TI-60

INTERNATIONAL COOPERATION ADMINISTRATION
OFFICE OF INDUSTRIAL RESOURCES

ECHNICAL INQUIRY SERVICE

CENTRIFUGAL PUMPS AND VALVES

FOREWORD

The Technical Inquiry Service answers inquiries from overseas on factory or commercial establishment, operation, management, and engineering. This report is one of a series based on these technical inquiries.

This report is designed to provide only a general picture of the factors that must be considered in arriving at a decision to establish a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice on the spot 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 endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

The report was prepared by John F. Holman & Co. Inc., 4000 Massachusetts Avenue, Northwest, Washington, D. C. Technical information, as well as review, was provided by the Hydraulic Institute, the Machinery Dealers National Association, and others listed in the Acknowledgments.

For further information and assistance, readers should contact their local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

TI-60

November 1959

ACKNOWLEDGMENTS

The author gratefully acknowledges the cooperation of the following organizations who provided data, advice, and photographs for use in this brochure:

American Well Works
Aurora, Illinois

Babbitt Steam Specialty Company
New Bedford, Massachusetts

Buffalo Pump Division
Buffalo Forge Company
Buffalo, New York

Chicago Pump Company
Chicago, Illinois

Crane Company
Chicago, Illinois

The Deming Company
Salem, Ohio

Embassy of Colombia
Sr. Santiago Salazar
Economic Counselor
Washington, D. C.

Fairbanks, Morse and Company
Chicago, Illinois

Foundry Division
Flynn and Emrich Company
Baltimore, Maryland

Goulds Pumps, Inc.
Seneca Falls, New York

Hydraulic Institute
New York City, New York

Mathewson Machine Works, Inc.
Quincy, Massachusetts

Micro Balancing, Inc.
Garden City Park, L.I., New York

Rice Pump and Machine Company
Belgium, Wisconsin

Stockham Valves and Fittings
Birmingham, Alabama

Walworth Company
New York City, New York

Worthington Corporation
Harrison, New Jersey

Technical information, as well as review of this brochure, was provided by:

Hydraulic Institute
122 East 42nd Street
New York City, New York

Machinery Dealers National Association
Dupont Circle Building
Washington, D. C.

CONTENTS

ILLUSTRATIONS

INTERNATIONAL COOPERATION ADMINISTRATION
OFFICE OF INDUSTRIAL RESOURCES

TECHNICAL INQUIRY SERVICE

IR-23600 PR

CENTRIFUGAL PUMPS AND VALVES

INTRODUCTION

The manufacturing plant described in this brochure is designed to produce centrifugal pumps and valves suitable for use in water supply lines.

GENERAL ASSUMPTIONS

In order to make realistic estimates, certain assumptions have been made. These are:

1. That adequate electric power, water, and sanitary facilities are available at the site;
2. That adequate transportation facilities are available at the site;
3. That there is an existing market for the type of pumps and valves listed above;
4. That iron and steel castings, bearing components, bronze trimmings and shafting are not generally available locally but must be imported;
5. That all costs for buildings, equipment, materials and supplies are based on costs in the United States;
6. That experienced machine tool operators and mechanics are available locally;
7. That all estimates are based on one 8-hour work shift per day 5 days a week, or 40 hours per week;
8. That while general assumptions will be made for each of the following items, for the purpose of completing cost estimates, adjustments should be made in accordance with actual local conditions:

a. Freight or transportation costs in and out;

b. Distribution and sales costs;

c. Interest on capital, taxes, and insurance;

d. Value of land required;

e. Labor costs.

PRODUCT DESCRIPTION

The heavy duty water valves and centrifugal pumps being considered in this study are generally illustrated in Figures 1 and 2; and illustrated in more detail in Appendix II at the end of this study. In view of the many various designs and sizes that may be manufactured to meet the water-handling needs of a modern industrial city, it is recommended that the plant owner carefully study the exact needs of his potential market before completing his planning.

Appendix II contains some basic data and observations concerning the common types of equipment, their limitations, their design and manufacturing problems, parts interchangeability, performance characteristics, and materials of construction. It is not expected that these data will be sufficient for an industrial engineer to use in planning a production program for a specific locality; but they are included to introduce the reader to the scope of these equipments.

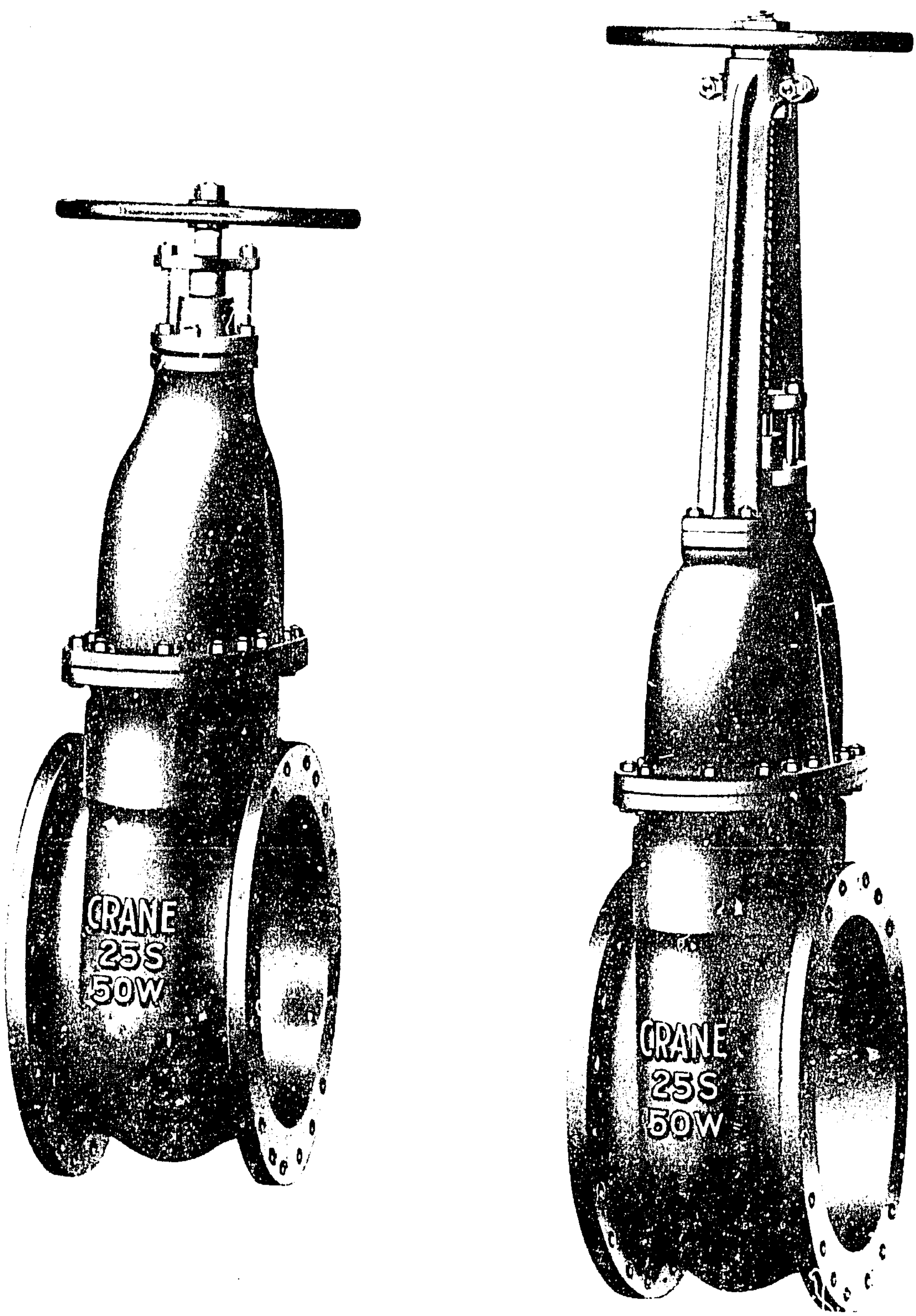


Figure 1. Exterior Views, Wedge Type Gate Valves

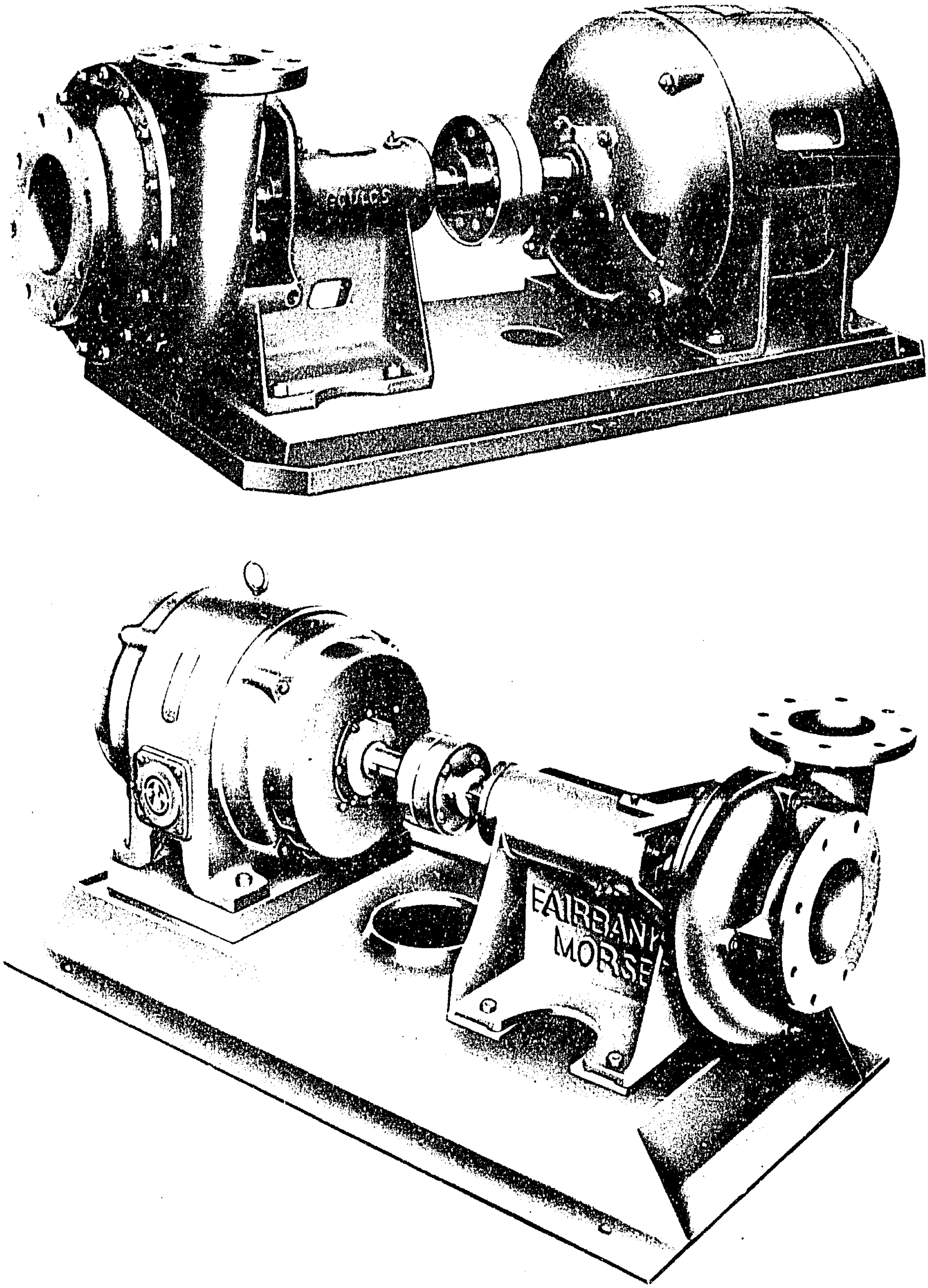


Figure 2. End Suction Volute Pump, Top Discharge

MANUFACTURING OPERATIONS

It has been assumed that pump casings, pump impellers, valve bodies and valve gates will be purchased as commercial grade castings. Pump bearings will also be purchased.

The principal machining operations for the manufacture of pumps and valves are the same. They are planing, milling, boring, turning, and drilling. Additional operations for pumps call for dynamic balancing of the impeller and shaft, and tapping of the case to receive the cap screws or studs for assembling the case.

Completed parts will be assembled into complete pumps and valves and tested for performance or tightness as the case may be. Units passing the tests are ready for delivery or storage. Units failing on test must be corrected and returned for further tests.

The following breakdown of valve and pump production has been assumed for the purpose of establishing a minimum size operation that may be operated profitably. The distribution of sizes and quantities has been established as the probable sales pattern that may be expected and which will develop the gross volume of income to justify the costs of the fixed assets.

PRODUCTION PROGRAM

Annual Gate Valve Production Assumption

Size (in.)	Quantity	Price each ($)	Estimated sales income	Actual sales income
4	1000	80.	$ 80,000	
8	600	215.	129,000	
12	200	490.	98,000	
16	100	920.	92,000	
			$399,000	

Annual Centrifugal Pump Production Assumption

Outlet size (in.)	Quantity	Price each ($)	Estimated sales income	Actual sales income
1½	500	140.	$ 70,000	
3	200	340.	68,000	
6	100	985.	98,500	
10	20	1,585.	31,700	
			$268,200	
Grand Total Sales			$667,200	

MANUFACTURING UNIT

In order to reduce machine setup time during manufacture, it is essential that the various parts of the valves be put through the plant on a lot or batch basis. It is also important that the same item be usable on as many different valve sizes and pressures as possible. Bolt sizes, for example, should be kept as low as possible. Stem sizes should also be kept at a minimum.

Every part produced should be checked against a standard for fit and size. Only in this way can final assembly of the valves be accomplished without difficulty. It also guarantees that replacement parts will fit valves in service that need repairs.

Lot sizes of parts will depend upon sales and the sizes of valves that are in biggest demand.

DIRECT MATERIALS

The material used for pump bodies for water works service is generally grey cast iron. Special parts, however, such as bearings, impellers, wearing rings, seals, etc., are bronze, stainless steel, or brass, as service conditions dictate. Only local conditions and uses can establish the extent to which special metals or alloys must be used.

