricating the various types of springs, are given in the following paragraphs.

COLD-FORMING PROCESS

Tension, Compression, and Torsion Coil Springs

Types. This group of light duty springs includes all variations of helical coil springs - tension or compression, single or double taper, squared or hooked ends; and all types of torsion coil springs.

Material. 0.003 inch to 0.750 inch diameter steel spring wire is used in the manufacture of these springs.

Coiling. This operation is performed on automatic coiling machines equipped with auxiliary reels and wire straighteners. The machine draws the wire from the wire reel and passes it through the straightener to remove the set taken by the wire during winding and shipment. The straightened wire is fed into the coiling machine which automatically delivers the type of spring determined by the preset controls. The spring ends are either ground square, hooked by the coiling machine,

looped in a separate operation by a special looping machine. (Such a machine, called "Modular Looper", is manufactured by the Torrington Manufacturing Co.). Figure 2 shows two sizes of segment-type coilers for producing tension and compression springs. Figure 3 shows two different sizes of automatic torsion spring winders.

Heat-treating and Tempering. Cold-wound springs are normally heat-treated and tempered to remove residual stresses and to increase their fatigue life. This process consists of heating the springs to the proper temperature in a furnace and then quenching in oil to obtain the required crystalline structure and hardness.

Surging, Set. When required, this operation is used to give a coil spring the specified free height. For example, a compression spring may be surged in a setting machine by closing the spring solidly and then releasing it. This operation is repeated until the spring attains the proper free height.

Cleaning, Polishing. The formed springs are cleaned either by degreasing in solvent tanks, or by burnishing in tumbling barrels. If required, they are then polished on grinding and buffing wheels.

Finishing. If required for appearance or corrosion resistance, the springs may be dipped in oil or coated with enamel or lacquer.

Quality Control. The production line operations should be checked periodically to insure that the equipment is operating properly, and that the completed springs will meet specification requirements.

Inspection Packing. The cleaned and polished springs are visually inspected for defects before applying the finish coating. Characteristics such as dimensions and tolerances, hardness, load deflection, and set are measured on precision instruments. If a coating is applied, the finish is inspected and the springs suitably packaged and transferred to stock or to the shipping department.

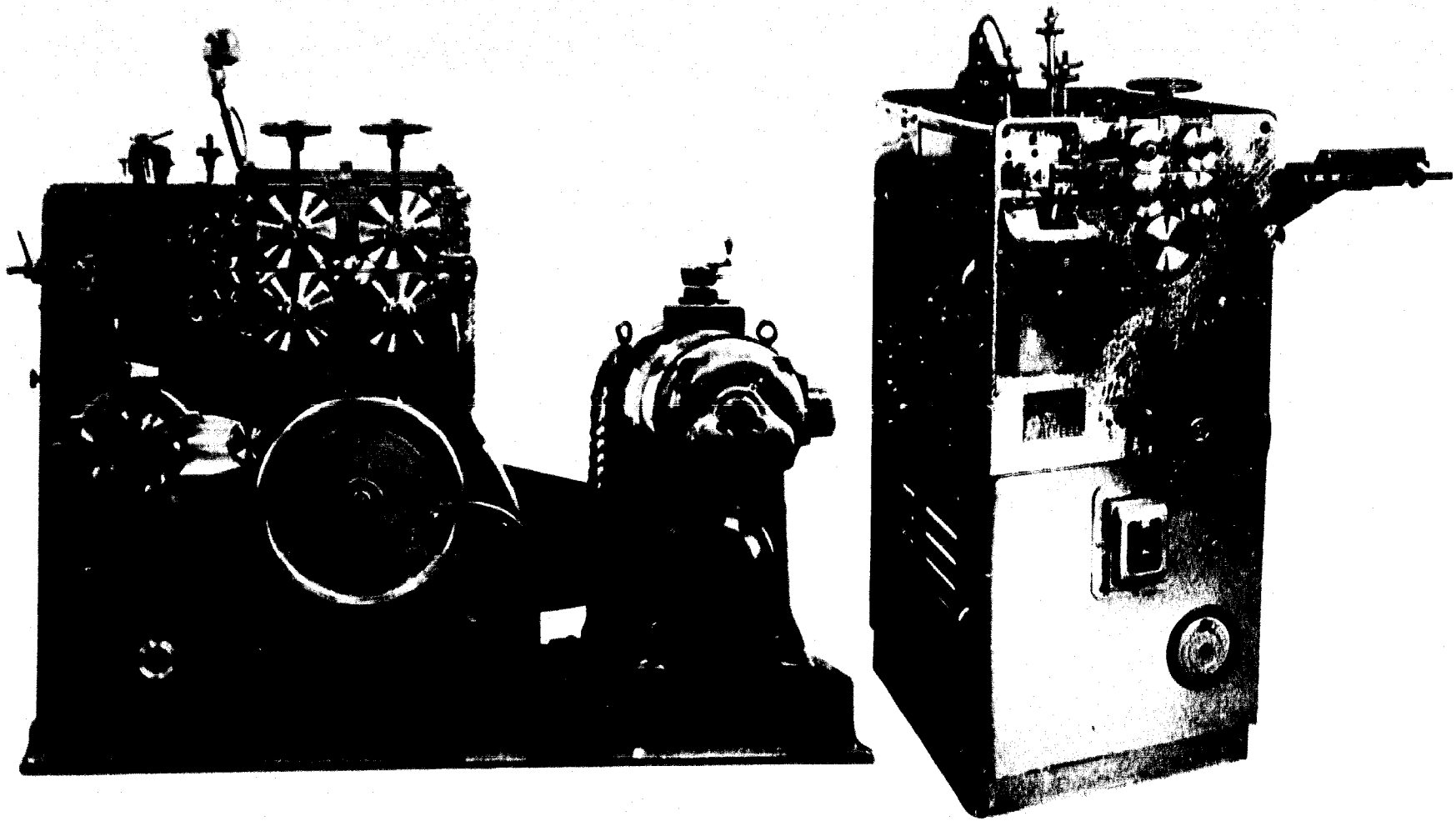

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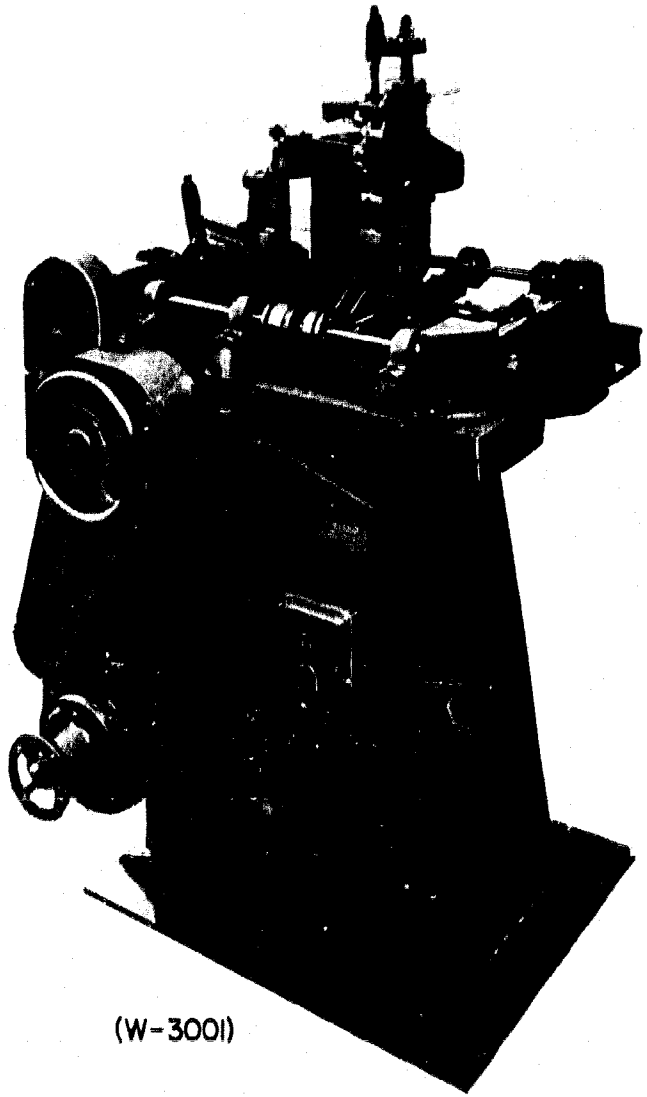
Figure 2. Two Sizes of Typical Segment-type Spring Coilers



