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COIL SPRINGS

This report presents, by means of a flow-diagram, a preliminary plant layout, an itemized equipment cost, and a listing of personnel requirements an overall picture of a minimum size plant for the manufacture of springs.

The plant described here has been planned, equipped, and staffed to produce seven general groups of spring products described in the following pages.

Those interested in establishing a spring manufacturing plant may readily add to, subtract from, or substitute, in the above-mentioned material and arrive at a plant investment and size to suit their particular means and purposes.

General Assumptions:

1. Costs are based on 1956 prices in the United States of America.

2. Adequate and suitable water, sewage, electrical and transportation facilities are available at the plant site.

3. The plant will operate one eight-hour shift per day for 252 working days per year.

4. Required raw materials of suitable quality and properly priced are available.

5. A market for spring products exists or can be developed at reasonable cost.

6. Sufficient land is available.

7. The following items cannot be estimated realistically:

a. - distribution methods and selling costs.

b. - in-and-out freight.

c. - land value, taxes, interest, and insurance.

d. - raw material quantity and cost.

The above items, a, b, c, and d are not included in any of the calculations contained herein.

SPRING MAKING PROCESS:

In the manufacture of springs two general production methods are used: cold-forming and hot-forming.

The cold forming method is employed for spring materials up to 7/16" diameter. Springs made from 1/2" diameter materials and larger are made by the hot-forming method.

Cold-Forming: No. 33 to No. 3 American Steel and Wire Gauge

Generally, the spring materials are received at the plant in coils weighing 25 to 150 lbs. These coils are readily handled and much material can be stocked in a small area.

The bulk of all cold-formed springs are made on automatic spring coilers. Each spring coiler has its own wire reel and wire straightener. These auxiliary devices are essential to quality springs; the wire reel allows the machine to draw its wire supply into the coiling mechanism for best machine performance.

The wire straightener, interposed between reel and machine, removes any set taken by the wire during winding at the steel mill and during shipment. It is important that wire, fed into the coiling mechanism, is straight in order that correct springs may be produced.

Depending upon spring specifications, the spring ends are either ground square or specially "hooked" by other equipment.

Following this, cold wound springs are normally heat treated and tempered to suit customers' specifications.

"Surging" of springs is performed to "set" springs. For example, in this operation, a compression spring is closed solid and released at least four times. The resulting free height of a surged or set spring is the free height specified by the customer.

At times, however, cold wound springs are not heat-treated or surged depending on the design and end-use of the spring.

It may be required that heat-treated springs are to be cleaned by tumbling or polishing for appearance, or in preparation for a rust retarding coating such as a paint spray, or paint dip coat.

The inspection department checks a finished spring product for dimensional compliance, material hardness and load-deflection. A roving inspector checks for dimensional compliance at the various manufacturing operations.

Depending on customers' specifications, springs may or may not be coated for corrosion retardation before packing and shipping.

Hot-Forming: 1/2" diameter to 2" diameter

The spring steels for these sizes are received as bar stock in straight lengths. An average length can be 20 feet long; greater or shorter lengths can be purchased. Details of the springs to be manufactured control the bar stock to be obtained.

The first operation in hot-forming of springs consists of cutting off a length of bar equal to the calculated developed length of the spring to be produced.

The ends of this bar are next heated and swaged to a taper. This is done to aid in the forming of square spring ends.

The bar, with both ends tapered, is then placed in a tunnel-type (both ends open)furnace, and its temperature is brought to the forging heat.

The operator of the coiling machine draws the hot rod partially out of the furnace far enough to attach the leading end to the winding mandrel. The coiling machine is set in motion, and the spring is wound. By preselected settings, this spring may be made right-hand or left-hand and may be a tension or compression spring, or a special shape.

The spring, while still hot, is at once stripped off the winding mandrel and placed in the quench tank.

Placing of the hot spring in the quench tank must be done with care to avoid any deforming of the spring shape. In the heat-treat department the spring is reheated, heat-treated and drawn in accordance with the customer specifications.