The direct materials for water service valves are grey cast iron for the bodies, brass for the seats, and steel for stems. Bolts are also of steel.

Supplies used in connection with the manufacture of pumps and valves are primarily machine tool cutters, cutting oils, drills, paint, and electric power.

PRODUCTION TOOLS AND EQUIPMENT

When selecting equipment for the initial plant, it is deemed better to select equipment so that about half of it would be suitable for handling large pumps and valves and the other would be suitable for medium sized pumps or valves. While the cost of finishing small pumps and valves may be slightly higher than if smaller and faster machine tools were selected, production costs would still be lower than if medium sized valves were finished on the large machines and the small machines forced to remain idle.

The following suggested equipment, therefore, will find use in a wide range of sizes of pumps and valves.

Operation	Machine	No. reqd.	Power unit	Cost each	Total cost	Actual cost
Jigs and standards		-	-	$ -	$ 25,000	________
Milling	Milling planer 30"x30"x8'	3	5 hp	40,000	120,000	________
Milling	Universal milling mach.#2	1	3 hp	7,000	7,000	________
Cutting	Slotter 24"	2	3 hp	12,000	24,000	________
Cutting	48" vertical boring mill	3	10 hp	60,000	180,000	________
Cutting	20" horizontal boring mill	3	5 hp	25,000	75,000	________
Cutting	16" turret lathe	4	10 hp	15,000	60,000	________
Drilling	Floor-type drill press	3	½ hp	650	1,950	________
Drilling	Radial drill (4' arm)	1	2 hp	14,000	14,000	________
Balancing	Dynamic balancer	1	1 hp	6,900	6,900	________
Valve testing	Pump and misc. equip.	1	1 hp	2,500	2,500	________
Pump testing	Motor and misc. equip.	1	50 hp	15,000	15,000	________
Handling	Overhead crane, 5-ton	1	3 hp	12,000	12,000	________
Handling	Portable jib hoist, 2-ton	1	-	3,000	3,000	________
Delivery	Flat bed trucks	12	-	75	900	________
	Pickup truck	1	-	2,750	2,750	________
				Total	$550,000	________

While the above estimated prices are for new equipment, there is a large supply of excellent reconditioned machinery that is available at prices from 30 to 50 percent below those quoted above.

OTHER TOOLS AND EQUIPMENT

It is customary for machinists to have their own tools, etc. Other and special tools will be supplied by the manufacturing company.

Jigs and standards will have to be produced as the design of each series of valves or pumps is adopted by the management. It is impossible to estimate the cost of these items until designs have been established. The sum of $25,000.00 is not unreasonable, however, and has been included in the overall cost estimate.

Material-handling trucks will be required to carry the various lots of material through the various departments for processing.

FURNITURE AND FIXTURES

Administration offices should be provided for the president, treasurer, auditor, payroll clerk, billing clerk, general manager and his assistant, engineering and design department, and a sales manager and his staff. Shop offices would be provided for the shop superintendent and his foremen. An office would also be provided for the shipping clerk and his men.

A total of twelve desks and the necessary filing equipment would be sufficient for the shop offices.

Administrative office equipment is estimated to average $300.00 per office or $3,600.00. Shop office equipment is estimated at $200.00 per office or $1,000.00, or a total of $4,600.00.

PLANT LAYOUT

The flow of the material from the raw material storage to the first test phase is illustrated in Figure 3.

There is no back-tracking and the material moves from the storage area in two independent lines. In the first are the smaller items such as valve stems, discs, impellers, packing glands, etc., which are processed on the lathes, drill presses, and small milling machines. At the end of this processing the small parts that are to be incorporated in valves continue on the valve assembly bay. Those that are to be incorporated in pumps are transferred to the other side of the shop to the pump assembly bay.

The second production line handles the processing of the heavier castings for valve and pump bodies. The first operation in this line is to finish the principal plane surface on the milling planers. This operation then establishes the base for all subsequent operations. At the end of this line, pump casings continue on to the pump assembly bay while valve body components are transferred across to the valve assembly bay on the opposite side of the shop.

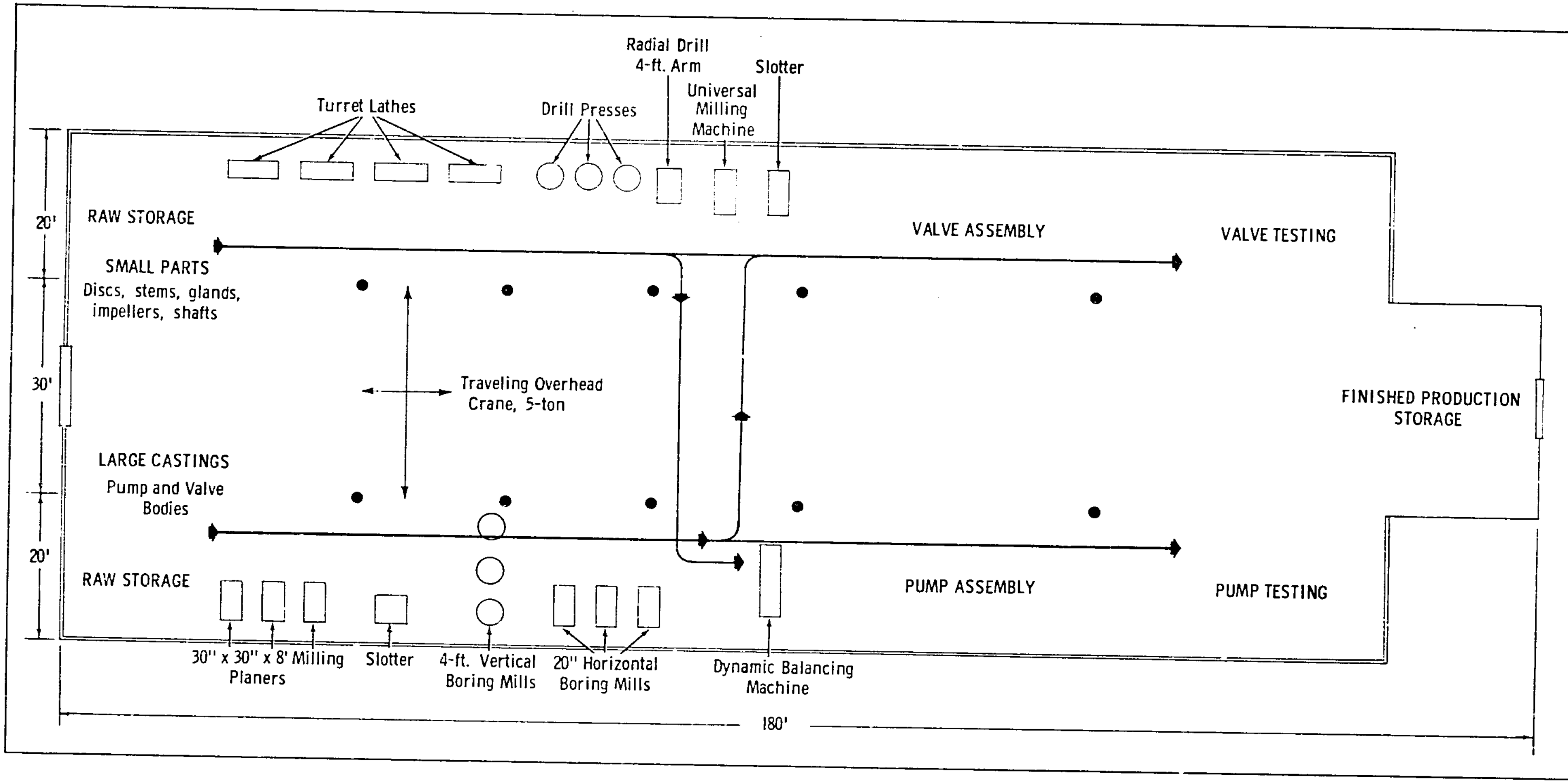


Figure 3. Plant Layout

Since a check for fit and size has been made as the parts progress through the plant, no difficulty should be experienced in the final assembly. The size of the plant is also indicated in Figure 3.

PLANT SITE

To provide adequate space for storage and for eventual expansion, at least 5 acres of level, well-drained land is required.

The site should be located as advantageously as possible with respect to transportation, electric power, sources of skilled labor, and the markets.

BUILDINGS

The plant should be the standard prefabricated steel building divided into bays. The building should be 70 feet wide by 180 feet long. Provisions should be made for ample ventilation. The cost for the building, complete with floor, is estimated at $75,000.00.

A covered storage shed of approximately 2,000 square feet will be required for the storage of supplies of steel and special parts that should be stored out of the weather. The estimated cost of this building, with racks, but without a floor, is $8,000.00.

A one-story office building of approximately 1,000 square feet will be required. The estimated cost of the building is $6,000.00.

POWER

It is assumed that a dependable source of electric power is available from the local power company. The total power required, based on the connected horsepower of all the motors, is approximately 150 kw. The estimated annual cost of power is $4,500.00.

FUEL

There is no requirement for any special fuel in the manufacturing processes. Fuel for heating the building during cold weather is determined by local requirements, and is estimated here at $1,200.00.

WATER

Very little water is required except for washroom use by the employees. A nominal estimated annual cost of $150.00 is being allowed.

TRUCKS

Small flat-bed trucks will be used to move the small and medium sized materials from department to department. Castings for the larger sized valves and pumps, which range from 500 pounds to 1,000 pounds, will be handled from storage direct to the first operation by overhead crane or by the portable 2-ton jib hoist, as the occasion dictates.

For the small and medium sized parts, at least a dozen flat-bed trucks will be required. These are estimated to cost $75.00 each or a total of $900.00. In addition to these, a one-ton pickup will be required, which is estimated to cost $2,750.00.

FIXED ASSETS

	Estimated	Actual
Land - 5 acres	$ 1,400	________
Plant Building	75,000	________
Office Building	6,000	________
Storage Shed	8,000	________
Plant Equipment and Truck	550,000	________
Office Equipment	4,600	________
Total Fixed Assets	$645,000	________

WORKING CAPITAL

Item		Estimated cost	Actual cost
Direct materials	30 days	$ 12,658	________
Direct labor	30 days	18,692	________
Indirect operating costs	30 days	5,921	________
Reserves for sales collections	30 days	55,600	________
		$ 92,871	________

CAPITAL REQUIREMENTS

	Estimated	Actual
Fixed assets	$645,000	________
Working capital	92,871	________
	$737,871	________

DEPRECIATION

Item	Estimated cost	Life in years	Est. annual depreciation	Actual depreciation
Buildings	$ 89,000	20	$ 4,450	________
Factory equipment	547,250	15	36,483	________
Truck	2,750	5	550	________
Office equipment	4,600	5	920	________
			$42,403	________

ANNUAL DIRECT OPERATING COST

Item	Estimated cost	Actual cost
Direct materials:		
Valves program	$113,017	______
Pumps program	38,889	______
Direct labor:		
Valves program	146,222	______
Pumps program	77,778	______
Total	$375,906	______

NOTE: See Tables I and II

ANNUAL INDIRECT OPERATING COST

Item	Estimated cost	Actual cost
Supplies and indirect materials	$ 8,700	______
Power	4,500	______
Water	150	______
Fuel	1,200	______
Indirect labor	39,000	______
*Miscellaneous	17,503	______
	$ 71,053	______

* Includes factors for spoilage, employee benefits, medical costs, contingencies.

ANNUAL COST OF PRODUCTION LABOR

Type of work	Workers needed	Hourly rate	Estimated annual pay	Actual annual pay
Skilled	15	$4.00	$120,000	________
Semi-skilled	10	3.20	64,000	________
Unskilled	8	2.50	40,000	________
			$224,000	________

ANNUAL COST OF INDIRECT LABOR

Item	Persons needed	Estimated annual salary	Actual annual salary
Manager	1	$ 15,000	________
Engineer	1	10,000	________
Bookkeeper	1	6,000	________
Secretary	1	4,000	________
Utility man	1	4,000	________
		$ 39,000	________

ANNUAL OPERATING BUDGET

	Estimated	Actual
Direct operating costs	$375,906	________
Indirect operating costs	71,053	________
	446,959	________
General & administrative costs	120,161	________
Profit before taxes (15%)	100,080	________
	$667,200	________

GENERAL & ADMINISTRATIVE COSTS

Item	Estimated costs	Actual costs
Interest on loans	$ 2,786	________
Insurance	2,000	________
Legal	1,000	________
Auditing	1,200	________
Sales, travel, bad debts, discounts, allowances	106,875	________
Advertising	1,000	________
Office supplies	300	________
Contingencies	5,000	________
	$120,161	________

MANUFACTURING COST ANALYSIS

Until pump and valve designs are established it is impossible to estimate the shop cost of any item. One way to secure a reasonable estimate of the production cost of an item, however, is to use a percentage of the material cost as the labor cost. Labor cost, as a percentage of material cost, may vary widely for different items but should be fairly stable within similar designs and under similar shop practices.

Assuming that the design of the valves and pumps will permit use to a maximum advantage of standards, jigs, and gages, a reasonable estimate may be obtained by applying a labor percentage factor that has been found to be the experience of similar industries.

Table I sets forth an analysis of the factory selling price, weight of the valve, the average selling price per pound and per ton of valves from 4 inches through 16 inches. There is a remarkable uniformity, with slight increases on both the very small sizes and the large sizes. This can be accounted for by the machine setup time and proportional time for machining.

The average cost of grey iron castings for valve bodies varies approximately from 25 cents per pound for the lighter more complicated castings to 14 cents per pound for the simpler heavier sizes, with 19 cents per pound as a good average.

TABLE I

125-psi Iron Body Wedge Type Gate Valves

(Outside Screw and Yoke)

Size of valves (in.)	Approx. weight (lbs)	Selling price ($)	Average price per pound (¢)	Average price per ton ($)
4	115	80	69	1,380
5	155	105	68	1,360
6	195	130	67	1,340
8	325	215	67	1,340
10	520	340	66	1,320
12	730	490	67	1,340
14	925	660	71	1,420
16	1275	920	72	1,440

A breakdown of the average selling price per pound can be approximated as follows:

	Estimated cost per pound (¢)	Percentage of total	Actual cost per pound
Direct Materials	19.0	28.3	________
Supplies	.1	.2	________
Labor (130% of Direct Materials)	24.7	36.7	________
Indirect Materials	.2	.3	________
Misc. and Shop Overhead	3.0	4.5	________
Total Operating Cost	47.0	70.0	________
Cost of Sales	10.0	15.0	________
Profit before Taxes	10.0	15.0	________
Total Selling Price	67.0	100.0	________

Table II sets forth an analysis of the factory selling price, weight of the pumps, and the average selling price per pound and per ton of self-priming centrifugal pumps, without motor or engine, from 1-1/2 inch through 10 inches with capacities at 50 foot head ranging from 40 gpm to 1850 gpm. Horsepower for this range of head varies from 1-1/2 hp to 50 hp.