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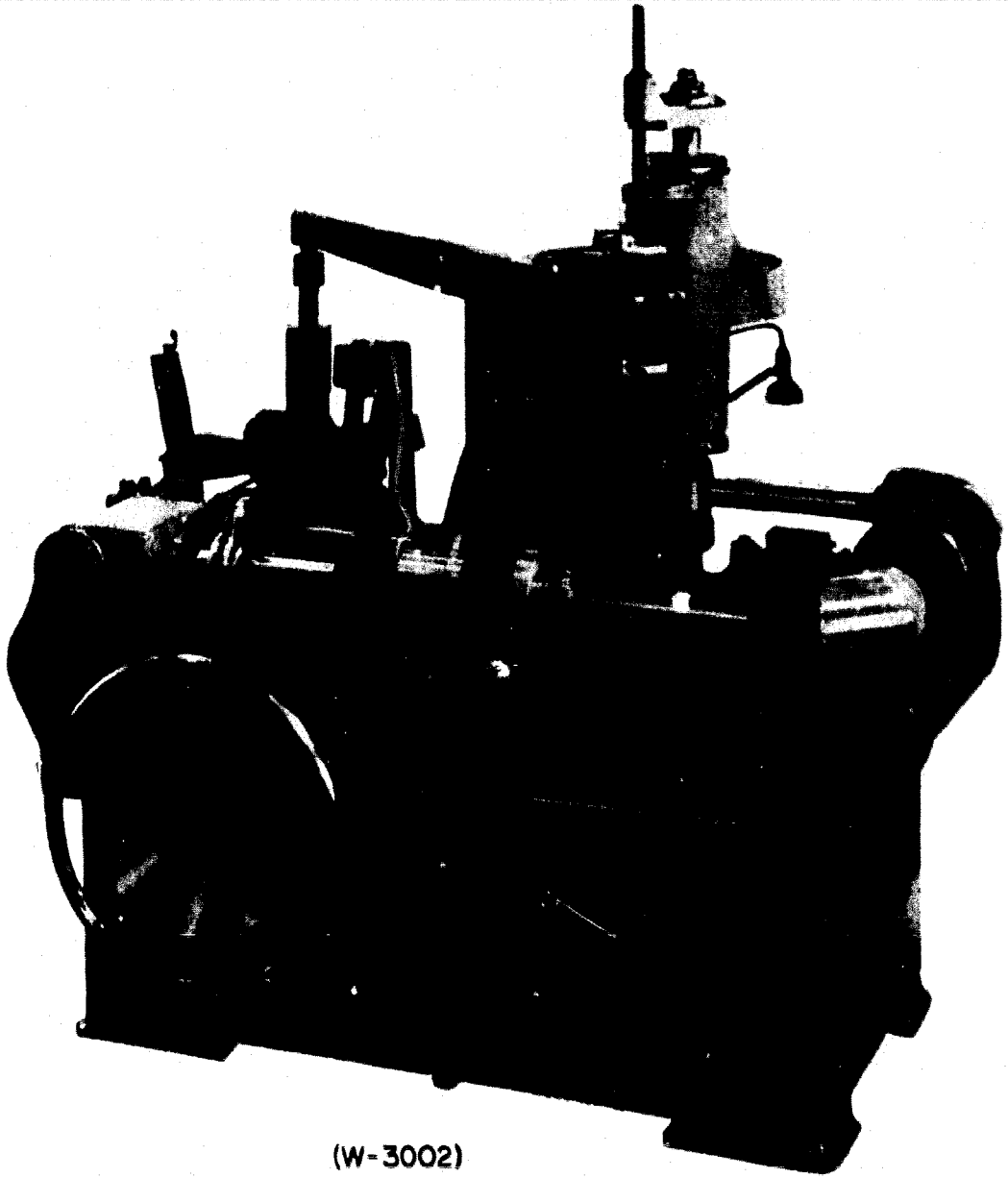

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Figure 3. Two Sizes of Typical Torsion Spring Winders

Rings

Types. This group includes both open and closed type rings. Standard sizes range from 1 to 3 inches in outside diameter, and special sizes up to 14 inches can be fabricated.

Material. 0.041 inch to 0.307 inch steel spring wire is used in the manufacture of these rings.

Fabrication. This operation is performed on automatic ring coiling machines equipped with auxiliary reels and wire straighteners. 1 to 3 inch rings can be produced with standard tooling, but the larger sizes require special tooling. The rings are produced in the open condition; when closed rings are desired, they are made from the open ones by brazing the ends together. The machine draws the wire from the wire reel and passes it through the straightener to remove the set taken by the wire during winding and shipment. The straightened wire is fed into the ring coiler which automatically delivers the proper size open ring. The rings then follow the same production procedures for heat treating and tempering, cleaning, polishing, inspection, and packing as previously described for coil springs.

Bowden Cable Casing

Types. This group consists of flexible cable casings up to 3/4 inch outside diameter.

Material. Round or flat steel spring wire, of the appropriate ASW gage, is used in the manufacture of these casings.

Fabrication. This operation is performed on an automatic Bowden cable coiling machine equipped with auxiliary reels and wire straighteners. The straightening and coiling operations are similar to those performed by previously described winding machines, except that the wire is continuously coiled in long lengths. The cable is then cut into the required lengths and the end fittings attached by brazing or silver soldering. The finished cable is then cleaned, coated, inspected, and packed as previously described.

HOT-FORMING PROCESS

Tension, Compression, and Torsion Coil Springs

Types. This group of heavy duty springs consists of helical tension or compression springs and all types of torsion coil springs.

Material. Round, square, or irregular cross-section steel spring bar stock, in sizes larger than 1/2 inch, are used in the manufacture of these springs. The bar stock usually comes in straight lengths about 20 feet long.

Cutting, Heating, Swaging. The bar stock is cut to the required length with an alligator shear. Both ends are heated in a forge and swaged to a taper in a taper rolling machine to assist in the forming of square spring ends. Figure 4 shows two sizes of taper rolling machines suitable for performing this operation. The tapered bar is then placed in a tunnel-type furnace and heated to forging temperature.

Coiling. The heated rod is attached to the winding mandrel of a hydraulic coiling machine which winds the bar into the spring shape determined by preselected settings of the machine controls.

Heat-treating and Tempering. The hot spring is stripped from the winding mandrel and quenched in oil, water, brine, or caustic. Subsequently, the spring is reheated and drawn in the heat-treat department to obtain the required crystalline structure and hardness.

Surging, Cleaning, Coating, Inspecting, Packing. These procedures are essentially the same as those described for cold-formed springs.

COLD- OR HOT-FORMING PROCESS

Flat Springs and Torsion Bars

Types. This group of flat springs includes single and laminated leaf springs, eliptic springs, flat spiral-coiled springs, torsion bars, and others.

