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SHALLOW-WELL HAND PUMPS

In the manufacture of shallow-well pumps the important factors to be analyzed, studied and clarified are:

(a) The size, type, and design of a hand pump that will raise water most efficiently from a maximum depth of 22 feet and that can be made economically in a small foundry employing only a few operators, mostly unskilled;

(b) A foundry and shop properly equipped to make these pumps of gray iron, and finish the castings accurately, for example, a plant equipped at the start with the smallest number of machines and tools, and with most of the work done by manual labor;

(c) Some technical controls to assure sound castings, a training system for the shopmen including protection against accidents, and a way of checking all shop operations to avoid waste.

Size and Style of Pumps:

The design of a simple type hand pump is shown in figure 1, d. It is made of gray cast iron, having a bore of 2 5/16", and a piston movement of 6", obtained by a hand lever. The bottom casing is tapped for 1 1/4" inside diameter pipe. This pump will deliver approximately 200 gallons per hour, with about 30 to 35 strokes per minute.

Foundry Practices:

Making good castings consists of preparing the molds, (making cavities in the sand, placing gates and risers at the right places) preparing the melt, and pouring the molten metal into the molds.

Preparing the Proper Patterns:

A split pattern, shown in figure 1, c. is provided with the necessary projections into which the projections of the ends of the dry sand core will fit when the pattern is lifted out of the mold. The round core is thus anchored in the mold so that it will not float out under the buoyant forces of the metal.

Core Making:

The core is used to form the cavity in the pump which is later machined accurately in the tool room to accommodate the piston. This cylindrical core is inserted in the mold after the wood pattern has been removed from the mold. The core is prepared in wooden molds (core boxes) and kep in an oven at a low temperature (about 400°F.) to harden and dry.

The core is surrounded by hot metal during pouring, therefore, it is subjected to very high temperatures and must be made of special core sand. This sand requires a high silica content. Special bonding materials must be mixed to the core sand for binding purposes. These come in both liquid and dry form and are made of wheat flour, rye meal, powdered rosin, and linseed oil.

Molding and Pouring:

The most important part of the job is making the cavities in the sand, for example, preparing the molds, because if this is not done correctly, a defective casting results. The molds are built into the required shape by hand, and the wood pattern for the mold should be oversize to allow for shrinkage in the casting. Cast iron shrinks about 1/8 inch per foot in cooling from the molten state to room temperature.

The best quality sand adapted for foundry use can be obtained only through careful examination of the sand available. It should be remembered that the expense of sand is only about 1% of the total cost of the casting. The sand should be well graded, tested and should stand a high sintering point of 2500°F. For each pouring operation a new mold must be made. Properly selected sand can be retamped and used for successive molds by adding a small amount of new sand to provide bond. Permeability or the ability of the tamped sand to permit the passage of gases through it is a very important property. The finer grained sand composed of sharp, angular-shaped particles are best for general molding work as they have good porosity, form a good bond, having more open structure than sands of round grain. Molding light castings, like pumps, is best done with snap and taper flasks, as these provide an excellent guide for a parallel lift of the plate and facilitate accurate lifting of the top part. Small hand ramming tools are used to ram the sand around each half of the pattern.

Gate and Riser:

The riser is that part of the mold where the excess metal above the casting flows and serves to keep the body of the mold full and to receive any dirt or scum which rises. The riser is designed also to carry off the air pushed out of the mold by the inflowing metal, when the mold is filled with the metal. For a small casting, a single riser and gate are sufficient as the hot metal does not have far to run.

Melting the Metal:

The cupola is the most widely used of all foundry furnaces for melting iron for all kinds of ordinary castings. The cupola is charged with pig iron, iron scrap (defective castings, gates and risers), and steel scrap, the relative proportions depending upon the desired composition of the castings to be poured. This is learned by experimentation. This cupola is a straight shaft furnace, open at the top, lined with special fire-clay brick and charged through doors about halfway up the shell, with alternate layers of coke and iron and with a little limestone added to flux the coke ash and make the slag more fluid. The slag consists of ash from the coke, impurities from the metal and material from the side-walls of the cupola.

The amount of coke used for each charge is from one-fourth to one-twelfth of the weight of the melted iron, depending upon the amount of steel scrap used and the pouring temperature desired. The chief requisites of foundry coke are purity, large size, good strength, and a minimum of reactivity with carbon dioxide gas.

Air is blown in through tuyeres near the bottom to burn the coke and to produce the heat of combustion necessary to melt the iron. At the bottom of the cupola is a pair of hinged cast-iron doors which are dropped after all molten metal has been withdrawn. This is to let the residue of iron in the cupola fall out and be taken away. The cupola is encircled near its base by the wind box, into which air is forced by a blower. The wind box is connected to the interior of the cupola by the tuyeres, which are of cast iron and flare upward slightly.

To heat the cupola, a fire is started from shavings and kindlings on the hearth of sufficient amount to ignite the coke.