TABLE II

Size	Outlet diameter (in.)	Weight of pump (lbs)	Selling price ($)	Average price per pound ($)	Average price per ton ($)
4	1-1/2	85	140	1.65	3,300
5	2	90	145	1.61	3,220
7	2	165	235	1.43	2,860
10	2	225	300	1.33	2,660
15	3	245	310	1.27	2,540
20	3	375	365	.98	1,980
30	4	385	475	1.23	2,560
50	4	475	615	1.30	2,600
90	6	965	985	1.02	2,040
125	8	1175	1,520	1.30	2,600
240	10	1225	1,585	1.30	2,600

A breakdown of the average selling price per pound of these pumps can be approximated as follows:

	Estimated cost per pound	Percentage of total	Actual cost per pound
Direct Materials	$ .19	14.5	______
Supplies	.01	1.0	______
Labor (200% of Direct Materials)	.38	29.0	______
Indirect Materials	.02	1.5	______
Misc. and Shop Overhead	.18	14.0	______
Total Operating Cost	$ .78	60.0	______
Cost of Sales	.32	25.0	______
Profit before Taxes	.20	15.0	______
Total Selling Price	$ 1.30	100.0	______

The average selling price per pound for both valves and pumps is well within the market for manufactured items of this nature and should be a profitable undertaking.

TRAINING

The principal classifications of skilled labor for this undertaking are lathe, milling machine and drill press operators. Special consideration will have to be given in the selection for the operation of the dynamic balancing machine for balancing pump impeller assemblies. Assembly and testing of the completed products should be manned by people of the same grade of skill as the production phases. A program of training should be initiated to develop these skills to the highest degree possible. Inferior work can lead to excessive production costs and a high percentage of rejected product components.

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

The requirement for, and the cost of, a safety program can be justified on either economic or humanitarian reasons. Some of the economic reasons are reduced labor turnover, less machine shutdown time, machine repair costs, and labor time lost through accidents.

It is recommended that the shop superintendent assume the duties of safety officer for the work force considered in this report; or delegate parts of the daily inspection duty in that regard to an assistant if the work force greatly exceeds forty men. In general, the equipment manuals that are usually furnished with each machine contain some guidance for the operator to insure his own safety, and these manuals should be made available to the operators. The most critical instructions for operator safety should be displayed as warning signs on or near the machine. Some space provision should be made for a clinic for emergency first aid treatment until the injured person can be removed safely to a hospital or doctor's office.

The following safety considerations are briefly noted here only to indicate the scope of the problem. They are arranged generally according to the principal manufacturing operations involved.

Materials Handling: Safety shoes, leg guards, gloves, adequate working aisles, no stacking of parts beyond safe limits, segregation of inflammables, no overloading of cranes or vehicles.

Machine Operations: Goggles, gloves only under special circumstances, no loose clothing to be caught in machinery, clean floor, no hand tools left near moving machinery, guards on all moving parts of equipment, ample aisle space around machine for operator and movement of parts.

In addition to manufacturer's manuals mentioned above, there is a large body of safety literature to guide a plant operator. The U. S. Navy Safety Precautions, OPNAV 34P1, is available through the Government Printing Office and contains valuable guidance in the safe use of most manufacturing tools. Industrial Accident Prevention, H. W. Heinrich, McGraw-Hill Book Co., New York, is a standard text on the principles and techniques of industrial accident prevention.

SUMMARY

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

There are some determinations, however, that should be made before a decision is reached to build and operate such a plant. Among the necessary determinations to be made are those with respect to the following items:

MATERIALS AND SUPPLIES

1. Are the majority of materials and supplies available locally?
2. Is the local material market competitive?
3. Are 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?

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 of royalties 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 skilled 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?

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 principal 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?

BIBLIOGRAPHY

Albert, C. D., "Machine Design Drawing Room Problems," 4th ed. rev., John Wiley & Sons, Inc., New York, 1951.

Babbitt, H. E., "Plumbing," 2d ed., McGraw-Hill Book Co., New York, 1950.

Babbitt, H. E., and Doland, J. J., "Water Supply Engineering," 5th ed., McGraw-Hill Book Co., New York, 1955.

Begeman, M. L., "Manufacturing Processes," 4th ed., John Wiley & Sons, Inc., New York, 1957.

Benedict, Jr., Otis, "Manual of Machine Shop Practice," McGraw-Hill Book Co., New York, 1944.

Binder, R. C., "Advanced Fluid Mechanics," 2 vols., Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Bolz, R. W. (edited by), "ASME Handbook—Metals Engineering—Processes," McGraw-Hill Book Co., New York, 1958.

Boston, O. W., "Metal Processing," 2d ed., John Wiley & Sons, Inc., New York, 1951.

Bradford, L. J., and Eaton, P. B., "Machine Design," 5th ed., John Wiley & Sons, Inc., New York, 1947.

Brady, G. S., "Materials Handbook," 8th ed., McGraw-Hill Book Co., New York, 1956.

Burghardt, H. D., and Axelrod, Aaron, "Machine Tool Operation, Part I," 4th ed., McGraw-Hill Book Co., New York, 1953.

Burghardt, H. D., and Axelrod, Aaron, "Machine Tool Operation, Part II," 3d ed., McGraw-Hill Book Co., New York, 1954.

Carborundum Company, "Tool Room Grinding," Niagara Falls, New York.

Carmichael, Colin (edited by), "Design and Production," John Wiley & Sons, Inc., New York, 1950.

Carter, Roy, Karassik, I. J., and Wright, E. F., "Pump Questions and Answers," McGraw-Hill Book Co., New York, 1949.

Church, A. H., "Centrifugal Pumps and Blowers," John Wiley & Sons, Inc., New York, 1944.

Church, A. H., "Mechanical Vibrations," John Wiley & Sons, Inc., New York, 1957.

Colvin, F. H., and Haas, L. L., "Jigs and Fixtures," 5th ed., McGraw-Hill Book Co., New York, 1948.

Colvin, F. H., and Stanley, F. A., "Drilling and Surfacing Practice," 3d ed., McGraw-Hill Book Co., New York, 1948.

Colvin, F. H., and Stanley, F. A., "Running A Machine Shop," 2d ed., McGraw-Hill Book Co., New York, 1948.

Colvin, F. H., and Stanley, F. A., "Turning and Boring Practice," 3d ed., Mc-Graw Hill Book Co., New York, 1948.

Cowden, D. J., "Statistical Methods in Quality Control," Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Cox, G. N., and Germano, F. J., "Fluid Mechanics," D. Van Nostrand Co., Inc., Princeton, New Jersey, 1941.

Crede, C. E., "Vibration and Shock Isolation," John Wiley & Sons, Inc., New York, 1951.

Daugherty, R. L., and Ingersoll, A. C., "Fluid Mechanics," 5th ed., McGraw-Hill Book Co., New York, 1954.

Den Hartog, J. P., "Mechanical Vibrations," 4th ed., McGraw-Hill Book Co., New York, 1956.

Elevatorski, E. A., "Hydraulic Energy Dissipators," McGraw-Hill Book Co., New York, 1959.

Forbes, W. G., Pope, C. L., and Everitt, W. T., "Lubrication of Industrial and Marine Machinery," 2d ed., John Wiley & Sons, Inc., New York, 1954.

Fuller, D. D., "Theory and Practice of Lubrication for Engineers," John Wiley & Sons, Inc., New York, 1956.

Gadzala, J. L., "Dimensional Control in Precision Manufacturing," McGraw-Hill Book Co., New York, 1959.

Hesse, H. C., "Engineering Tools and Processes," D. Van Nostrand Co., Inc., Princeton, New Jersey, 1941.

Hicks, Tyler, "Pump Selection and Application," McGraw-Hill Book Co., New York, 1957.

Higdon, Archie, and Stiles, W. B., "Engineering Mechanics," 2d ed., Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Hinman, C. W., "Practical Designs for Drilling, Milling, and Tapping Tools," 2d ed., McGraw-Hill Book Co., New York, 1946.

Horger, O. J. (edited by), "ASME Handbook—Metals Engineering—Design," McGraw-Hill Book Co., New York, 1953.

Hoyt, Samuel (edited by), "ASME Handbook—Metals Properties," McGraw-Hill Book Co., New York, 1954.

Huckert, Jesse (edited by), "ASME Handbook—Engineering Tables," McGraw-Hill Book Co., New York, 1956.

Hunsaker, J. C., and Rightmire, B. G., "Engineering Applications of Fluid Mechanics," McGraw-Hill Book Co., New York, 1947.

Immer, J. R., "Layout Planning Techniques," McGraw-Hill Book Co., New York, 1950.

Kristal, F. A., and Annett, F. A., "Pumps," 2d ed., McGraw-Hill Book Co., New York, 1953.

Laurson, P. G., and Cox, W. J., "Mechanics of Materials," 3d ed., John Wiley & Sons, Inc., New York, 1954.

LeGrand, Rupert (edited by), "The New American Machinists' Handbook," McGraw-Hill Book Co., New York, 1955.

Littleton, C. T., "Industrial Piping," McGraw-Hill Book Co., New York, 1951.

MacDuff, J. N., and Curreri, J. R., "Vibration Control," McGraw-Hill Book Co., New York, 1958.

Machinery Dealers National Association, Current machinery lists, Washington, D. C.

Marek, C. T., "Fundamentals in the Production and Design of Castings," John Wiley & Sons, Inc., New York, 1950.

Marks, L. S. (edited by), and Baumeister, T. (revised by), "Mechanical Engineers' Handbook," 6th ed., McGraw-Hill Book Co., New York, 1958.

Miner, D. F., and Seastone, J. B. (edited by), "Handbook of Engineering Materials," John Wiley & Sons, Inc., New York, 1955.

Morris, J. L., "Metal Castings," Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Morris, J. L., "Modern Manufacturing Processes," Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Muhlenbruch, Carl, "Experimental Mechanics and Properties of Materials," 2d ed., D. Van Nostrand Co., Inc., Princeton, New Jersey, 1955.

Muther, Richard, "Practical Plant Layout," McGraw-Hill Book Co., New York, 1955.

Nordhoff, W. A., "Machine-shop Estimating," 2d ed., McGraw-Hill Book Co., New York, 1959.

Parsons, C. W. S., "Estimating Machining Costs," McGraw-Hill Book Co., New York, 1957.

Peterson, R. E., "Stress Concentration Design Factors," John Wiley & Sons, Inc., New York, 1953.

Rouse, Hunter, and Howe, J. W., "Basic Mechanics of Fluids," John Wiley & Sons, Inc., New York, 1953.

Russell, G. E., "Hydraulics," Henry Holt & Co., New York.

St. Clair, L. J., "Design and Use of Cutting Tools," McGraw-Hill Book Co., New York, 1952.

Salisbury, J. K. (edited by), "KENT—Mechanical Engineers' Handbook," 12th ed., John Wiley & Sons, Inc., New York, 1950.

Schoder, E. W., and Dawson, F. M., "Hydraulics," 2d ed., McGraw-Hill Book Co., New York, 1934.

Stieri, E., "Fundamentals of Machine Shop Practice," Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Timoshenko, Stephen, "Vibration Problems in Engineering," 3d ed., D. Van Nostrand Co., Inc., Princeton, New Jersey, 1955.

Wagener, A. M., and Arthur, H. R., "The Machinists' and Draftsmen's Handbook," D. Van Nostrand Co., Inc., Princeton, New Jersey, 1945.

Wilcock, D. F., and Booser, E. R., "Bearing Design and Application," McGraw-Hill Book Co., New York, 1957.

LITERATURE REFERENCES

Periodicals

"Plumbing and Heating Business," Plumbing & Heating Publishing Company, 130 East 59th St., New York, N. Y.

"Materials in Design Engineering," Reinhold Publishing Corp., 430 Park Ave., New York, N. Y.

"Power," McGraw-Hill Publishing Company, 330 West 42nd St., New York, N. Y.

Standards

"Standards of the Hydraulic Institute, 10th Edition," and "Pipe Friction Manual," Hydraulic Institute, 122 East 42nd St., New York, N. Y.

American Water Works Association, 521 Fifth Ave., New York, N. Y.

APPENDIX I

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 following are some of the Professional Engineers listed by the Board of Registration for Professional Engineers of the District of Columbia by its Department of Occupations and Professions, who are specialists in water supply equipment.

Raymond W. Colton
Munsey Building
Washington 4, D. C.

Lester B. Knight
969 Hill Road
Winnetka, Illinois

Jerome H. Kovarik
1716 Oakcrest Drive
Alexandria, Virginia

Edward B. Landry
12 Kentbury Way
Bethesda 14, Maryland

Robert J. Lyon
805 Kerwin Road
Silver Spring, Maryland

Edwin C. Nelson
5448 Dawes Avenue
Alexandria, Virginia

Joseph C. Nickels
4502 Traymore Street
Bethesda 14, Maryland

Leonard Peller
1401 Arch Street
Philadelphia 5, Penna.

William M. Walker
5825 Osceola Road
Washington 16, D. C.

APPENDIX II

PRODUCT SELECTION CONSIDERATIONS

Centrifugal Pumps

Centrifugal pumps, as the name implies, depend on centrifugal force to move liquids from low to high levels.

There are four general forms of centrifugal pumps, the differences being in the path of the liquid through the pump.

The volute-type of centrifugal pump is the simplest form. In this type a rotating impeller, located off center in the pump casing, picks up the liquid from a suction inlet located at the center of the impeller hub. The liquid is thrown by the impeller and presses outward in the diverging pump case toward the outlet. In this way the velocity head received from the high speed of the impeller is changed to a lower velocity and a higher pressure at the outlet. This type of pump is low in cost, easy to operate under a wide variety of conditions, and not beset with many problems of wear. With various types of impellers this type of pump is suitable for handling liquids containing solids or abrasive materials that would be disastrous to the close tolerances required in the other types of centrifugal pumps.