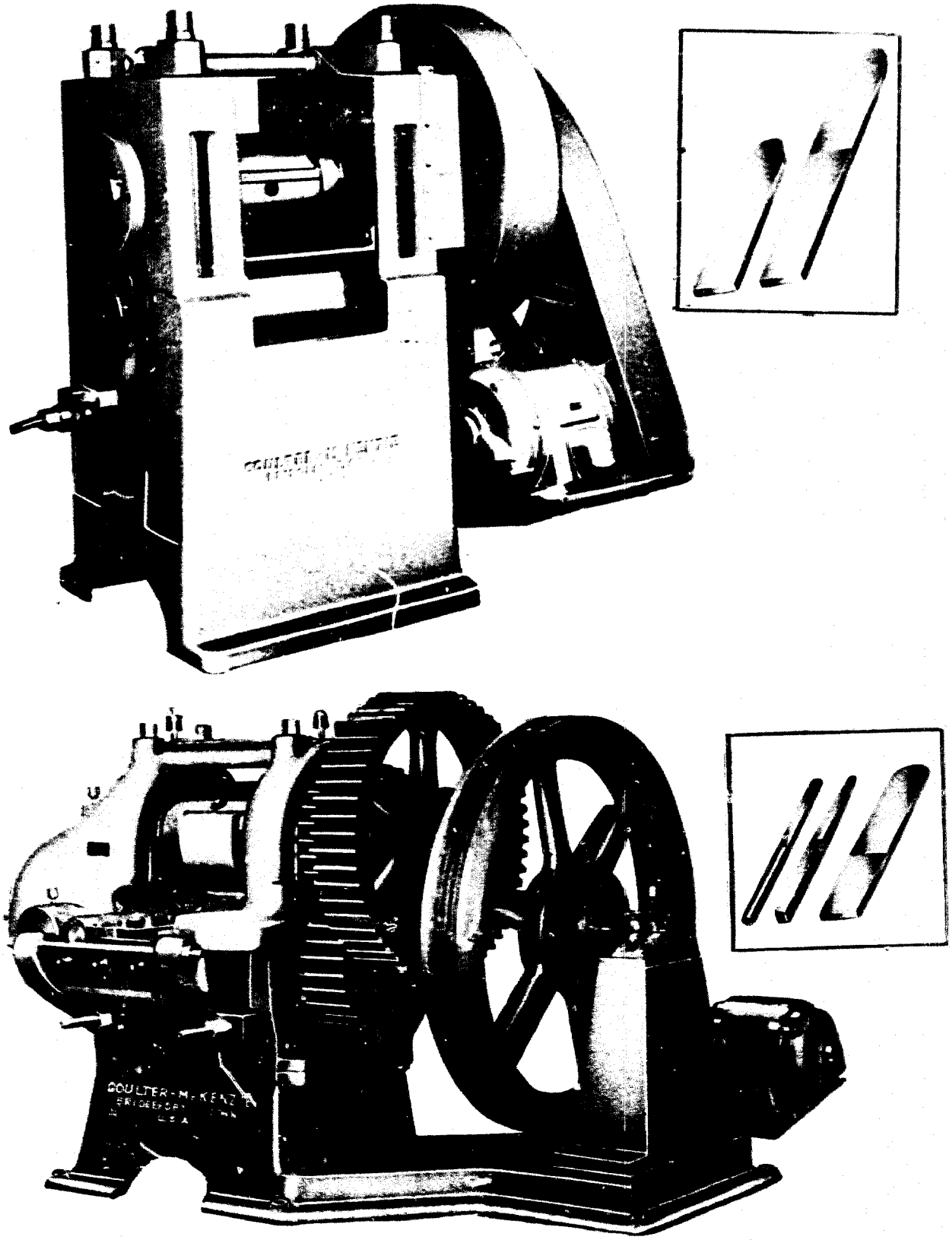

Figure 4. Two Sizes of Typical Taper Rolling Machines

Material. Steel spring stock, in strip or bar form and sizes up to 3/4 inch by 2 inches, is used in the manufacture of these springs.

Fabrication. Either hot- or cold-forming methods may be used to fabricate these springs. The method used will depend on the type, size, and gage thickness of the raw stock. General machine shop equipment such as punch presses, taper rolls, engine lathes similar to the one shown in figure 5. anvils and forging tools, forming rolls, and milling machines such as that shown in figure 6, are often used, either exclusively or in conjunction with the automatic equipment, to produce these springs. Although these items are formed mostly by manual operations, the procedures followed in their fabrication, heat treating, tempering, cleaning, coating, inspection, and packing are very similar to those described for the hot- and cold-forming of other spring types.

Special Shapes

Special spring shapes are always made to a customer's individual specifications and no details can be given for their fabrication. It is assumed that lot sizes will be small, that general-use spring equipment and manual methods will be employed, and that the prices for these special items will vary according to the operations required in their manufacture. A Verti-Slide wire and strip forming machine, illustrated in figure 7, is a very valuable adjunct for a plant manufacturing springs of this nature. It is included in the list of equipment for this plant to increase its versatility.

Any manufacturing plant of this nature must maintain a well equipped tool and die shop to fabricate special jigs and dies and the forming tools required by the automatic spring winding machines, as well as to repair and maintain the production equipment. A heat treat department, equipped with furnaces, tempering baths, quench tanks, etc., and an inspection department equipped with the necessary measuring instruments and hardness testers, will also be required.