Surging, cleaning, inspection, and coating of springs are performed the same as with cold-wound springs, and for the same general reasons.

Special Shapes

In a spring plant of the job-shop type many special shapes are made where the shape and the small quantity worked prohibit the expense of tooling and special machines. Special shapes of large quantity can be produced up to a point on standard automatic equipment, and the remaining operations performed on general use equipment and by manual operations.

Special shapes will be made or completed in the special shapes area of the plant; this area has been suitably equipped with general use equipment.

A tool room with suitable equipment has been provided to make, maintain, and repair the many miscellaneous small tools essential to spring making.

PRODUCT GROUPS

1. Special Shapes, depending on wire or bar diameter, can be made by either the hot or cold method, by general use equipment, by automatics with secondary manual operations, or entirely by manual operations.

2. Flat Stock Springs, up to 3/4" x 2", may consist of

   Single Leaf Flat Springs
   Laminated Leaf Springs
   Semi-Eliptic or Double Eliptic Springs
   Spiral Coiled Springs
   and other types

The equipment required for these types of springs can consist of general use equipment such as punch presses, engine lathes, blacksmith shop tooling, etc. Finalization of equipment of necessity must be made when more detailed information and plant policies become available.

3. Tension and Compression Springs,
(1/2" to 2" diameter - Hot Method)

This general group of springs consists of heavy duty springs and takes into the group the helical tension and compression springs made of either round, square, or rectangular cross-section spring materials. Also in this group will be the heavy duty torsion springs. All required manufacturing operations will be done on semi-automatic equipment plus manual operations.

4. Tension and Compression Springs,
(No. 33 to No. 3 American Steel and Wire Gauge - Cold Method)

In this group are included all of the variations possible in helical coil springs, either tension or compression, single or double taper, squared or hooked ends. Except for very special end hooking, the production equipment is automatic.

5. Torsion Springs,

This group takes in all of the possible variations of torsion springs in the above wire range. The production equipment is fully automatic, but is supplemented by manual operations in the event of end-hooking requirements beyond the tooling capacity of the machines.

6. Rings, closed-open, Cold Method
No. 19 (.041) to No. 1 (.306) American Steel and Wire Gauge

Open rings of from 1" to 3" outside diameter can be made from standard tooling; with special tooling rings up to 14" outside diameter can be made. The machine is automatic and has a production rate of from 27 to 348 rings per minute. Such rings that are to be sold as "closed" rings, are generally tied by brazing with silver solder.

7. Bowden Cable

Cable casings for use in flexible shafting and other similar uses.

The machine will produce casing up to 3/4" outside diameter at the rate of from 750 to 1,000 feet per hour.

EQUIPMENT REQUIREMENTS

The preliminary plant layout shows the major equipment considered necessary for a minimum plant to produce quality springs.

A. MAJOR EQUIPMENT COST

Item No.	Description	Cost Installed
1	A Number 18 Alligator Shear, capacity 2" diameter and overall floor space 44" x 121".	$ 17,000.00
2	Battery of 4 Tension and Compression Spring Coilers with Reels and Wire Straighteners. 1 W 20 Torrington Clutch type Spring Coiler. 1 W 21 Torrington Standard Clutch type Spring Coiler. 1 W 225 Torrington Standard Clutch type Spring Coiler. 1 W 23 Torrington Standard Clutch type Spring Coiler.	40,538.00
3	Battery of 4 Torsion Spring Coilers with Reels and Wire Straighteners. 1 W 3000 Torrington Torsion Spring Winder 1 W 3001 Torrington Torsion Spring Winder 1 W 3002 Torrington Torsion Spring Winder 1 W 76 Torrington Ring Coiling Machine	40,384.00
4	Sleeper and Hartley Flexible Casing Coiler Model No. 3.	8,500.00
5	Gas or Oil Fired Muffle Tunnel type Bar Heating Furnace, 26' inside length.	2,500.00
6	Coulter and McKenzie No. 2 Taper Rolling Machine.	25,000.00
7	Gas or Oil Fired Open type End Heating Forge.	2,500.00
8	Coulter and McKenzie No. 3 Taper Rolling Machine.	30,000.00