An improvement in the simple volute-type centrifugal pump is the diffuser-type pump. In the diffuser-type the impeller is surrounded by a group of gradually expanding passages formed by expanding guide vanes in the pump casing. In these expanding passages the direction of flow is changed and the velocity head converted into pressure head before the water enters the outer portion of the casing. The selection of the diffuser-type pump is based on application requirements.

The turbine-type centrifugal pump, sometimes called a regenerative pump, is so designed that it can develop several times the pressure that can be developed by the volute-type pump having the same impeller diameter and speed.

Figure 4 illustrates the construction differences of the volute, and turbine types of centrifugal pumps. Manufacturing operations required to produce these three types of pumps are simplest in the turbine-type and most difficult in the diffuser-type.

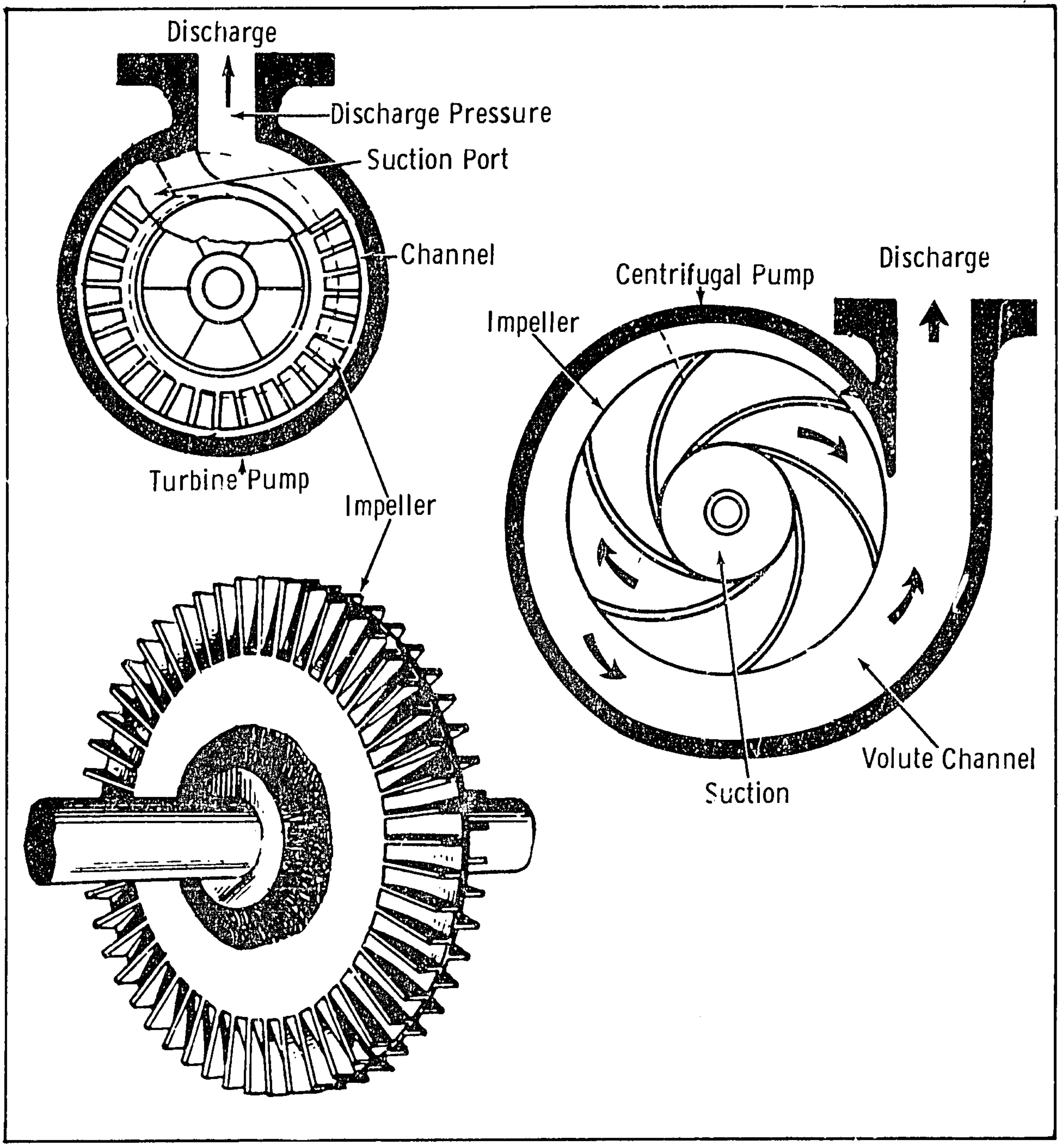


Figure 4. Cross Sections Through Centrifugal and Turbine Pumps

For low heads and large capacities, the propeller-type or axial flow pump is most suitable. Its special field of application is for drainage, irrigation, sewage, and similar services. This pump has an open propeller or screw-type impeller. Propeller-type pumps can have either vertical or horizontal shafts. They are particularly suitable for low heads. Propeller-type pumps are not generally suited to water works systems and are not considered within the scope of this project.

Positive displacement rotary gear pumps are not generally applicable to water handling problems and are not considered here.

Standard commercial pumps are available in a wide variety of casing sizes, speeds, capacities, and heads. They range from small pumps for domestic use up to capacities of 4000 gpm or over, and heads up to over 400 feet. By changing the speed or impeller diameter, a single casing design can be made to cover a wide variety of applications.

Figure 5 illustrates the variation in head and capacity from one such casing design with impellers ranging from 12 inches in diameter down to 8 inches in diameter. The various horsepower requirements for the different capacities are also shown.

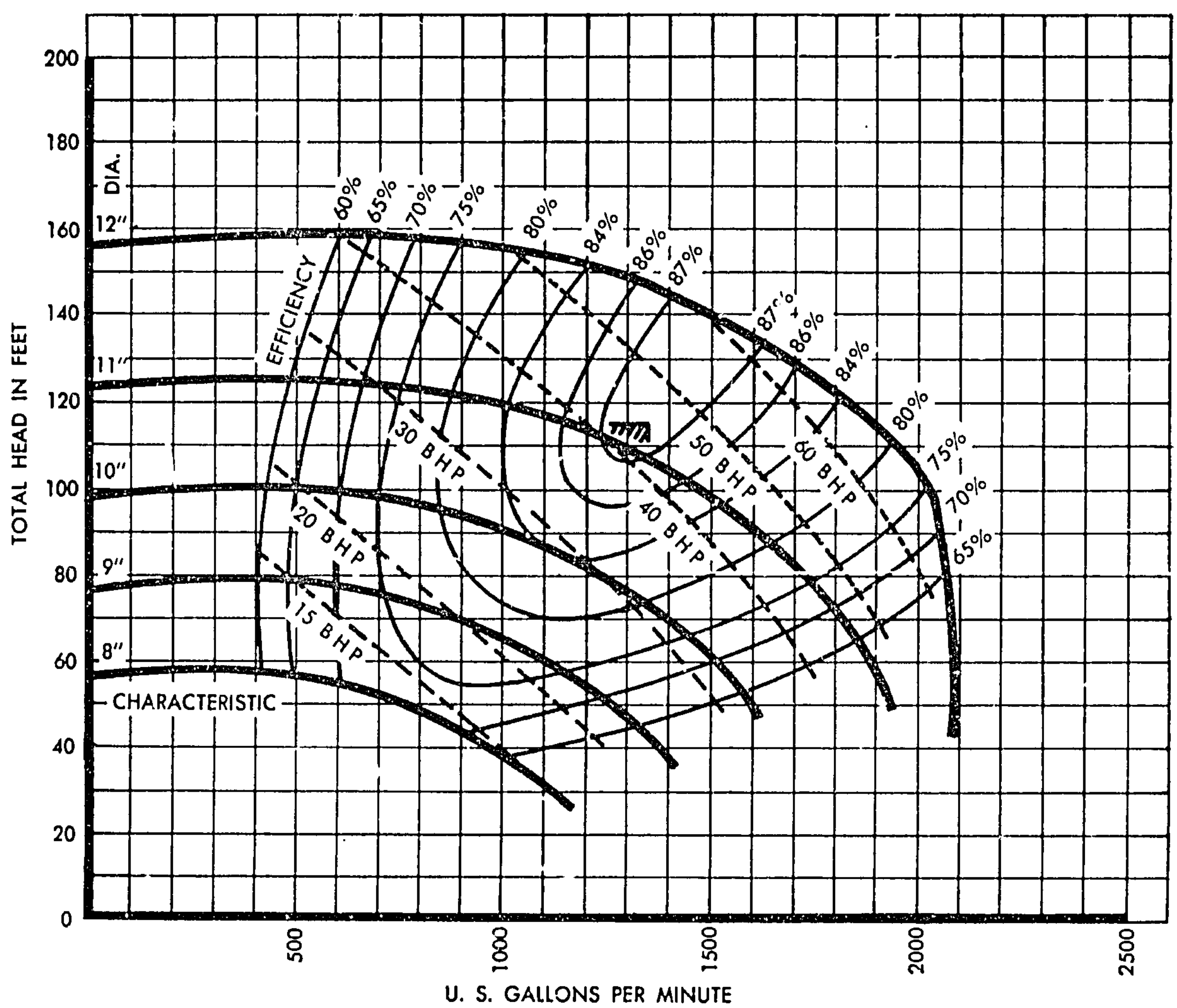


Figure 5. Typical Performance Curve of a Centrifugal Pump at 1750 rpm But With Varying Impeller Diameter

Figure 6 illustrates the performance of a pump with a fixed impeller diameter but with varying speeds from 800 RPM up to 2500 RPM.

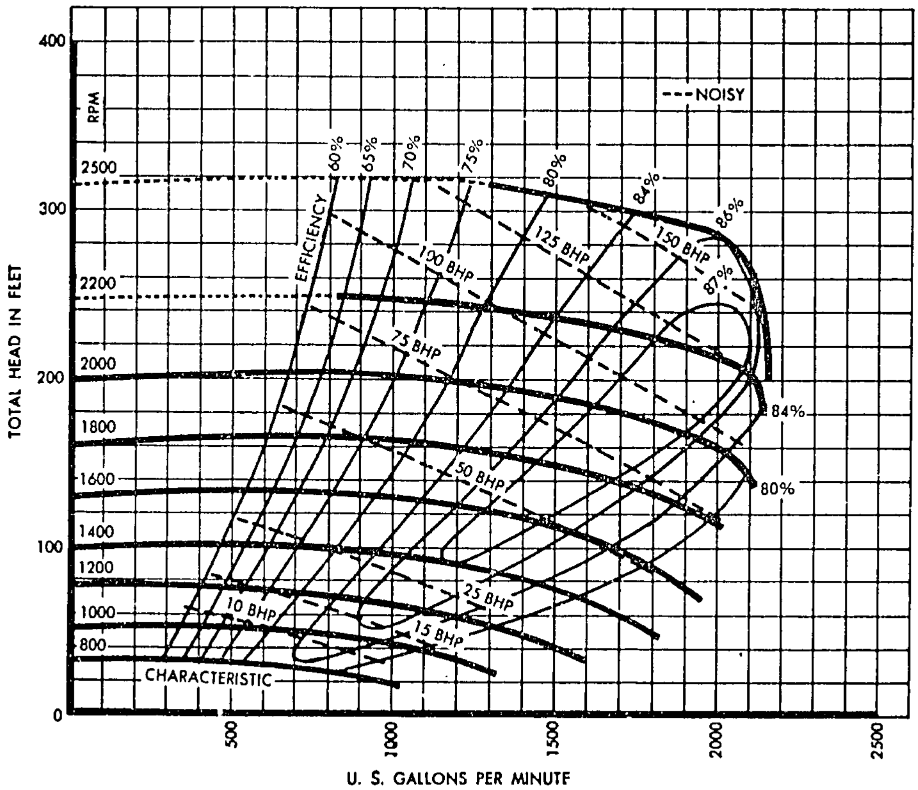


Figure 6. Typical Performance Curve of a Centrifugal Pump With Constant Impeller Diameter But Varying Speeds

Figure 7 shows, in another manner, the related effect as a percentage, of capacity, head and power, of changes in the pump speed.

From these three illustrations it is readily apparent that the selection of a pump for a particular duty is not a simple matter.

A particular pump design usually consists of a series of casing sizes with various size impellers. This reduces the number of sizes to be manufactured and also reduces the number of spare parts required by the user.

The tabulation in Figure 8 illustrates this point, showing the same pump operating at various heads but with different horsepower motors. Similar tabulations are available from the various pump manufacturers.