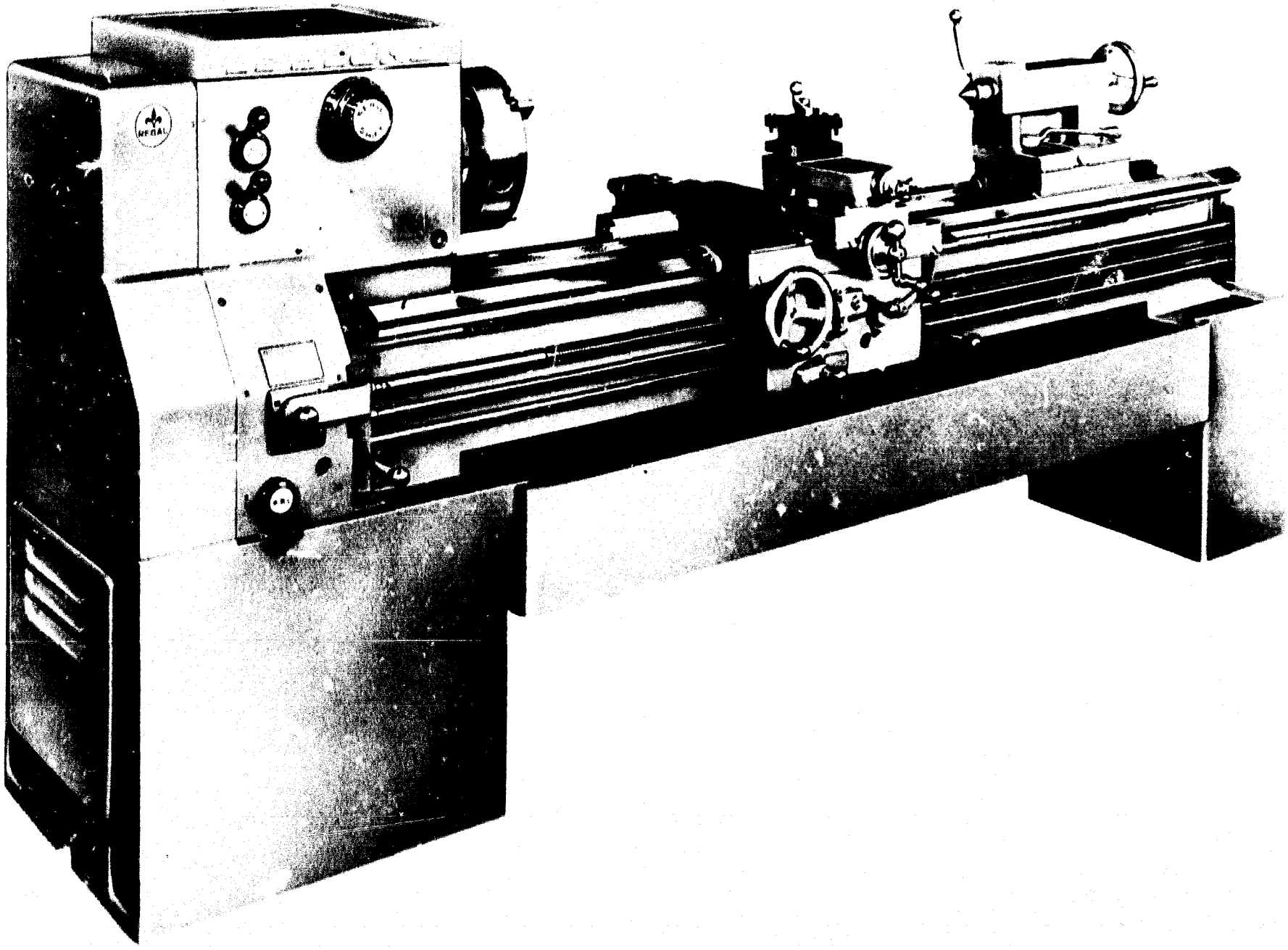

Figure 5. Typical Engine Lathe with Preselective, Automatic Shifting Headstock

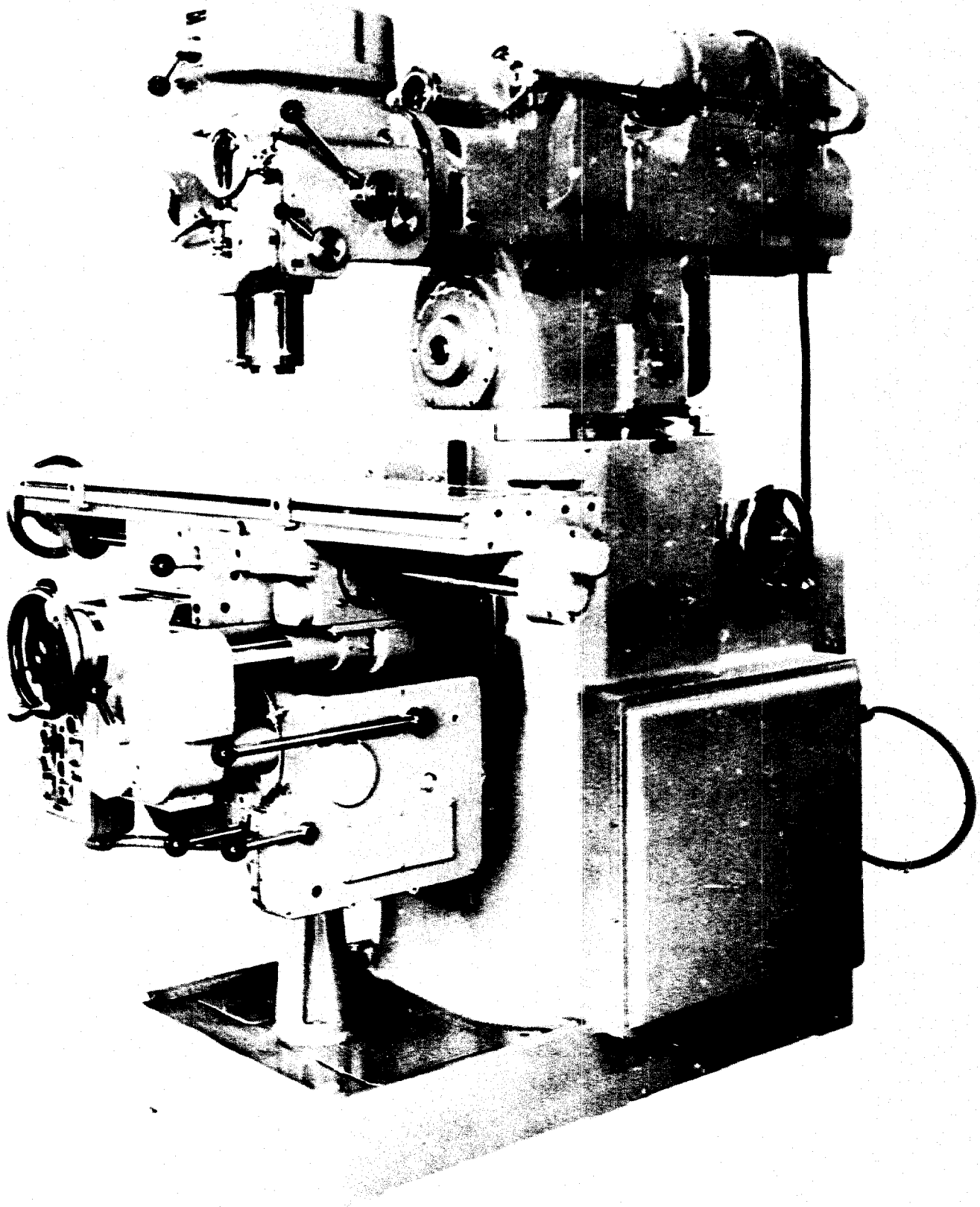

Figure 6. Typical Universal Type Milling Machine with Vertical Head

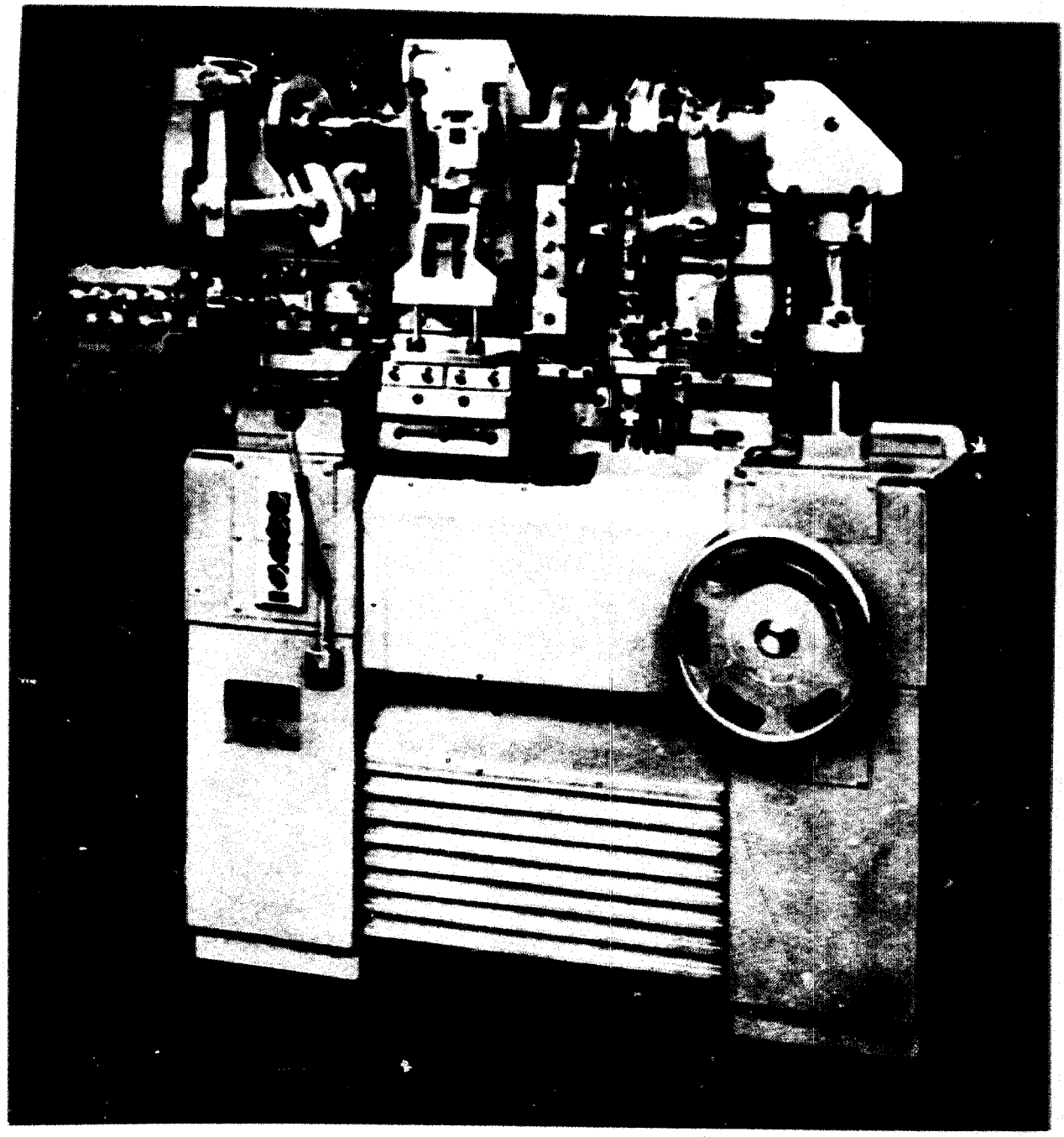

Figure 7. Typical Verti-Slide (Four-Slide) Wire and Strip Forming Machine

PLANT SITE

Approximately one acre of land will be required to accommodate the building and to allow for normal future expansion. It should be located as advantageously as possible with respect to transportation, power, water, fuel, sources of labor, and a substantial market for its finished products. The cost of the land is estimated at $2,000.