A. MAJOR EQUIPMENT COST

Item No.	Description	Cost Installed
9	Gas or Oil Fired Muffle Tunnel type Bar Heating Furnace, 26' inside length.	$ 2,500.00
10	1 W 775 Torrington Ring Coiling Machine, Cold Method.	10,763.00
11	Sleeper and Hartley Spring Setting Machine, Light Duty.	3,500.00
12	24" Coulter and McKenzie Hydraulic Coiling Machine, Hot Method.	30,000.00
13	48" Coulter and McKenzie Hydraulic Coiling Machine, Hot Method.	38,000.00
14	Coulter and McKenzie Hydraulic Bulldozing Machine for Spring Setting.	30,000.00
15	3 Quenching Tanks	1,000.00
	Total	$282,185.00

B. SECONDARY EQUIPMENT REQUIRED

Listed by Product Groups as shown on the Flow-Chart

1. Special Spring Shapes:
(Hot and Cold Method)

Since no details are known of special spring shapes to be made, the following is assumed; Lot sizes will be small; pricing of these special springs will be to suit; general use equipment and manual operations will be used.

Quantity	Description	Cost
5	Work Benches with Vise	$ 375.00
1	Medium Size Engine Lathe	6,500.00
2	Bench Lathes	5,000.00
2	Kick Punch-Presses	700.00
2	Drill Presses	5,000.00
1	Cut-off Shear, Manual	750.00
-	Miscellaneous Small Tools	1,000.00
		$19,325.00

2. Flat Stock Springs, Hot and Cold Methods

On the assumption that the five types of flat springs, outlined above, are to be manufactured, from flat stock up to 3/4" x 2" and that furthermore the lot-sizes will be small; that general use equipment and manual operations will be used, and that selling prices will be set in accordance with these conditions, the following equipment is deemed necessary:

Quantity	Description	Cost
For cut-off and any shaping of ends of the heavy bar sections, the equipment in the Hot-Forming area will be used as far as possible.		
2	Anvils and Forging Tools	$ 500.00
1	Forming Rolls	6,000.00
1	5 Ton Power Punch Press	5,500.00
1	Electric Arc Welding Set, Portable	7,000.00
1	Milling Machine	7,500.00
	Total	$26,500.00

3. Tension or Compression Springs, (Hot Method)

The secondary equipment listed under Groups No. 1 and No. 2 will be satisfactory for any condition arising. No additional equipment needed.

4. Tension or Compression Springs, (Cold Method)

Quantity	Description	Cost
1	End Squaring Disk Grinder	$ 1,430.00
1	End Hooking Machine	4,500.00
	(Both machines to be located in the "Special Shapes" area)	$ 5,930.00

5. Torsion Springs, (Cold Method)

No additional equipment required

6. Rings, Open-Closed, (Cold Method)

Quantity	Description	Cost
2	Acetylene Burner Outfit	$ 1,200.00
2	All-metal Work Benches	150.00
1	Exhaust System	500.00
		$ 1,850.00

7. Bowden Cable Casing

No additional equipment needed.

C. ESSENTIAL SERVICE EQUIPMENT

1. Inspection Department

Miscellaneous small hand-measuring instruments	$ 650.00
1 - Rockwell Hardness Tester	350.00
Cabinets, Benches	500.00
Total	$ 1,500.00

2. Heat Treat Department

Miscellaneous sizes and types of heat treat furnaces, tempering baths, quench tanks, baskets, racks, and exhaust system	$30,000.00

3. Tool and Die Shop

Equipped to produce forming tooling for spring making machines, simple punch and dies, simple jigs, and to repair and maintain production tooling.