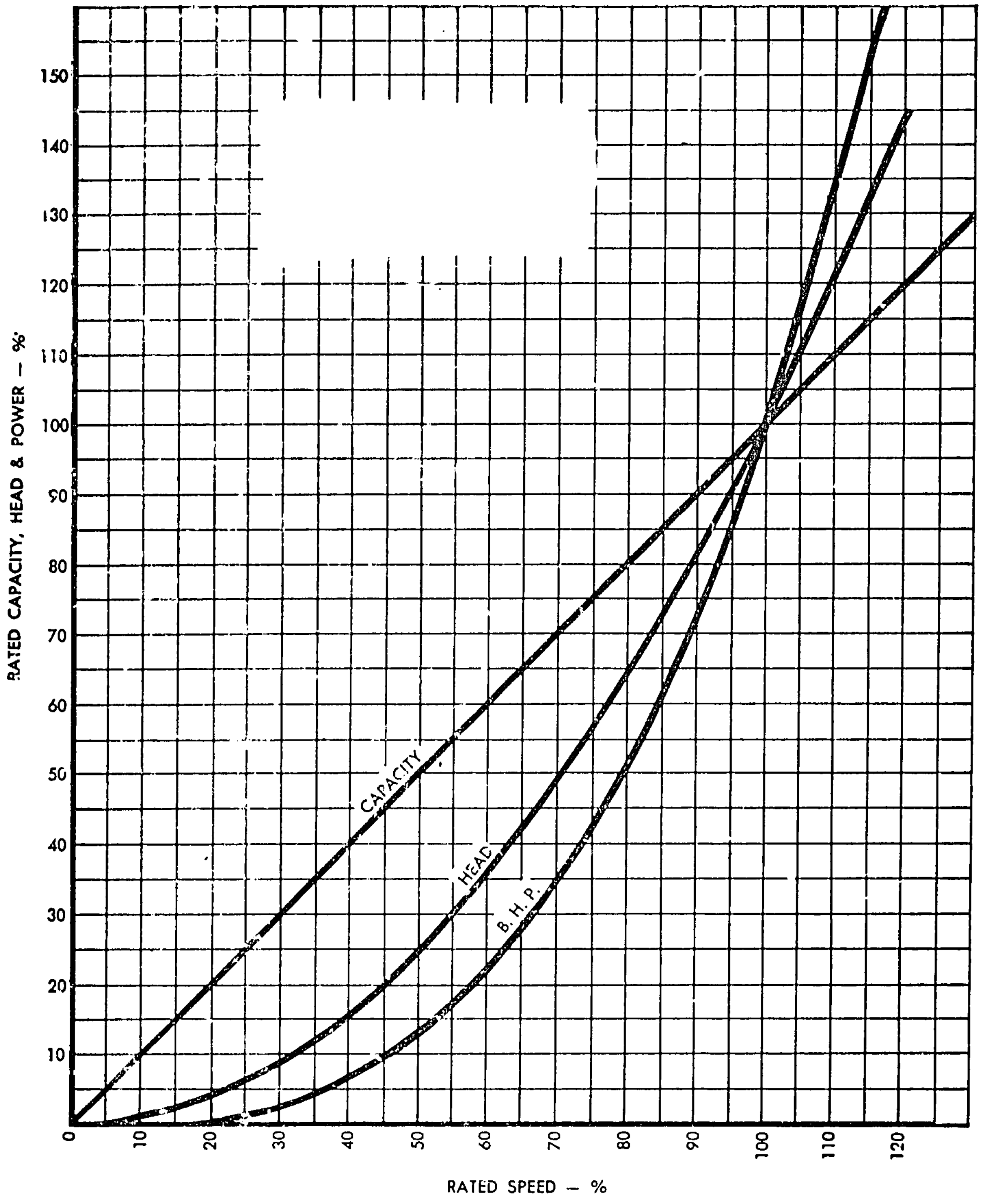


Figure 7. Chart Showing Effect of Speed Change on Centrifugal Pump Performance

SINGLE SUCTION PUMP
Capacity Ratings

1150 AND 1760 R.P.M.

ALL RATINGS ARE FOR CLEAR, COLD WATER BASED ON 15 FT. TOTAL DYNAMIC SUCTION LIFT
MAXIMUM WATER TEMPERATURE 180° F.

CAPACITY U. S. GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER (MEASURED AT SUCTION & DISCHARGE FLANGES)															
		15	20	25	30	35	40	45	50	60	70	80	90	100	110	120
40	SIZE HP		2"X1½" ¾	2"X1½" 1												
50	SIZE HP		2"X1½" ¾	2"X1½" 1	2"X1½" 1	2"X1½" 1½	2"X1½" 1½	2"X1½" 1½	2"X1½" 2							
60	SIZE HP		2"X1½" 1	2"X1½" 1	2"X1½" 1	2"X1½" 1½	2"X1½" 1½	2"X1½" 1½	2"X1½" 2	2"X1½" 3	2"X1½" 3	2"X1½" 3				
70	SIZE HP	2½"X2" ¾	2"X1½" 1	2"X1½" 1	2"X1½" 1½	2"X1½" 1½	2"X1½" 1½	2"X1½" 2	2"X1½" 2	2"X1½" 3	2"X1½" 3	2"X1½" 3	2"X1½" 5	2"X1½" 5		
80	SIZE HP	2½"X2" ¾	2"X1½" 1	2"X1½" 1½	2"X1½" 1½	2"X1½" 1½	2"X1½" 1½	2"X1½" 2	2"X1½" 2	2"X1½" 3	2"X1½" 3	2"X1½" 5	2"X1½" 5	2"X1½" 5		
90	SIZE HP	2½"X2" ¾	2"X1½" 1	2"X1½" 1½	2"X1½" 1½	2"X1½" 1½	2"X1½" 2	2"X1½" 2	2"X1½" 3	2"X1½" 3	2"X1½" 3	2"X1½" 5	2"X1½" 5			
100	SIZE HP	2½"X2" ¾	2½"X2" 1	2"X1½" 1½	2"X1½" 1½	2"X1½" 2	2"X1½" 2	2"X1½" 2	2"X1½" 3	2"X1½" 3	2"X1½" 3	2"X1½" 5	2"X1½" 5			
125	SIZE HP	2½"X2" 1	2½"X2" 1	2½"X2" 1½	2"X1½" 2	2"X1½" 2	2"X1½" 3	2"X1½" 3	2"X1½" 3	2"X1½" 3	2"X1½" 5	2"X1½" 5	2"X1½" 5	2½"X2" 7½	2½"X2" 7½	2½"X2" 10
150	SIZE HP	3"X2½" 1	2½"X2" 1½	2½"X2" 1½	2½"X2" 3	2½"X2" 3	2"X1½" 3	2"X1½" 3	2"X1½" 5	2"X1½" 5	2"X1½" 5	2"X1½" 5	2½"X2" 7½	2½"X2" 7½	2½"X2" 7½	2½"X2" 10
175	SIZE HP		3"X2½" 1½	2½"X2" 2	2½"X2" 2	2½"X2" 3	2½"X2" 3	2½"X2" 3	2½"X2" 5	2½"X2" 5	2½"X2" 5	2½"X2" 5	2½"X2" 7½	2½"X2" 7½	2½"X2" 10	
200	SIZE HP		3"X2½" 2	3"X2½" 2	2½"X2" 3	2½"X2" 3	2½"X2" 5	2½"X2" 5	2½"X2" 5	2½"X2" 5	2½"X2" 5	2½"X2" 7½	2½"X2" 7½	2½"X2" 7½	2½"X2" 10	3"X2½" 15
225	SIZE HP	4"X3" 1½	4"X3" 2	3"X2½" 2	3"X2½" 3	3"X2½" 5	2½"X2" 5	2½"X2" 5	2½"X2" 5	2½"X2" 5	2½"X2" 7½	2½"X2" 7½	2½"X2" 7½	2½"X2" 10	2½"X2" 10	3"X2½" 15
250	SIZE HP	4"X3" 2	4"X3" 2	4"X3" 3	3"X2½" 3	3"X2½" 5	3"X2½" 5	3"X2½" 5	2½"X2" 5	2½"X2" 7½	2½"X2" 7½	2½"X2" 7½	2½"X2" 7½	2½"X2" 10	3"X2½" 15	3"X2½" 15
275	SIZE HP		4"X3" 3	4"X3" 3	3"X2½" 3	3"X2½" 5	3"X2½" 5	3"X2½" 5	3"X2½" 5	2½"X2" 7½	2½"X2" 7½	2½"X2" 7½	2½"X2" 10	3"X2½" 10	3"X2½" 15	4"X3" 15
300	SIZE HP		4"X3" 3	4"X3" 3	4"X3" 3	4"X3" 5	4"X3" 5	3"X2½" 7½	3"X2½" 7½	3"X2½" 7½	3"X2½" 7½	3"X2½" 10	3"X2½" 10	3"X2½" 10	3"X2½" 15	4"X3" 15
325	SIZE HP			4"X3" 3	4"X3" 5	4"X3" 5	4"X3" 5	4"X3" 7½	3"X2½" 7½	3"X2½" 7½	3"X2½" 10	3"X2½" 10	3"X2½" 10	3"X2½" 15	3"X2½" 15	4"X3" 15
350	SIZE HP			4"X3" 5	4"X3" 5	4"X3" 5	4"X3" 5	4"X3" 7½	4"X3" 7½	4"X3" 7½	3"X2½" 10	3"X2½" 10	3"X2½" 15	3"X2½" 5	4"X3" 15	4"X3" 15
375	SIZE HP				4"X3" 5	4"X3" 5	4"X3" 7½	4"X3" 7½	4"X3" 7½	4"X3" 10	3"X2½" 10	3"X2½" 15	3"X2½" 15	3"X2½" 15	4"X3" 15	
400	SIZE HP							4"X3" 7½	4"X3" 7½	4"X3" 10	4"X3" 10	3"X2½" 15	3"X2½" 15	3"X2½" 15	4"X3" 15	
425	SIZE HP								4"X3" 10	4"X3" 10	4"X3" 10	4"X3" 15	4"X3" 15	4"X3" 15	4"X3" 15	
450	SIZE HP									4"X3" 10	4"X3" 15	4"X3" 15	4"X3" 15	4"X3" 15		
475	SIZE HP									4"X3" 15	4"X3" 15	4"X3" 15	4"X3" 15	4"X3" 15		
500	SIZE HP									4"X3" 15	4"X3" 15	4"X3" 15	4"X3" 15	4"X3" 20		
525	SIZE HP										4"X3" 15	4"X3" 15	4"X3" 20			
550	SIZE HP										4"X3" 15	4"X3" 15	4"X3" 20			

RATINGS TO LEFT OF HEAVY LINE—1150 R.P.M.
RATINGS TO RIGHT OF HEAVY LINE—1760 R.P.M.

Figure 8. Single Suction Pump Capacity Rating Table

Interchangeability of component parts is well illustrated in the tabulation set forth in Figure 9. It can be seen that several of the items are identical for all groups, while others are identical within each group. This greatly simplifies the manufacturing steps and reduces the number of different parts to be produced and carried in stock. The tabulation also gives the various materials used in the different components and for operation under various conditions.

ITEM No.	No. REQ'D PER PUMP	PART NAME	MATERIAL			INTERCHANGEABILITY BY GROUP AND CASING CLASS																				
						GROUP S								GROUP M												L
			BZ. FITTED	ALL IRON	ALL BZ.	1-1/4x1-1/2-5	1-1/4x1-1/2-7	1-1/4x1-1/2-8	1-1/2x2-5	2x2-7	2-1/2x2-1/2-6	3x3-5	4x4-7	1-1/2x2-9	2x2-1/2-9	2x3-7	2-1/2x3-9	2-1/2x3-13	3x4-7	3x4-13	4x5-7	4x6-11	4x6-13	5x5-7	6x6-9	8x6-11
100	1	CASING	1000	1000	1103																					
101	1	IMPELLER	1103	1000	1103																					
182	1	SUCTION COVER	1000	1000	1103																					
103	1	WEARING RING - SUCTION	1106	1000	1106	1	1	1	2	3	4	5	6	7	8	5	9	5	6	6	6	10	10	10	11	12
105	1	STUFFING BOX SEAL RING	1102	1000	1102	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
106	1 SET	STUFFING BOX PACKING	* DIE FORMED			S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
107	1	STUFFING BOX SPLIT GLAND	1106	1000	1106	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
111	1	BEARING END COVER	1000			S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
112	1	BALL BEARING - COUPLING END	Steel			S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
113	2	GREASE RELIEF FITTING	Steel			L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
122	1	SHAFT	SAE 1112			S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
123	1	DEFLECTOR	1102	1000	1102	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
126	1	SHAFT SLEEVE	1106	AISI 303	1106	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
127	1	WEARING RING - DISCHARGE	1106	1000	1106	·	·	·	·	3	·	4	·	7	8	5	9	9	6	13	6	10	14	10	10	11
168	1	BALL BEARING - INBOARD	Steel			S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
178	1	IMPELLER KEY	AISI 303			S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
182	1	SUCTION COVER (See 182 Above)																								
193	2	GREASE FITTING	Steel			L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
199	1	IMPELLER WASHER	AISI 303			S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
228	1	SUPPORT HEAD	1000			S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
247	1	DRIP BASIN	None	None	1103	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
304	1	IMPELLER NUT	Brass	Steel	Brass	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
332	1	GREASE SEAL (COUPLING END)				S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
333	1	GREASE SEAL (INBOARD)																								
351	1	SUCTION COVER GASKET (See 182)	1/64" Thick Asbestos																							
353	2	GLAND STUD	14% Cr. Steel	AISI 416		S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
354	2	GLAND HOLDING WASHER	14% Cr. Steel	AISI 416		M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
355	2	GLAND STUD NUT	Steel			S	S	S	S	S	S	S	S	L	L	L	L	L	L	L	L	L	L	L	L	L
356	8 to 16	STUDS & HEX NUTS (Casing to Cover)	Steel																							
361	1	RETAINING RING (Shaft)	Steel			S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
361-A	1	RETAINING RING (Brg. End Cover)	Steel			S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	L
370-B	4	HEX.HD. MACH. BOLTS (Casing to Supp. Hd.)	Steel																							
370-C	3 to 4	HEX. HD. TAP BOLTS (Brg. End Cover)	Steel																							
370-D	3 to 4	HEX. HD. TAP BOLTS (Brg. End Cover)	Steel																							

* WHITE METAL, GRAPHITE, LONG FIBRE ASBESTOS

CONSTRUCTION DETAILS

GENERAL	WEIGHT - BARE PUMP BRONZE FITTED IN POUNDS	78	81	89	78	89	89	91	121	182	172	164	196	220	192	230	205	257	250	225	247	534
	CASING THICKNESS - MIN.	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"	5/16"	5/16"	5/16"	5/16"	3/8"	5/16"	1/2"	5/16"	3/8"	1/2"	5/16"	3/8"	3/8"
	MAXIMUM DIAMETER SOLIDS	5/32	3/16	3/16	5/16	1/4	1/2	5/8	5/8	1/4	1/4	7/16	5/16	5/16	1/2	7/16	1/2	1/2	7/8	1/2	1-1/8	1-1/4
	†MAXIMUM TOTAL WORKING PRESSURE PSI	150	150	150	150	150	150	150	100	150	150	150	150	150	150	150	150	150	150	150	100	100
	MAXIMUM TEST PRESSURE PSI	250	250	250	250	250	250	250	150	250	250	250	250	250	250	250	250	250	250	250	150	150
	NUMBER OF WEARING RINGS	1	1	1	1	2	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2
	SIZE PRIME TAPPING	1/4	1/4	1/4	1/4	3/8	3/8	1/2	1/2	3/8	3/8	3/8	1/2	1/4	1/2	3/8	1/2	1/2	3/8	1/2	3/4	3/4
STUFF. BOX	STUFFING BOX BORE	1-5/8								2-3/8												3
	STUFFING BOX DEPTH	1-7/8								2-5/8												3-1/8
	STUFFING BOX PACKING SIZE	1/4"Sq.								3/8"Sq.												3/8"
	STUFFING BOX - NUMBER OF PACKING RINGS	5								5												6
	WIDTH OF SEAL RING	7/16								5/8												3/4
SHAFT	SHAFT DIAMETER AT IMPELLER	11/16								1												1-3/8
	SHAFT DIAMETER IN STUFFING BOX	7/8								1-1/4												1-3/4
	SHAFT DIAMETER AT COUPLING END	1-1/8								1-5/8												2-1/8
	SHAFT SLEEVE O.D. IN STUFFING BOX	1-1/8								1-5/8												2-1/4
BRGS.	BALL BEARING - COUPLING END	MRC 306-SF or Equal								MRC 309-SF or Equal												*
	BALL BEARING - INBOARD	MRC 206-SF or Equal								MRC 209-SF or Equal												▲
TEMP. LIMITS	MAX. LIQUID TEMP. (Without Cooling)	180° F.																				
	MAX. LIQUID TEMP. (With Quenching Gland)	220° F.																				
	MAX. LIQUID TEMP. (With Water Cooled Supt. Hd.)	250° F.																				
	MAX. LIQUID TEMP. (With Quenching Gland & W.C. Supt. Hd.)	350° F.																				