BUILDING

A one-story fire proof building with a concrete floor will be required. Suggested dimensions are 106 feet wide by 115 feet long giving 12,190 square feet of floor space. The cost of the building, including all utilities, is estimated at $60,000. Figure 8 gives a proposed plant layout and figure 9 the suggested flow of work through the plant.

POWER

The total connected power requirements for this plant are approximately 150 kilowatts per hour. The annual power cost is estimated at $3,900 based on 1.3 cents per kilowatt hour. Even in the United States, power costs vary considerably with locality.

WATER

Approximately 800,000 gallons of water are required annually for production, sanitation, and fire protection. The cost of water is estimated at $240.

FUEL

The annual requirement of fuel for heating is estimated at $500.

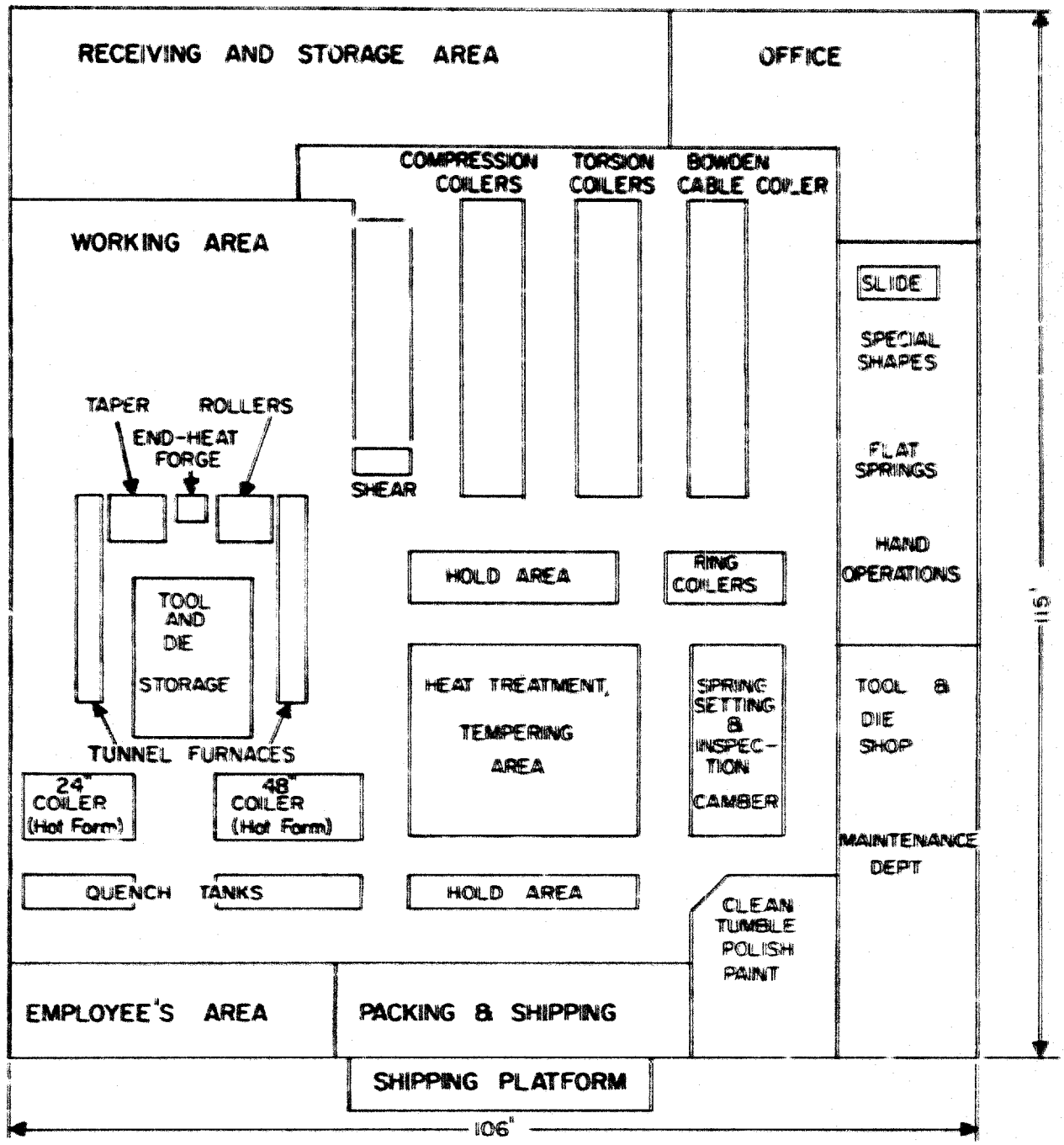

Figure 8. Proposed Plant Layout

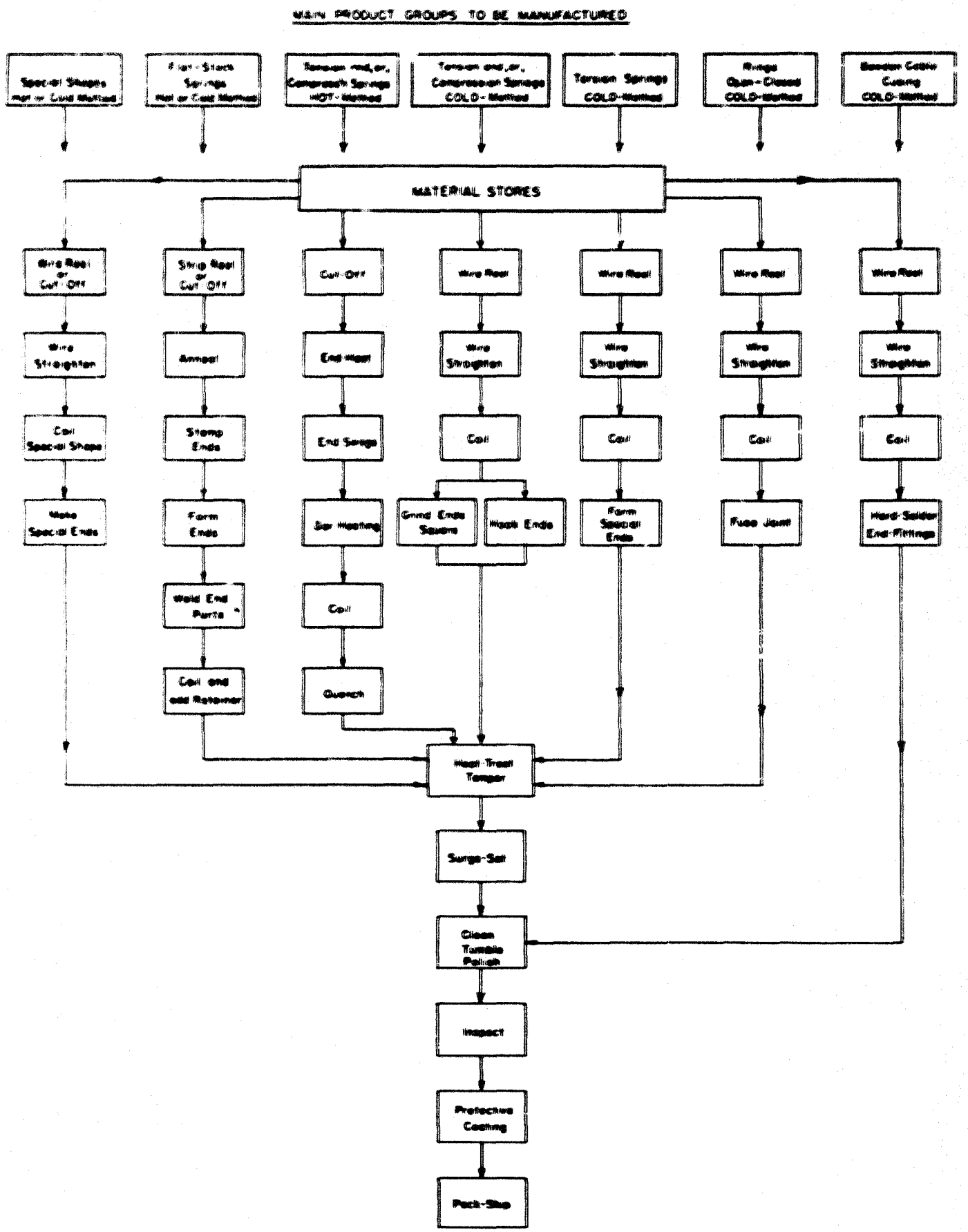

Figure 9. Suggested Work Flow Through the Plant

DIRECT LABOR

Occupation	Number Required	Hourly Rate	Annual Cost Estimated	Annual Cost Actual
Skilled Machinists	6	$2.50	$31,200	
Semi-skilled Workmen	9	1.75	32,760	
Unskilled Workmen	6	1.50	18,720	
Totals	21		$82,680	

INDIRECT LABOR

Occupation	Number Required	Hourly Rate	Annual Cost Estimated	Annual Cost Annual
Plant Manager	1		$12,000	
Supervising Foreman	1	$3.50	7,280	
Senior Engineer	1	4.00	8,320	
Junior Engineer	1	3.00	6,240	
Bookkeeper	1	3.00	6,240	
Stenographer-Typist	1	2.00	4,160	
Typist-Clerk	1	1.50	3,120	
Receiving-Shipping Clerk	1	1.50	3,120	
Inspector	1	3.00	6,240	
Maintenance Foreman	1	3.50	7,280	
Maintenance Mechanic	2	2.50	10,400	
Tool and Die Maker	2	3.25	13,520	
Fork Lift Operator	1	1.75	3,640	
Warehouse Man	2	1.25	5,200	
Totals	17		$96,760	

DIRECT MATERIALS

Item	Unit	No. of Units	Unit Cost*	Annual Costs Estimated	Annual Costs Actual
Spring Steel Stock	ton	120	$170.	$20,400	

* Includes in-freight and handling charges

SUPPLIES

Item	Annual Cost Estimated	Annual Cost Actual
Packaging Material	$ 2,800	
Cutting Tools, Wheels, etc.	1,000	
Lubricants and Hand Tools	1,000	
Welding Rods and Gas	1,000	
Brazing Alloys and Flux	2,000	
Maintenance and Repair Parts	4,000	
Office Supplies	500	
Heat-treating Materials	1,200	
Finishing Materials	500	
Retainers for Flat Springs	500	
Total	$14,500	

PRODUCTION TOOLS AND EQUIPMENT

Description	Suggested Model No.	Number Required	Estimated Cost Unit	Estimated Cost Total	Actual Cost
2-inch Alligator Shear - Secrest Machine Corp.	Belort G-3	1	$ 6,250	$ 6,250	
Spring Coilers, Complete, Torrington - 4 Models	W-11A	1	6,180		
	W-125A	1	7,915		
	W-225	1	23,605		
	W-23	1	26,305	64,005	
Torsion Spring Winder, Complete, Torrington - 4 Models	W-3000	1	6,430		
	W-3001	1	8,015		
	W-3015	1	17,630		
	W-3002	1	20,180	52,255	
Tunnel-type Heating Furnace		2	3,000	6,000	
Open-type End Heating Forge		1	3,000	3,000	