Quantity	Description	Cost
1	Tool-room Engine Lathe, 8"	$ 8,500.00
1	Tool-room Bench Lathe	3,500.00
1	Tool-room Shaper	6,500.00
1	Vertical Miller	12,000.00
1	Tool-room, Horizontal Miller	10,000.00
2	Tool-room Drill Presses	6,000.00
1	Surface Grinder	8,000.00
-	Miscellaneous precision measuring instruments.	2,500.00
-	Surface Plates, Benches, and Cabinets	1,000.00
	Total	$58,000.00

4. Maintenance Department

	Miscellaneous small tools, benches	$ 1,000.00

5. Packing and Shipping Department

	Miscellaneous small tools	500.00
1	Fork Pallet Truck, gasoline	6,500.00
3	Hand Pallet Trucks	1,500.00
100	Pallets @ $12.00	1,200.00
1	Platform Scale, 3000 # capacity	1,500.00
	Total	$11,200.00

6. Cleaning and Finishing Department

2	Tumbling Barrels	$ 4,400.00
1	Buffing Wheel	1,000.00
1	Grinding Wheel	750.00
1	Paint Spray Set-up	750.00
1	Degreasing and Rinse Tank	750.00
1	Paint Dip Tank	250.00
	Total	$7,900.00

Building Requirements

A building of approximately 106' x 115 is required. The building floor should be of concrete.

The cost of a suitable building with a roofed-over area of 12,190 square feet, at a cost of $10.00 per square foot would be $121,900.

SUMMARY OF EQUIPMENT COSTS

A - Major Equipment	Total	$282,155.00
B - Secondary Equipment		
For Product Group No. 1		19,325.00
For Product Group No. 2		26,500.00
For Product Group No. 3		-
For Product Group No. 4		5,930.00
For Product Group No. 5		-
For Product Group No. 6		1,850.00
For Product Group No. 7		-
	Total	$53,605.00
C - Essential Service Equipment		
1. Inspection Department		1,500.00
2. Heat Treat Department		30,000.00
3. Tool and Die Shop		58,000.00
4. Maintenance Department		1,000.00
5. Packing and Shipping Department		11,200.00
6. Cleaning and Finishing Department		7,900.00
	TOTAL	$109,600.00
Total Equipment Cost		$445,390.00

LABOR REQUIREMENTS, yearly

Direct Labor:

15	All around Machine Operators for Hot and Cold Winding and Hand Operations, Ring Forming, Grinding and other @ $5,000	$75,000.00
6	Laborers @ $3,500	21,000.00
21		$96,000.00

Indirect Labor:

1	Plant Superintendent	12,000.00
1	Secretary-Clerk	3,500.00
1	Senior Engineer	12,000.00
1	Junior Engineer	6,000.00
1	Paymaster	8,000.00
2	Typist-Clerks @ 3,500	7,000.00
1	Production Control Manager	8,000.00
2	Production Control Clerks @ $5,000	10,000.00
2	Inspectors, @ $6,000	12,000.00
1	General Foreman	9,000.00
1	Tool Room Foreman, working	8,000.00
2	Tool Makers, @ $7,000	14,000.00
2	Maintenance Mechanics, @ $6,000	12,000.00
1	Material Stores Clerk	5,000.00
1	Shipping Clerk	5,000.00
20		$131,500.00

Sales and Administration

1 - Plant Manager	$ 15,000.00
1 - Secretary to Manager	4,000.00
1 - Purchasing Agent	10,000.00
1 - Secretary-Clerk	3,500.00
1 - Sales Manager	12,000.00
1 - Salesman	8,000.00
1 - Sales Clerk-Typist	3,500.00
1 - Treasurer Accountant	12,000.00
	$ 68,000.00

SUMMARY:

Direct Labor	$ 96,000.00
Indirect Labor	131,500.00
Sales and Administration	68,000.00
Yearly Payroll	$295,500.00
Monthly Payroll	$ 24,625.00

Direct Labor Hours

Premise: 252 working days per year, and/or 21 working days per month of 8 hours each.