*MRC 313 SF OR EQUAL
▲MRC 312 MF OR EQUAL
† ANY PART OF WHICH MAY BE SUCTION PRESSURE

TYPICAL BRONZE ANALYSIS

NO	Cu%	Sn%	Pb%	Zn%	P%
1102	84 86	4 6	4 6	4 6	-
1103	76 8	8	15	.	05 15
1106	84	8	8	.	10 15
1000			Cast Iron		

Figure 9. **Materials of Construction and Parts Interchangeability Chart**

Single-stage pumps are the simplest to design and manufacture and production should be limited to this type until adequate experience has been gained in production techniques and pump testing.

Figure 10 shows an end-suction pump arranged for side discharge. With standard bolt circles on the supporting flange, the discharge outlet can be rotated to any angle desired by the user. The same flexibility also applies to the inlet side.

Figure 11 illustrates a double-suction, horizontally split case single-stage pump. In double-suction pumps, the hydraulic forces in the pump casing are balanced and there is no problem of end thrust to be compensated for in its mechanical design.

Figure 12 shows a cross sectional view of a single inlet, single-stage pump such as illustrated in Figure 10.

Most centrifugal pumps are not self-priming, and provision must be made for priming them. There are several methods, but they are provided for in the installation of the pump and not within the scope of this paper.

In some pumps a self-priming feature is provided for in the casing design. One such pump is illustrated in Figure 13. A baffle wall and a suction check valve are incorporated within the pump casing which provides the necessary water seal for the impeller. After the initial fill of the pump body, the priming is entirely automatic.

Since the impeller of a centrifugal pump operates at relatively high speeds, it is necessary for the rotating parts to be dynamically balanced. Such a machine is illustrated in Figure 14. These machines are capable of rapid micro-accurate balancing which will insure quiet and satisfactory pump operation.

In examining the materials used for the various components shown in Figure 9, the use of different materials is recommended to reduce the effects of corrosion and wear. The determination of the most suitable materials is primarily dependent on the characteristics of the water. Figure 15 explains the means and shows the various materials best suited for liquids of varying acidity and alkalinity. The use of materials other than those recommended will only lead to excessive maintenance and replacement.