Taper Rolling Machines, Coulter & McKenzie - 2 Models	2-1/2	1	16,590		
	3	1	31,500	48,090	
Ring Coilers, Torrington - 2 sizes		1	11,000		
		1	12,000	23,000	
Spring Setting Machine, Light Duty		1	4,200	4,200	
Hydraulic Hot Spring Coiling Machines, Coulter & McKenzie - 2 sizes	24-inch	1	36,230		
	48-inch	1	41,911	78,141	
Cambering Machine, Coulter & McKenzie	40A	1	32,780	32,780	
Verti-Slide Machine, Complete, Torrington	V-80	1	15,518	15,518	
Flexible Casing Coiler, Torrington		1	10,000	10,000	
Miscellaneous Heat-treating Equipment and Accessories				32,000	

PRODUCTION TOOLS AND EQUIPMENT (Continued)

Description	Suggested Model No.	Number Required	Estimated Cost Unit	Estimated Cost Total	Actual Cost
End Hooking Machine,		1	$ 5,000	$ 5,000	
Disc Grinder (End Squaring),		1	1,500	1,500	
Forming Rolls, Secrest Machine Corp.	Belort 20B	1	7,400	7,400	
Universal Milling Machine, Vertical Head-Elliott Co.	U. S. Burke Quartet No. 2	1	11,000	11,000	
Total				$400,139	

OTHER TOOLS AND EQUIPMENT

Description	Number Required	Unit Cost	Cost Estimated	Cost Actual
General				
Engine Lathe, Medium (LeBlond Regal)	1	$ 7,500	$ 7,500	
Bench Lathes	3	2,500	7,500	
Kick Punch-Presses	2	500	1,000	
Drill Presses	4	250	1,000	
Anvils and Forging Tools	2	250	500	
Cut-off Shear, Manual	1	750	750	
Power Punch Press, 5 Ton	1	1,000	1,000	
Electric Arc Welder, Portable	1	250	250	
Acetylene Burner Outfits	2	150	300	
Tool and Die Department				
Vertical Miller #2	1	12,000	12,000	
Horizontal Miller #2	1	10,000	10,000	

OTHER TOOLS AND EQUIPMENT (Continued)

Description	Number Required	Unit Cost	Cost Estimated	Cost Actual
Surface Grinder 8 x 24 inch	1	$ 8,000	$ 8,000	
Lathe, 16 inch	1	10,000	10,000	
Shaper	1	6,500	6,500	
Precision & Hand Measuring Tools			3,000	
Platform Scale	1	1,500	1,500	
Clean-Finish Department				
Tumbling Barrels	2	2,200	4,400	
Hand Buffer	1	200	200	
Grinding Wheel, 10 inch, Heavy Duty	1	200	200	
Paint Sprayer	1	125	125	
Degreasing Tank	1	500	500	
Paint Dip Tank	1	200	200	
Rockwell Hardness Tester	1	500	500	
Hand-lift Trucks, Hydraulic	3	200	600	
Pallets	100	12	1,200	
Lift Fork Truck	1	6,500	6,500	
Fume & Smoke Exhauster	1	200	200	
Miscellaneous				
Tools, Bins, Vises, Racks, Surface Plates, Carts, etc.			4,000	
Total			$89,425	

FURNITURE AND FIXTURES

Description	Number Required	Unit Cost	Cost Estimated	Cost Actual
Executive Desk and Chair Sets	2	$130	$ 260	
Standard Desk and Chair Sets	7	100	700	
Typewriters and Tables	3	110	330	
Calculators	2	110	220	
File Cabinets	3	50	150	
Storage Cabinet	1	30	30	
Locker Sections	30	20	600	
Coat Rack	1	30	30	
Water Fountain	1	100	100	
Chairs	6	15	90	
Miscellaneous			90	
Total			$2,600	

DEPRECIATION

Description	Estimated Cost	Years Life	Per Year Estimated	Per Year Actual
Building	$ 60,000	20	$ 3,000	
Production Tools and Equipment	400,139	10	40,013	
Other Tools and Equipment	89,425	10	8,942	
Furniture and Fixtures	2,600	10	260	
Total	$552,164		$52,215	