Number of direct-labor employees = 21

Direct Labor Hours per Month = 21 x 8 x 21 = 3528

Average Direct Labor Rate per hour = $\frac{8000}{3528}$ = $ 2.27

Overhead Rate

Depreciation Schedule

	Cost	Years Estimated Life	Annual Depreciation
Land	-	-	-
Building	$121,900.	20	$ 6,095.
Major Production Equipment	282,185.	10	28,219.
Secondary Production Equipment	53,605.	12	4,467.
Miscellaneous Production Equipment	109,600.	15	7,307.
	$567,290.		$46,088.

Monthly Overhead Expense

Depreciation	$ 3,841.
Indirect Labor	10,958.
Power, Fuel, Water	300.
Miscellaneous Supplies	250.
Insurance, Taxes, Interest	-
Total Monthly Overhead	$15,349.

$$\text{Overhead Rate} = \frac{\text{Overhead}}{\text{Direct Labor Hours}} = \frac{15349}{3528} = \$4.35$$

CAPITAL REQUIREMENTS

Working Capital

		Estimated
Inventory		
Direct Material	(60 days)	$ 3,400.
Supplies	(60 days)	500.
Payroll	(60 days)	49,250.
Water, Fuel, Power	(60 days)	600.
Reserves for Accounts receivable		50,000.
	Total Working Capital	$103,750.

Fixed Assets

Land		-
Building		$121,900.
Equipment		445,390.
	Total Fixed Assets	$567,290.

Total Capital

Working Capital		$103,750.
Fixed Assets		567,290.
	TOTAL CAPITAL REQUIRED	$671,040.

Assumed:

Average spring steel cost $170. per ton

Monthly steel requirements = 10 tons

Production Planning and Control

In order to operate efficiently and thereby attain minimum manufacturing costs, it is necessary that all manufacturing organizations have some formal type of production planning and control. The size of the planning and control group and the procedures, forms, etc., employed depend on the size and nature of the operations.

Production planning and control must be specifically designed for a particular manufacturing operation. There are no standard forms or procedures which have universal application.

Included in the bibliography are several references on Production Planning and Control which give detailed information on this important management function.

Conclusion

Since the variety of springs which this plant can produce is almost infinite, it can be readily seen that a projected profit and loss statement based on any assumed production would be meaningless.

Largely because of allowances for down time etc., custom made products are substantially higher priced than those which are made by mass production methods. It follows, therefore, that if the custom manufacturer, by sales effort and efficient management can operate his plant at a high percentage of its capacity, the profits realized will be substantial.

Bibliography

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Bethel, Lawrence L., Production Control, Mc Graw-Hill, New York, N.Y.

Landy, Thomas M., Production Planning and Control, Mc Graw-Hill, New York, N.Y.