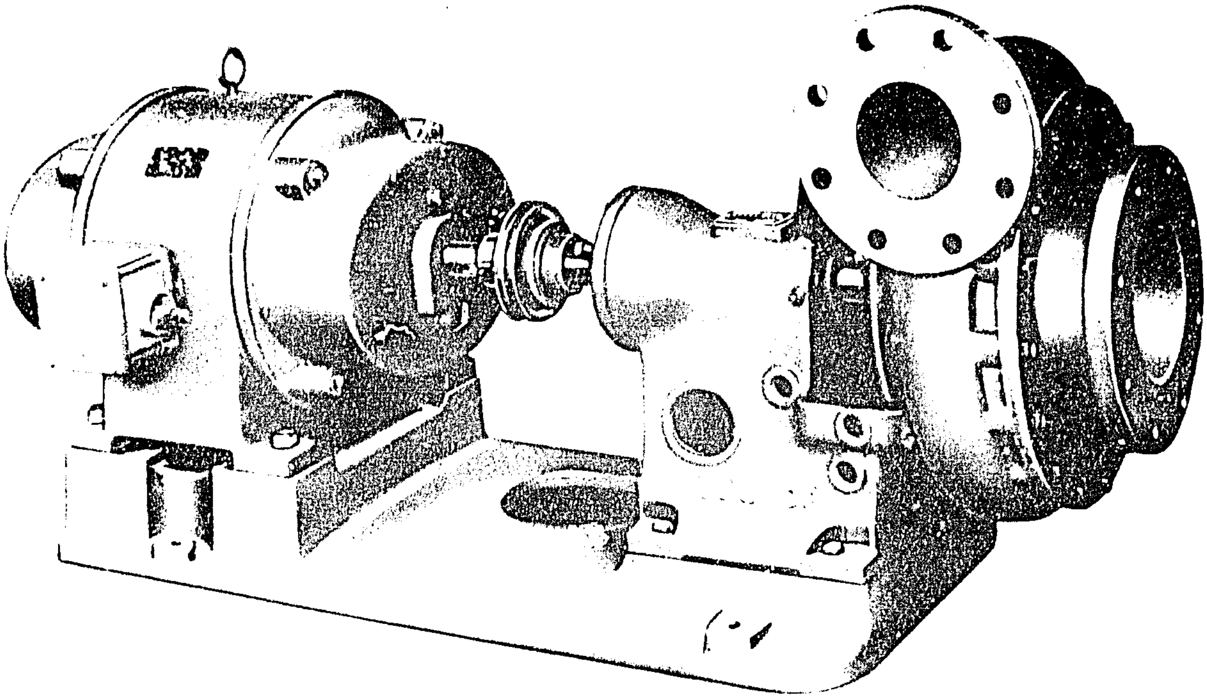


Figure 10. End-Suction Volute Pump, Side Discharge

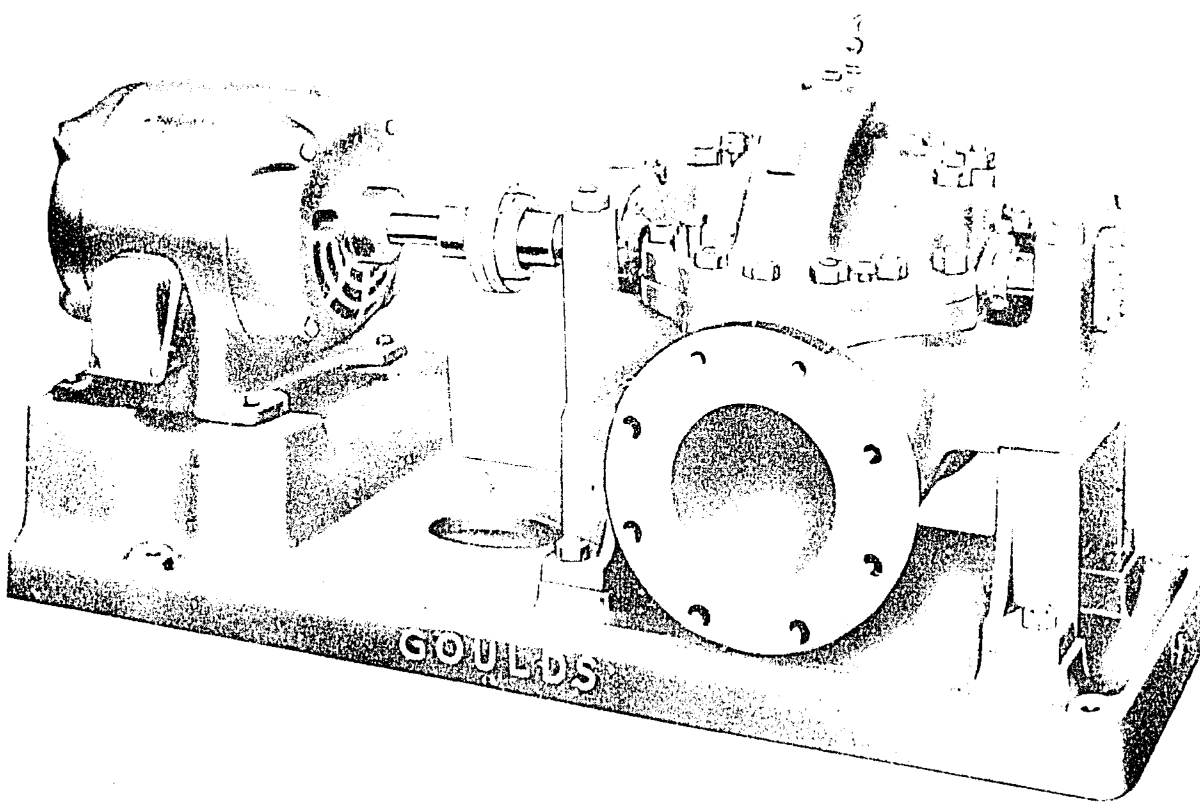


Figure 11. Double Suction Volute Pump, Side Discharge

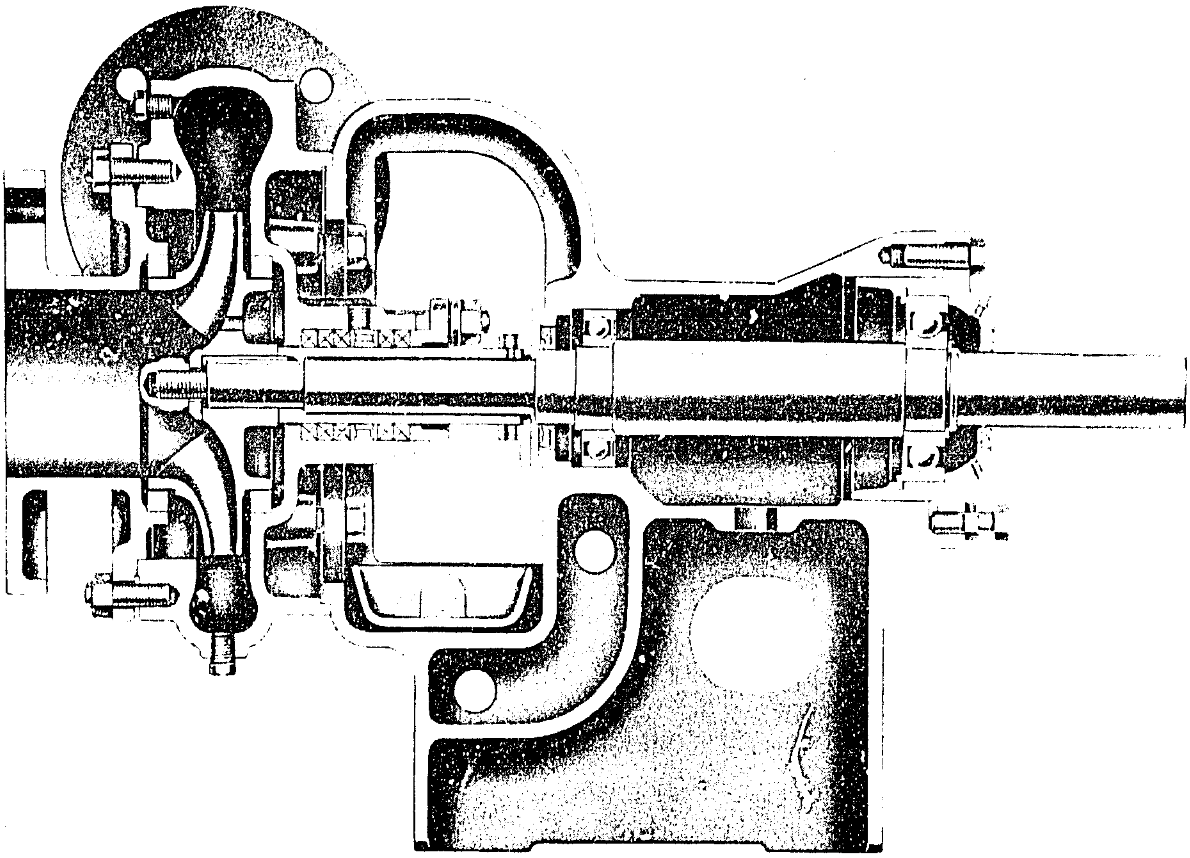


Figure 12. Cross Section, End Suction Volute Pump

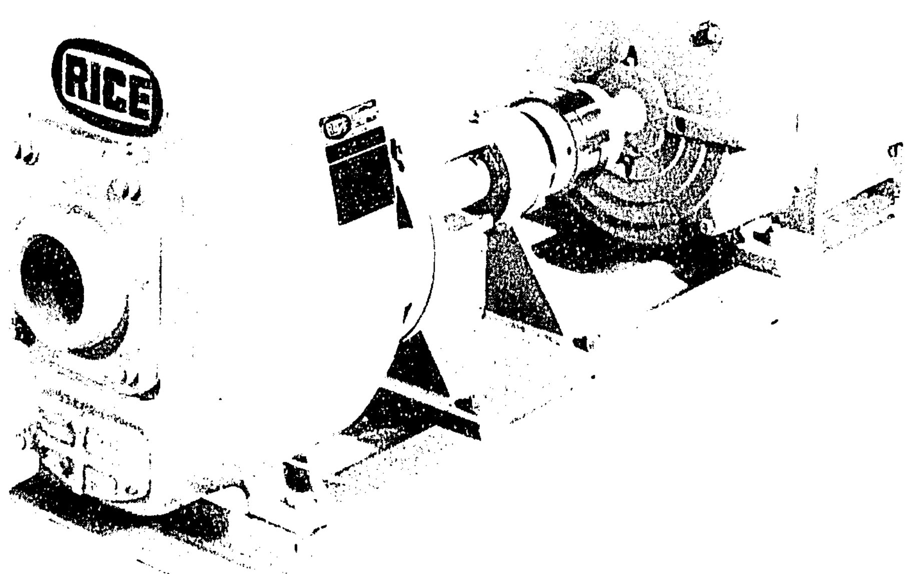


Figure 13. Self-Priming Pump, End Inlet

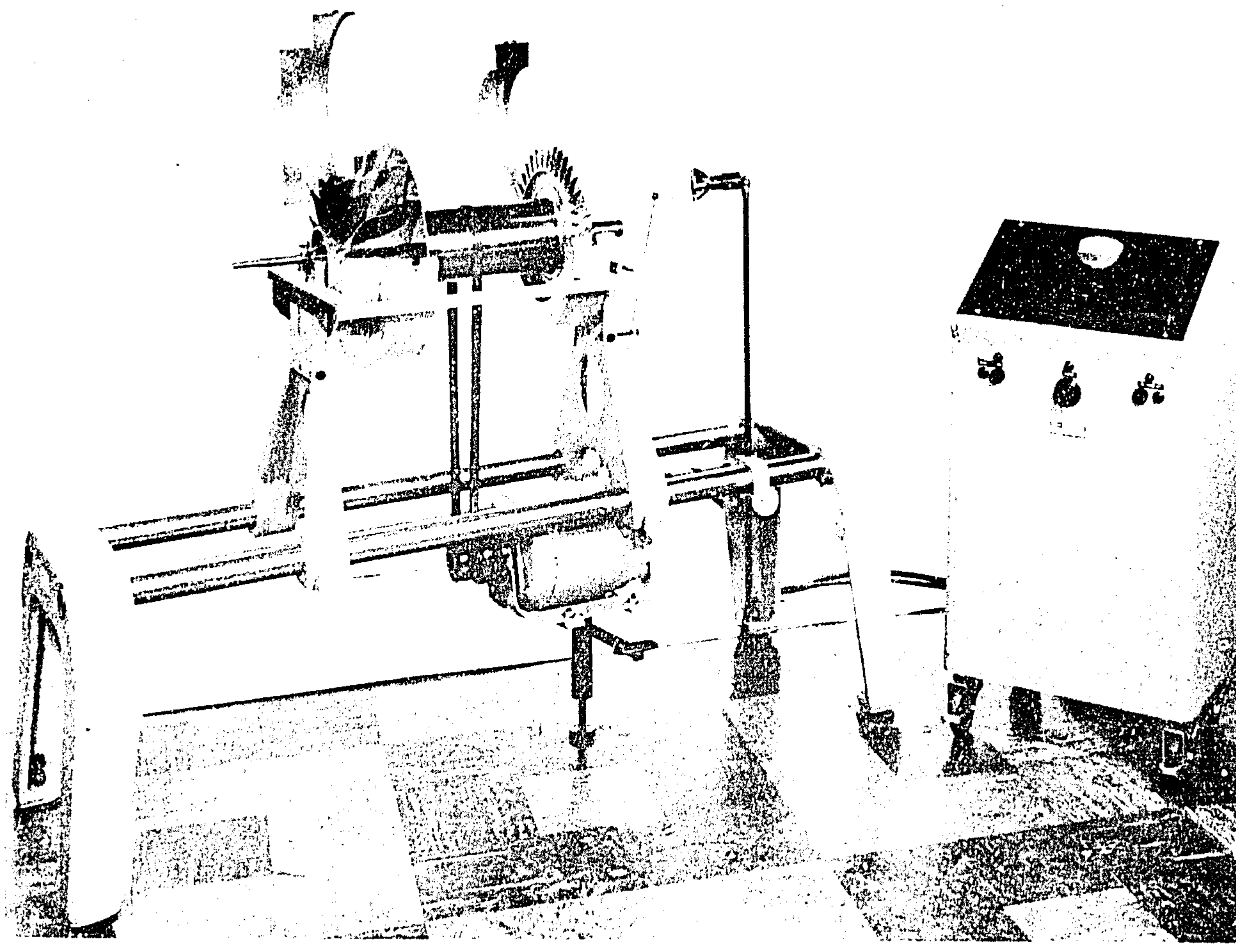


Figure 14. Dynamic Balancing Stand

The pH value of a liquid is the measure of the corrosive qualities of a liquid, either acidic or alkaline. It does not measure the amount of quantity of the acid or alkali; but, instead the hydrogen or hydroxide ion concentration in gram equivalents per liter of the liquid. pH value is expressed as the logarithm to the base 10 of the reciprocal of the hydrogen ion concentration in gram equivalents per liter. The scale of pH values range from zero through 14. The neutral point is 7. From 6 decreasing to zero denotes increasing acidity. From 8 through 14 denotes increasing alkalinity. It may also be stated that from 6 to zero hydrogen ions predominate; and, from 8 through 14 hydroxide ions predominate. At 7, the neutral point, the hydrogen and hydroxide ions are equal in quantity. The difference in pH numbers is 10 fold. For example, a solution of 3 pH (.001 hydrogen ion concentration in gram equivalents per liter) has 10 times the hydrogen ion concentration of a 4 pH solution (.0001 hydrogen ion concentration in gram equivalents per liter). Likewise, a 10 pH solution has 10 times the hydroxide ion concentration of a 9 pH solution. The pH value of a solution can be obtained by colorimetric methods using "universal indicator" or by electric meters designed especially for the purpose.

The table outlines materials of construction usually recommended for pumps handling solutions where the pH value is known

Knowing the pH value of a solution does by no means answer all questions as to the corrosive qualities or characteristics of a solution. Temperatures of the solution effects the pH value. For example, a water solution may have a pH of 7, or neutral, at room temperature but at 212° F it may have a pH value less than 7 or on the "acid side" of neutral 7. Corrosion effect by dissolved oxygen in a solution and corrosion by electrolysis cannot be predicted by pH values, but knowing the pH value of a liquid to be pumped is an excellent point to start in determining the materials of construction.

pH Value	*Material of Construction*
0 to 4	Corrosion Resistant Alloy Steels
4 to 6	All Bronze
6 to 8	Bronze Fitted or Standard Fitted
8 to 10	All Iron
10 to 14	Corrosion Resistant Alloys

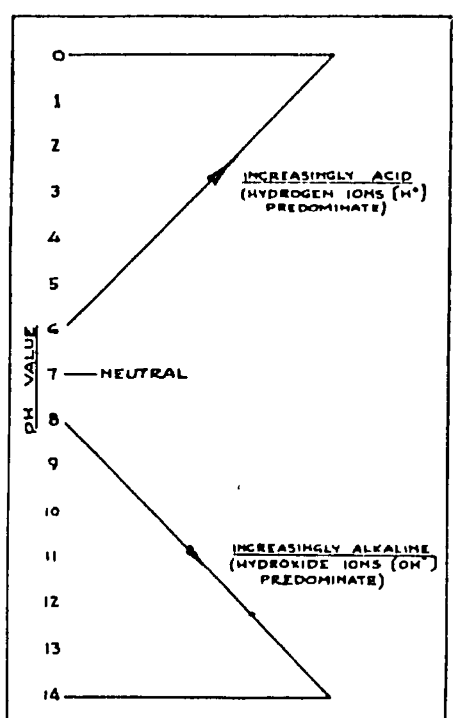


Figure 15. pH Values - Their Explanation and Use in Pump Selection

In order that the pump industry have an orderly and uniform standard method of presenting its information and conducting its performance tests on pumps, there was organized in 1917 what was known as the Hydraulic Society. In 1933 the Society was reorganized and the name changed to the Hydraulic Institute. The Institute establishes standards of performance, manufacturing tolerances, methods of tests, and also publishes engineering information of an informative character not falling within the classification of Institute Standards. Manufacturers in the United States generally follow the Standards of the Hydraulic Institute.

One of the sections of the Standards deals exclusively with centrifugal pumps. Standard definitions and nomenclature are given, as well as information on net suction heads and correction charts for various operating conditions. Test procedure is set forth in detail, as well as detailed information required by the manufacturer to furnish a pump to do a given job.

Procedure for the testing of small scale models of large pumps is also given in detail. This permits the pump manufacturer to determine performance of the design of a large pump which otherwise might not be possible until actually installed.

Test facilities will be required to check design of all pumps to be manufactured and such facilities are included in the plant layout.

Valves

Valves for use on water supply lines are rated, first, according to the line pressure on which they are to operate, such as 25 pounds, 125 pounds, or 250 pounds per square inch pressure.

Valves may next be classed as all iron, or brass-trimmed. In this case the body itself is of iron. Brass-trimmed valves are recommended for use on water, oil, or steam lines. All iron valves are recommended for oil, gas, or for fluids that corrode brass.

Gate valves can also be classed as the solid wedge type or the double disc type. Gate valves manufactured in accordance with the specifications of the American Water Works Association are the double disc type.

The seats of the A.W.W.A. valves are parallel. The double disc valves are equipped with a spreader device that forces each disc against its seat. This type is naturally more expensive to manufacture and is not recommended as a product to be manufactured until the plant has acquired considerable production experience on the simpler wedge type gate valve.

Figure 16 illustrates the wedge type gate valve. It is apparent in this type that any wear due to operating the valve partially open will in time permit leakage when the valve is closed tight. This type of valve should be operated either fully open or closed.

This figure also shows how the brass rings on the disc and on the seats are attached to their respective parts to give brass closing surfaces.

Figure 17 tabulates the general dimensions of these valves for pipes from 2 inches to 30 inches in diameter. These sizes are the determining factor in the selection of sizes of machine tools to be selected in equipping the shop.

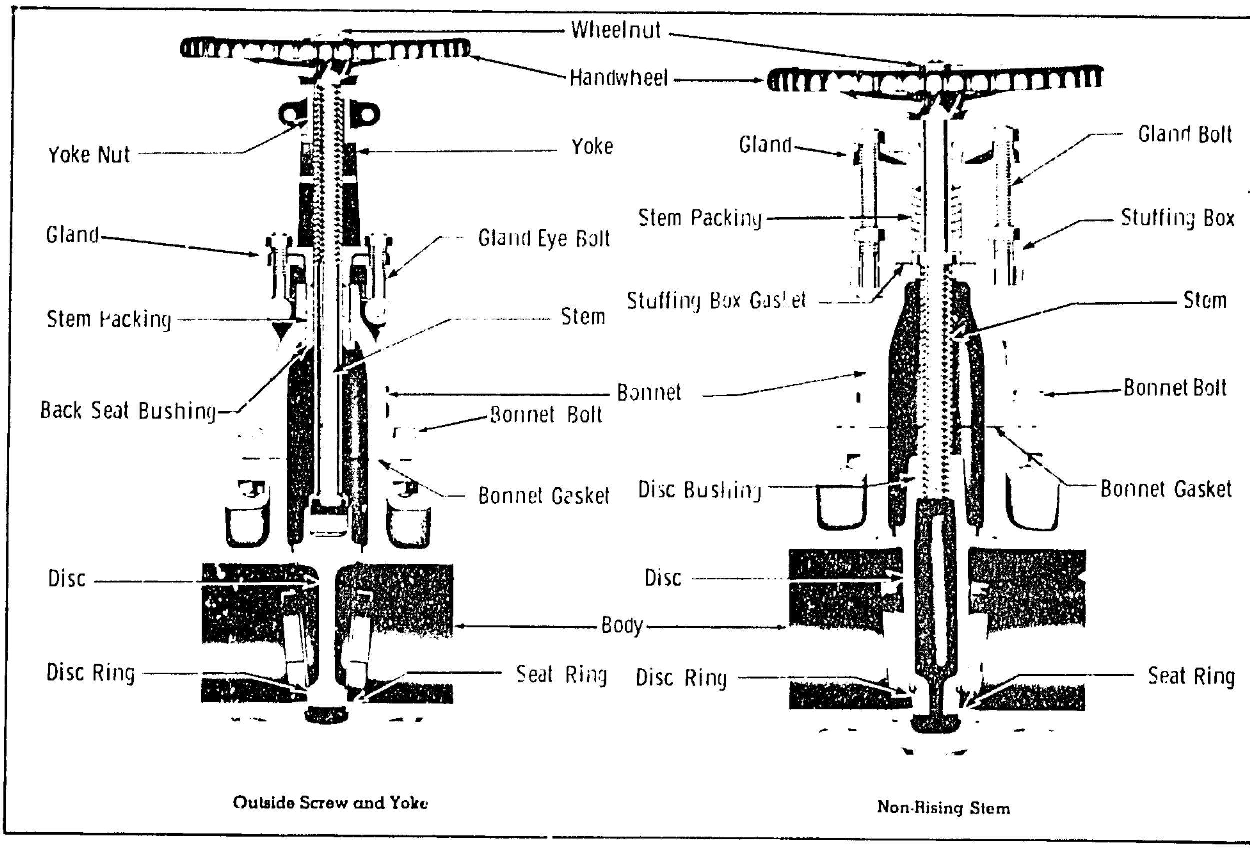
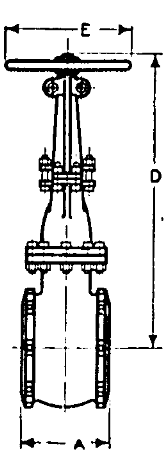


Figure 16. Sections of Wedge Type Gate Valves



Dimensions and Weights

Size... in.	2	2 1/2	3	4	5	6	8	10	12	14	16	18	20	24	30
A..... in.	6 1/8	6 3/4	7 1/8	7 3/4	8 1/4	8 3/4	....	....	....	....	....	....	....	....	....
B..... in.	7	7 1/2	8	9	10	10 1/2	11 1/2	13	14	15	16	17	18	20	21
D—Open .... in.	15	16 7/8	19 1/4	24	28 3/4	32 1/2	41	49 7/8	57 1/2	65 1/4	74 3/8	82 3/8	91	107 1/8	134
E..... in.	8	8	9	10	12	12	16	18	18	20	22	24	24	30	36
F..... in.	6	7	7 1/2	9	10	11	13 1/2	16	19	21	23 1/2	25	27 1/2	32	38 3/4
G..... in.	5/8	11/16	3/4	15/16	15/16	1	1 1/8	1 3/16	1 1/4	1 3/8	1 7/16	1 5/16	1 11/16	1 7/8	2 1/8
Turns to Open..	6 7/8	8 3/8	10	8 3/4	10 7/8	12 7/8	17	21 1/8	25 1/4	29 3/8	33 1/2	37 5/8	41 7/8	50	93
Wt. Lb.: Scrd....	35	42	58	·95	133	169	....	....	....	....	....	....	....	....	....
Flgd...	42	53	68	115	157	198	328	526	706	971	1346	1663	2186	3262	4825

*For steam service requiring valves 18 inches and larger we recommend the use of 150 Lb Cast Steel Valves.