MANUFACTURING OVERHEAD

Item	Cost Estimated	Cost Actual
Depreciation	$ 52,215	
Indirect Labor	96,760	
Power	3,900	
Water	240	
Fuel	300	
Supplies	14,500	
Total	$167,915	

MANUFACTURING COST

Item	Cost Estimated	Cost Actual
Direct Materials	$ 20,400	
Direct Labor	82,680	
Manufacturing Overhead	167,915	
Total	$270,995	

FIXED ASSETS

Item	Cost Estimated	Cost Actual
Land	$ 2,000	
Building	60,000	
Production Tools and Equipment	400,139	
Other Tools and Equipment	89,425	
Furniture and Fixtures	2,600	
Total	$554,164	

WORKING CAPITAL

Item	Cost Estimated	Cost Actual
Direct Materials, 30 Days	$ 1,700	
Direct Labor, 30 Days	6,890	
Manufacturing Overhead, 30 Days	13,993	
Reserve for Sales Collections, 30 Days	1,667	
Total	$ 24,250	

CAPITAL REQUIREMENTS

Item	Cost Estimated	Cost Actual
Fixed Assets	[illegible]	
Working Capital	24,250	
Total	$[illegible]	

SALES REVENUE

The annual production capacity of this plant is rated at 200,000 pounds of springs with an estimated average selling price of $2.00 per pound, giving a total annual sales revenue of $400,000.

RECAPITULATION OF COSTS, SALES AND PROFITS

Item	ANNUAL COSTS Estimated	Total	Actual
Direct Materials	$ 20,400		
Direct Labor	82,680		
Manufacturing Overhead	167,915		
Total Manufacturing Costs		$270,995	
Interest on Loans	2,000		
Insurance	600		
Legal	1,500		
Auditing	500		
Unforeseen Expense, Bad Debts, etc.	4,000		
Total Administrative Cost		8,600	
*Total Sales Costs		20,000	
Profit before Taxes		100,405	
Total Annual Gross Sales		$400,000	

Note: *Includes Sales Commissions, Travel, Freight-out, Discounts, and Allowances.

BUDGET CONTROL

A requisition form designed to provide accurate records of procurement and indicate the purpose of procurement with the least amount of time and effort is shown on page 34.

This form has an account number for each type of the various expenditures which the manager will review in detail, monthly or oftener, in order to control his expenses. Some items, such as power and water, are usually under contract and are easily checked by reference to monthly bills. For simplification, items (marked with an asterisk in the table on page 33) are omitted from the purchase requisition. Variations in the labor costs are easily reviewed by examination of the payroll vouchers. The simplified type of control thus provided makes certain that the manager can control expenditures promptly.

In addition to the requisition form, a sample voucher check is shown on page 35. Voucher checks should be used for the payment of all expenditures and the appropriate book account number placed on each voucher.

At the end of each month the manager will receive a statement of all expenditures broken down by budget accounts, as shown on page 33. If the expenditures exceed the budgeted monthly allowances of any of the accounts, the bookkeeper will furnish the manager with a breakdown of all expenditures relative to the budgeted accounts exceeded. All these supporting data can be secured by reference to the purchase requisitions and the check vouchers. This reference will enable the manager to determine what caused the over-expenditure and take corrective action.

If at any time during each month it becomes apparent that expenditures will exceed any of the budget accounts, the bookkeeper will bring this to the attention of the manager for his information and action.

BUDGET CONTROL ACCOUNTS

Account Number	Monthly Expense	Monthly Budget	Annual Budget	Actual
10 Administrative		$ 383	$ 4,600	
20 Sales		1,667	20,000	
30 Direct Materials		1,700	20,400	
40 Supplies		1,208	14,500	
51 Power*		325	3,900	
52 Water*		20	240	
53 Fuel		25	300	
60 Unforeseen Expense (Reserve Account		333	4,000	
71 Direct Labor*		6,890	82,680	
72 Indirect Labor*		8,063	96,760	
80 Depreciation (Reserve Account)		4,351	52,215	
Total		$24,965	$299,595	

PURCHASE REQUISITION	COMPANY NAME	DATE

- ☐ 10 ADMINISTRATION
- ☐ 20 SALES
- ☐ 30 MATERIALS
- ☐ 40 SUPPLIES
- ☐ 50 UTILITIES
- ☐ 60 UNFORESEEN EXPENSE

INDICATE BELOW THE USE OF MATERIALS

- ☐ DIRECT MATERIALS
- ☐ MAINTENANCE MATERIALS
- ☐ MAINTENANCE SERVICES
- ☐ OPERATING SUPPLIES

	PLEASE ORDER THESE MATERIALS OR SERVICES	DELIVERY WANTED	
QUANTITY	DESCRIPTION	UNIT	TOTAL

QUOTES FROM		REQUISITIONED BY	
QUOTES FROM		APPROVED BY	
QUOTES FROM		ORDER NO.	ORDER DATE

R. W. MITCHELL MANUFACTURING COMPANY

1422 BOSWORTH STREET, S. E.

65-22
514

ANYWHERE, U. S. A._____ 19____ No. 10000

PAY _____ DOLLARS $ _____

TO THE ORDER OF

R. W. MITCHELL MANUFACTURING COMPANY

TO FIRST NATIONAL BANK
ANYWHERE, U. S. A.

BY SAMPLE CHECK

VICE PRESIDENT

ACCOUNT NUMBER

Sample voucher check to be used for the payment of all expenditures in connection with Budget Control.

R. W. MITCHELL MANUFACTURING COMPANY

ENGINEERS

The services of professional engineers are desirable in the design of this plant, even though the proposed plant is small.

A correct design is one which provides the greatest economy in the investment of funds and establishes the basis of operation that will be most profitable in the beginning and will also be capable of expansion without expensive alteration.

The addresses of professional engineers who specialize in industrial design, some of whom may be willing to undertake such work on low cost projects overseas, can be secured by reference to the published cards in various engineering magazines. They may also be reached through their national organizations, one of which is the

National Society of Professional Engineers
2029 K Street, Northwest,
Washington 6, D.C.

Manufacturers of industrial equipment employ engineers familiar with the design and installation of their specialized products. These manufacturers are usually willing to give prospective customers the benefit of technical advice by those engineers in determining the suitability of their equipment in any proposed project.

The equipment manufacturers also know, and can recommend, professional engineers in private practice who are willing and able to provide appropriate consulting services.

TRAINING

Manufacturing an inferior quality of product during the training period could create sales resistance that might be difficult to cope with later. To avoid such possibilities, the quality of the product should be maintained at all times, including the training period.

In some areas skilled operators may be available locally. In other areas all the operators may have to be trained.

If skilled operators are not available, adequate training would be assured by using one or more of the following methods:

A. If the plant is designed and installed by a competent engineering firm, the contract should be negotiated, if possible, on a turn-key basis. On this basis the contractor agrees to operate the plant and produce the quality and quantity of the product stated in the contract for an agreed period of time. Such a contract would assure adequate personnel training, since full quantity and quality could not be produced with an untrained organization.

B. The engineering firm that designs and installs the plant can usually make training arrangements to have key personnel placed, for training purposes, in a foreign industry that produces the same type of product. This would provide training for the key personnel while the plant is being installed.

C. If neither of the above methods is possible, then qualified and experienced individuals should be employed for the key positions, either permanently or temporarily, to perform the key operations and assist in training the organization, even if they must be secured outside the country.

D. The manager should have years of successful experience in this type of business and be fully qualified in all phases of management, including the training of employees.

SAFETY

There is always danger of accident and injury in any industrial plant. Because of this, the manager should take specific action to bring to the attention of each employee the importance of safety precautions and intelligent first aid.

Practically all machines have safety appliances, and the manager should see that these are in good working condition and that the operators are making full use of them.