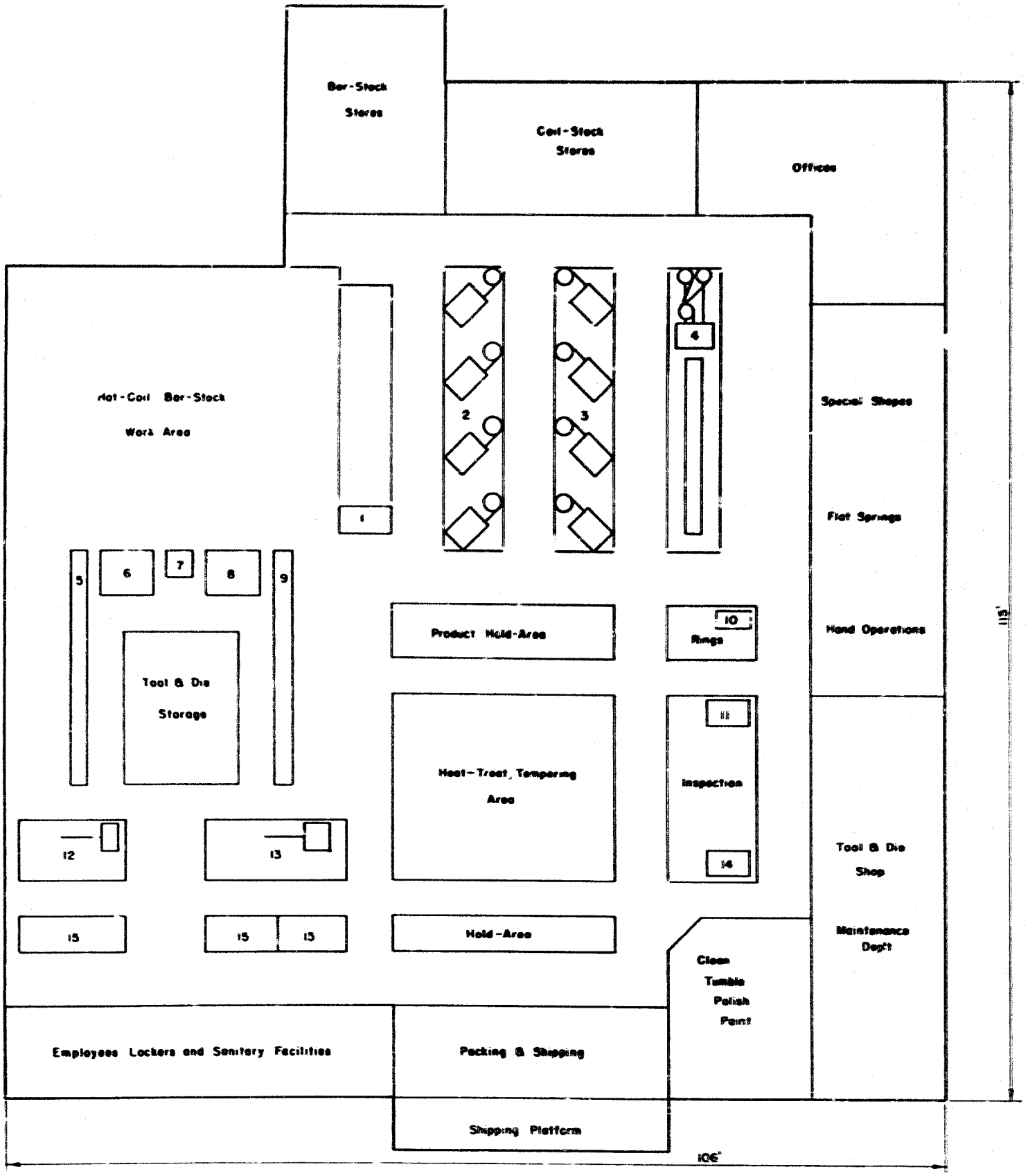
Moore, Franklin G., Production Control, McGraw-Hill, New York, N.Y.

Engineering Firms engaged in the design and building of spring plants

Morris and Van Wormer, Engineers, 25 Broad Street New York 4, N.Y.

Stone and Webster, 90 Broad Street, New York 4, N.Y.