†Can be furnished with Steel Stem instead of Bronze Stem when so specified.

We recommend that valves 14 inches and larger for steam service be furnished with a by-pass.

Flanged Valves are shipped faced and drilled unless otherwise specified. When ordered faced only, they will be furnished at the same price.

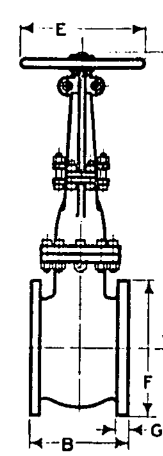


Figure 17. Dimensions and Weights

Valves built in accordance with American Water Works Association standards employ double discs with parallel seats instead of the wedge type gate. Figure 18 shows a cross section of such a double disc gate valve in the closed position. The mechanism is so devised that the first turns of the hand wheel cause the double discs to drop down into position, thus seating against their respective body seats. The final turns of the hand wheel cause the two parallel discs to spread and fit firmly against the body seats. Each disc is free to find its final position, independent of the other disc. On opening the valve the process is reversed.

Figure 19 illustrates two types of wedging mechanisms, depending on the size of the valve and the pressure class.

Discs with spreaders: The upper spreader, engaging the valve stem, raises and lowers the discs. When the valve is being closed, the lower spreader strikes a stop in the bottom of the body; further rotation of the wheel brings the wedging surfaces of the spreaders into contact, and the spreaders force the discs outward against the seats.

Discs with wedges: A disc nut engaging the valve stem raises and lowers the discs. When the valve is being closed, two hooks carrying manganese bronze wedges, strike a stop in the bottom of the body; further rotation of the wheel forces the wedges between the discs, and the wedges force the discs outward against the seats.

Figure 20 shows the exterior view of two types of double disc gate valves of the 25 pound class. Figure 1 shows the exterior view of two wedge type gate valves of the same pressure class. Note the difference in reinforcing the valve bonnet.

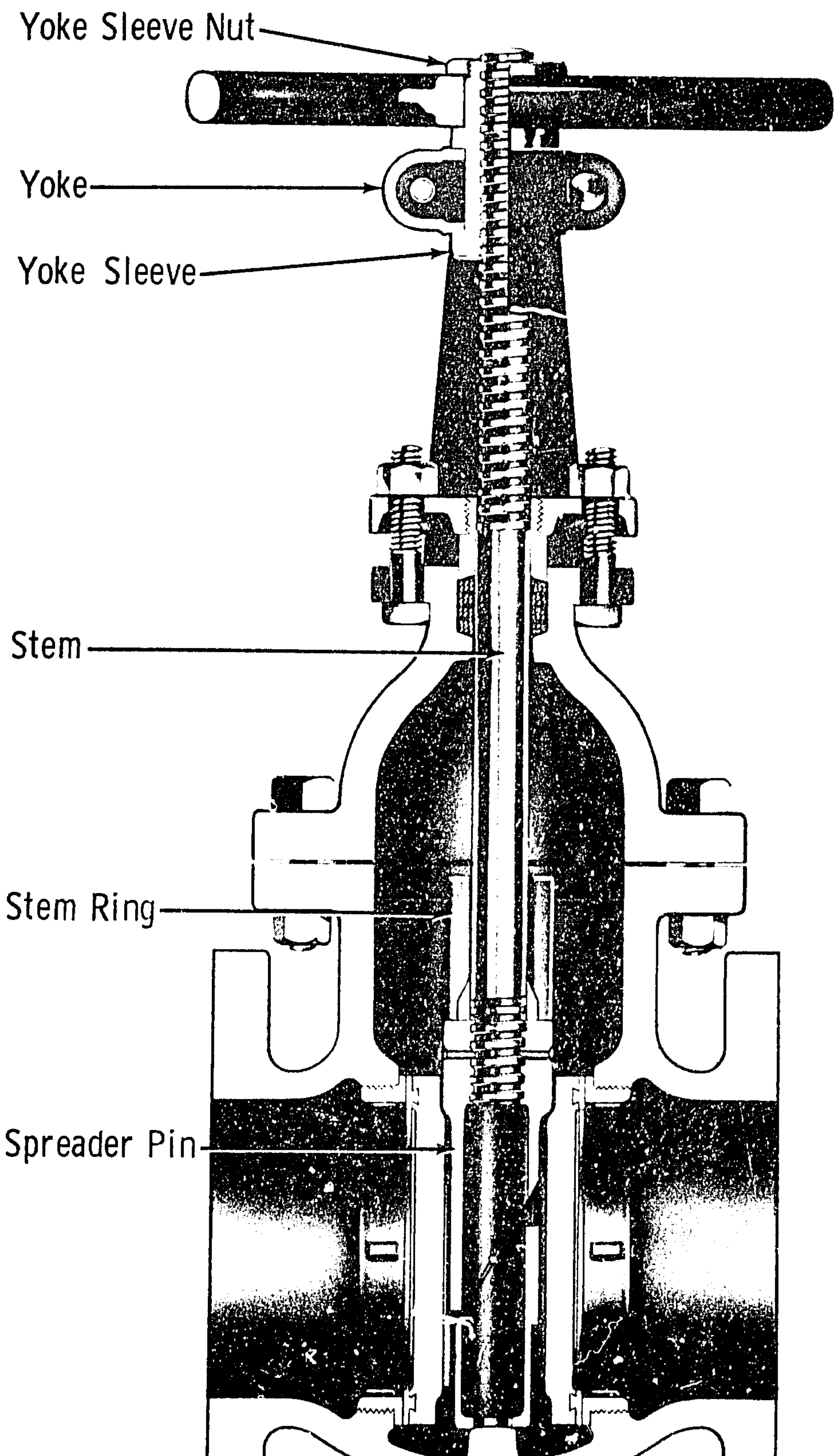
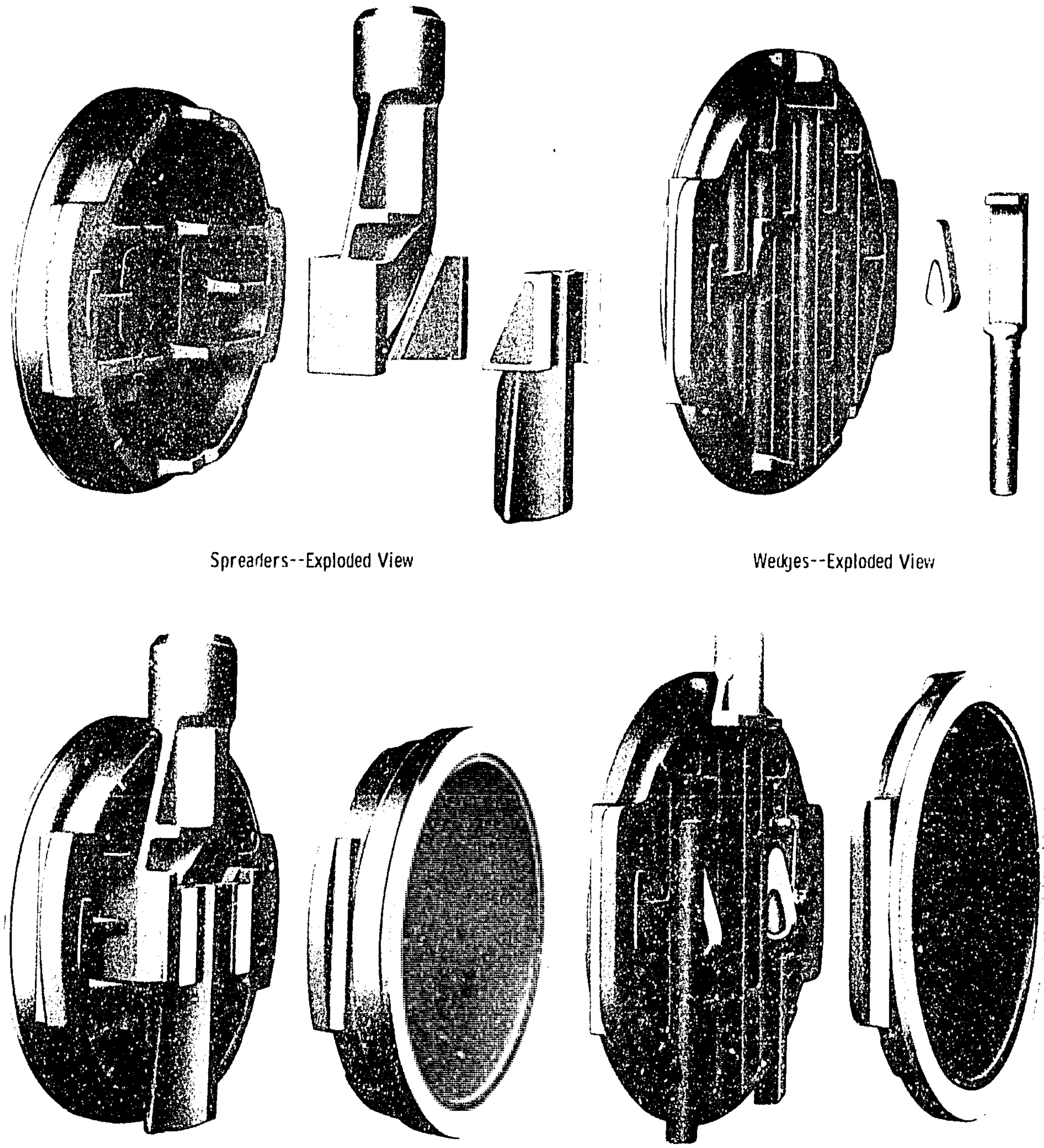


Figure 18. Section of Iron Body Double Disc Gate Valve, Outside Screw and Yoke Valve Closed



Spreaders--Exploded View

Wedges--Exploded View

Spreaders--Assembled View

Wedges--Assembled View

Figure 19. Wedging Mechanisms for Double Disc Gate Valves

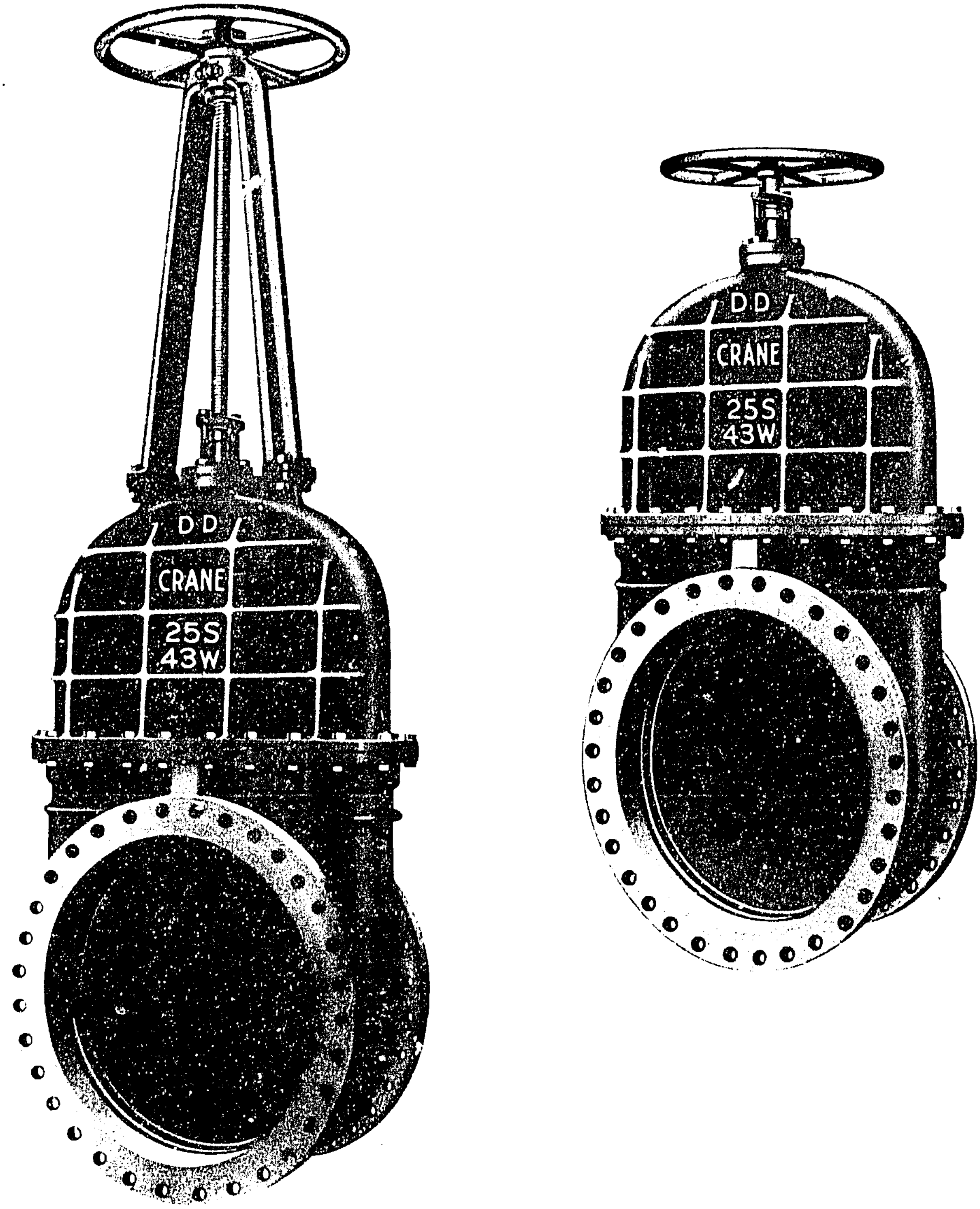


Figure 20. Exterior Views, Double Disc Gate Valves