In addition to constant watchfulness to make sure that all practicable safety precautions are taken, first aid supplies should be readily available. One complete first aid kit should be maintained near the manager's office, and others at appropriate places throughout the plant. Some of the employees should be trained to provide first aid service.

The use of accident posters in the plant have proved to be of value in reducing accidents. It is recommended that such posters be used, and that some direct special action be taken by the manager, at least once each month, to bring to the attention of all personnel the importance of safety precautions.

A fire brigade should be established and each member trained as to his responsibility in case of fire. Fire drills should be conducted periodically.

It is recommended that the employees be encouraged to offer suggestions or recommendations relative to prevention of accidents, removal of fire hazards and maintaining general interest in all safety factors.

SUMMARY

A small plant, built and operated according to the assumptions made in this report would be a profitable undertaking.

Provision is made for inserting local cost in connection with all cost figures shown in this report. A careful analysis should be made of all cost figures to determine the local potential profits in any location where such a plant is being considered.

There are some determinations, however, that should be made before a decision is reached to build and operate such a plant.

For example, what are the possibilities of future expansion within the country for this industry?

What other products could be manufactured with the machinery and equipment specified in this report?

Is there a market for such additional products?

How does this industry compare with other industries that may be needed in the country relative to the following factors:

1. The economic value to the country.

2. The needs of the majority of the people.

3. The amount of investment capital required.

Consideration should also be given to such factors as :

The amount of power required and the availability of a dependable supply. If an adequate supply is not available the installation of power equipment may be required.

The water requirements for all purposes including fire protection and potable water for drinking purposes.

The fuel requirements and availability. If local fuel can be used the boiler should be adaptable to such fuel.

The transportation facilities to and from the plant. If they are not adequate an investment in trucks may be required.

OTHER CONSIDERATIONS

There are other important subjects, shown below, that should be fully investigated and considered. Information on these subjects is usually available from such sources as banks, government agencies, exporters and importers, wholesalers, retailers, transportation companies and manufacturers.

MATERIALS AND SUPPLIES

1. Are all materials and supplies available locally?
2. Is the local material market competitive?
3. Is satisfactory delivery of local materials assured at reasonable prices?
4. What materials and supplies must be imported?
5. Are they available in world markets at competitive prices?
6. Would prompt delivery of imported materials and supplies be assured so that large inventories would not be required?

MARKET FACTORS

1. Is there already a demand for the product?
   - A. Who are the principal consumers?
   - B. Who are possible new consumers?

2. How is demand for the product now satisfied?
   - A. By local production? If so, what is the volume of annual production?
   - B. What percentage of consumption is filled by local production?
   - C. By imports? If so, what is the volume of annual imports?
   - D. What percentage of consumption is met by imports?
   - E. From what areas are imports derived?

3. What is the estimated annual increase in local consumption over the next five years?
   - A. How were such estimates made?
   - B. By reference to official figures on population growth, family budgets, imports, etc.?
   - C. By consultation with trade or industry, ministries, associations, bankers, commercial houses, wholesalers, retailers, industrial consumers, etc.?

4. If the product is already being manufactured, can the existing and estimated future local market absorb production of the new plant without price-cutting or other dislocations?

5. Would the estimated sales price and quality of the new product make it competitive with an imported equivalent?
   A. After adjusting cost to local conditions, is the estimated sales price of the product so high that tariff protection is necessary to protect it from imports?

EXPORT MARKETS

1. Could the product compete in export markets on the basis of price, quality and dependability of supply?
2. Can export markets for the product be developed?
3. If so, in what areas and in what annual volume?
4. What procedures would be necessary to develop export markets?
5. What would it cost?

MARKETING PROBLEMS

1. In calculating costs of the product, has adequate allowance been made for the expense of a sales department, advertising and promotion that might be required?

2. Do consumer prejudices against locally manufactured products exist?
   A. If so, why?
   B. Would they apply to the new product?
   C. If so, how could they be overcome and what would it cost to do so?

3. Do marketing and distribution facilities for the product exist?
   A. If not, can they be set up?
   B. What would it cost to do so?

4. Will the product be sold to:
   A. Wholesalers?
   B. Retailers?
   C. Direct to consumer?
   D. Other industries?
   E. Government?

FINANCIAL FACTORS

1. Technical advice on selection of machinery and equipment.
   A. In selecting the machinery and equipment for the new plant, have reputable and competent engineers and technicians been consulted?
   B. Have they been asked for advice on the most suitable types of machinery and equipment for the process and locality?
   C. Have they carefully compared costs of various suppliers?
   D. Credit terms offered purchasers?

FINANCIAL REQUIREMENTS OF THE PROJECT

1. In estimating the cost of the project, has careful consideration been given to:
   A. The effect on costs of delays in construction schedules?
   B. In delivery and installation of machinery and equipment?
   C. In import of essential raw materials and supplies?

2. In calculating cash flow and working capital requirements, has careful consideration been given to:
   A. Maintaining adequate inventories of raw materials?
   B. Supplies and spare parts?
   C. Seasonal fluctuations in the business?
   D. The time required to liquidate credit sales to customers and bad debts?
   E. The period necessary to get the plant into production?
   F. Cash required to amortize its principle loans?

3. If the economy is in a period of inflation, has full allowance been made for the influence of rising prices and wages on the cost of the project and on working capital requirements?

SHORT TERM BANK CREDITS

1. Has it been possible to make arrangements with local banks to finance short-time working capital requirements of the business?

FINANCIAL PLAN

1. Has a definite plan to finance the project been worked out?
   A. Is sufficient capital available locally?
   B. If not, what is the plan to obtain the required capital?

ECONOMIC FACTORS

1. How much foreign exchange (and in what currency) is required to import machinery, equipment and supplies.
   - A. How much foreign exchange (and in what currency) is required for annual interest payments and amortization of any loans contracted to import machinery and equipment, or for payment o oyalties and technical services?
   - B. How much foreign exchange (and in what currency) is required for annual import of raw materials and supplies?
   - C. What are estimated annual foreign exchange earnings and in what currencies?
   - D. Has careful consideration been given to the possibility of depreciation in the foreign exchange value of the local currency?
   - E. Has careful consideration been given to the possibility of import controls, or restrictions on availabilities of foreign exchange necessary to operate the business?
   - F. What benefits would the new business bring to the economy in the use of local raw materials in employment and in technology?
   - G. Do dependable facilities exist for transportation, power, fuel, water and sewage?
     - (1) If not, can existing deficiencies be eliminated satisfactorily?
     - (2) What would be the cost to do so?

PERSONNEL

1. Is there an adequate labor supply near the plant location?
   - A. If not, how can the problem be solved?

2. Can the problem of training competent management and supervisory personnel be solved?
   - A. Also, the training of skilled labor?
   - B. Is technical advice available in the locality?
   - C. If not, where can it be obtained and what will it cost?

LAWS AND REGULATIONS

1. Do existing labor laws, government regulations, laws and taxes favor establishment of new business?
   - A. If not, can existing obstacles be removed?
   - B. If so, how and when?

TECHNICAL AND TRADE ASSOCIATIONS

American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania

American Iron and Steel Institute, 150 East 42nd Street, New York, New York

American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio

Society of Automotive Engineers, 29 West 39th Street, New York 18, New York

Spring Manufacturers Association, Box 1440 Bristol, Connecticut

American Welding Society, 29 West 39th Street, New York 18, New York

BIBLIOGRAPHY

Metals Handbook, 1948 Edition, American Society for Metals

Practical Metallurgy, 1940, George Sachs and Kent R. Van Horn, American Society for Metals

Mechanical Engineers Handbook, Fifth Edition, Lionel S. Marks, McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y.

Handbook of Fastening and Joining of Metal Parts, 1st Edition, 1956, Vallory H. Laughner and Augustus D. Hargan, McGraw-Hill Book Company, Inc.

Modern Welding Practice, 1958, A. D. Althouse and C. H. Turnquist, The Goodheart-Willcox Company, Inc., Chicago, Illinois

1956 SAE Handbook, Society of Automotive Engineers, Inc.