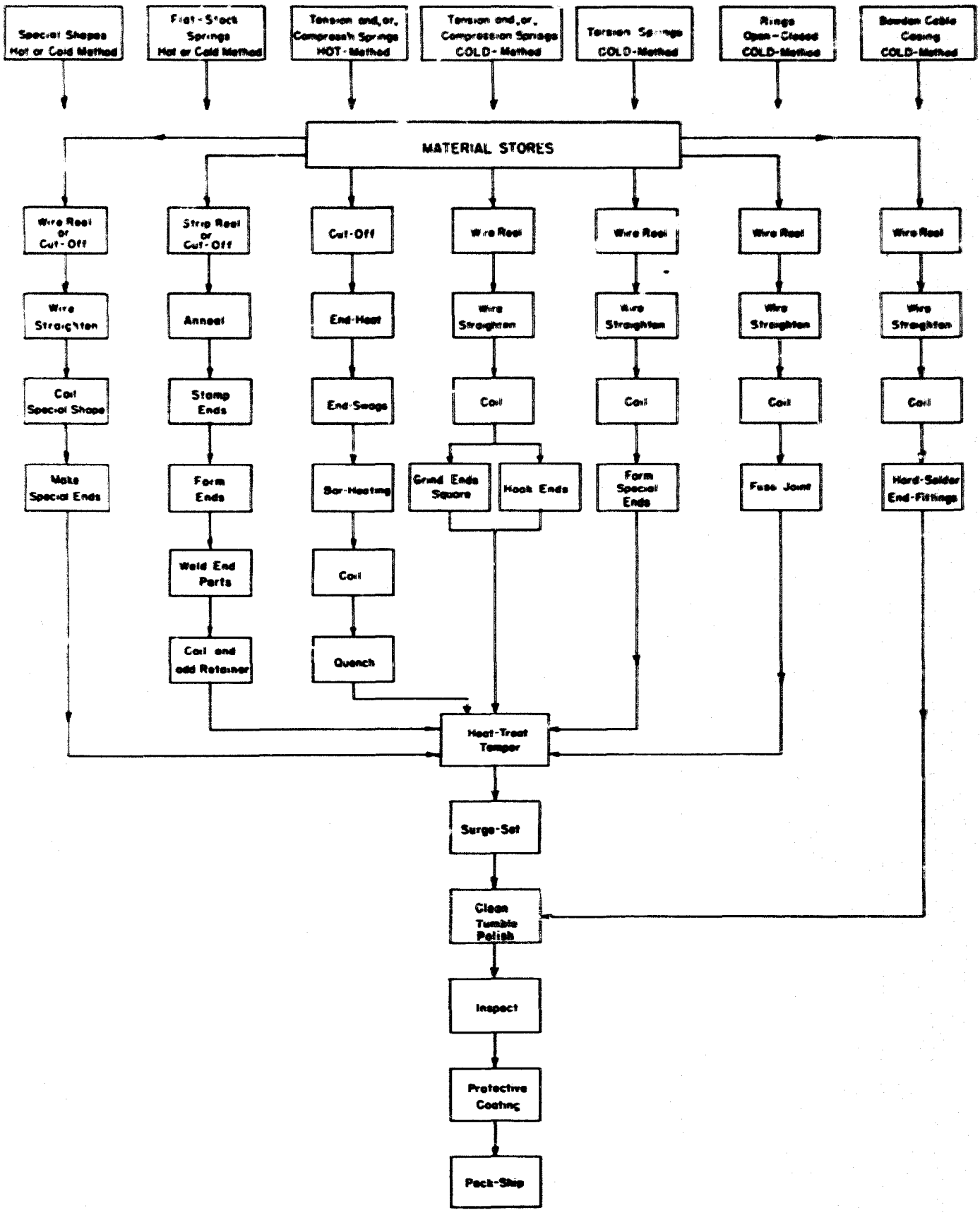
Ebasco Services, Inc., 2 Rector Street, New York 5, N.Y.



Bill of Major Manufacturing Equipment

1 Cut-Off Shear, up to 2" dia
2 Battery of 4 Tension-Compression Spring Coilers
3 " of 4 Torsion Spring Coilers
4 Bowden Cable Casing Winding Machine
5 Tunnel Type Bar Heating Furnace, 26' long
6 Taper Rolling Machine, 1 1/4" Dia. max.
7 End-Heating Furnace
8 Taper Rolling Machine, 2" Dia. max.
9 Tunnel Type Bar Heating Furnace, 26' long
10 Ring Coiling Machine, Cold Method
11 Spring Setting Machine, light Duty
12 24" Hydraulic Coiling Machine, Hot Forming Method
13 48" " " " " " "
14 Hydraulic Spring Setting Machine, heavy Duty
15 Quenching Tanks

FLOW DIAGRAM

SPRING MANUFACTURING PLANT

MAIN PRODUCT GROUPS TO BE MANUFACTURED