Pouring the Casting:

The upper part of the mold, called the cope, must be weighted down so that the buoyant force of the metal will not lift it and allow some metal to flow between the cope and the lower part called the drag, and solidify there. The molder takes a ladle-full of metal at the proper temperature from the furnace and pours it down the gate of the mold in a steady stream, taking care not to break the stream at any time. It is best to keep the gate full of metal at all times in order to minimize the washing of sand into the mold. Pouring is continued until the level of the metal reaches to the top of the riser. The metal, allowed to solidify and cool before being shaken out of the mold, now emerges as a raw casting. The gate and riser are cut off the surface of the casting, and the raw pump body is passed on to the cleaner.

Cleaning the Casting:

To prepare the casting for use, it is necessary to remove the gate and riser, fins, scabs, and sand. Removal of the dry sand core by rapping is usually the first operation. Gate and riser can be broken off with a hammer and a chisel, or cut off with a hacksaw. Removing the fine chips and lumps is done with an electrical, portable grinding wheel, and the surface

sand which might have fused with the casting may be brushed off with a coarse iron brush.

Making the Bottom Plate and Handle:

While these are much simpler castings, the processes used are the same as for the pump body.

Machining:

Finishing of the pump body, the bottom plate, and the piston is done in the tool room.

By using a special jig to hold the head of the pump body in the chuck of a lathe the inside part of the pump body is bored out to a diameter of 2 5/16 inches. Gaging is done with a simple gage. The holes are drilled in a small upright drill press for the screws and the threads are cut with a tap.

Also the piston and top valve are machined on the lathe and a special die is used to cut out the leather discs for the valves.

Threading the bottom plate is done on the lathe, while the threads on the pipe are cut with a hand threader.

Control of Productivity:

Once the foundry is in operation, some time and thought should go to measuring and controlling the productivity of the shopmen. Observance of their daily activities may lead to certain fixed figures either in terms of time or tonnage per week, per man; figures which would indicate a better way of using the available mechanics, and a more expeditious handling of the raw materials.

From such weight and time figures management may judge what phase of the day's work may be improved. It may then be possible to note operations uselessly repeated, to find out how to make materials more readily available at each station, how to introduce some tool or material handling equipment which can speed up casting of the pumps, reduce fatigue of the operators, or how molders can spend more time in the actual production of the castings and less in general labor around the shop.

Employing an outside, experienced foundryman as a consultant is an accepted practice. He can help management by instructing the shopmen in better mold and core making and more efficient handling and cupola operations. An experienced foundryman can establish some control by better planning the weekly pouring of the metal, using the best way of cleaning the castings, initiating some sort of training and application of safety measures for personnel, finding the best way to check the accuracy of the finished product, and maintaining general cleanliness and better order in the shop.

There are no suitable or reliable formulae to gage exactly the weekly productivity for the thousands of different shapes produced today in the hundreds of foundries. Prices are finally established on the

market place today by comparison with similar products offered by other shops.

It should be remembered that a specialty foundry making a pump is a one-man organization in that the shop foreman must be responsible for all metallurgical problems and shop techniques, such as charging the furnace, making the molds and cores, and for melting, cleaning, and inspecting the finished product.

As the business grows, modernization may be effected through increased plant layout, better production equipment, improved ventilation and dust control, and mechanized or motorized handling. Among the economical advantages of such modernization are the savings made through eliminating manual operations; a better chance for the workers to increase their earnings and raise their standard of living; bigger output of finer castings, and maintaining at the same time the competitive status of the shop.

EQUIPMENT

1 Cupola, complete with bricks, tuyeres, plates, 36-inch diameter	$6,000
diameter	$ 6,000.000
1 Turbo compressor, 5 horsepower	1,000.00
Cupola Tender's pick and taping chisel	10.00
Sand screening unit, 3 horsepower	800.00
Small sand mixer, 5 horsepower, 5 cubic feet	400.00
Molders tools, trowels, slicks, gate cutter, lifter, leaf and square, spoon, bead, square and rounded corner, shovels and forks	200.00
Foundry riddles, bellows, core brushes, dusters and hand spray	100.00
Snap flasks, clamps, sprue cutter, chaplets, gaggers	400.00
Hand ladle shanks and two-wheel buggy ladle	150.00
1 Optical pyrometer	225.00
1 Electrical grinder, spare abrasives	250.00
Material in stock, such as sand, coke, limestone, refractory brick, and dies	3,000.00
	$12,735.00

Tool room equipment:

2 Lathes with chucks, 2 jigs to hold pump and bottom plate, and tools for inside boring of pump, and threading bottom plate	$ 4,000.00
1 Hand thread cutter	250.00
Taps for threading holes in bottom plate	35.00
Lathe tools for facing operations	30.00
1 Small upright drill	100.00
1 Die for cutting leather discs	75.00
1 Band saw for pattern shop	250.00
1 Hand planer	100.00
Small tools for pattern shop, such as sander, and gluepot	200.00
Vises, lockers, gages, sandpaper, mold wash, clamps, and chisels	250.00
	$ 5,290.00

Labor Requirements:

1	Foundry foreman	$ 4,500.00
2	Molders	8,000.00
1	Helper and 1 cleaner	5,000.00
2	Machine shop operators in tool room at $3,250.00	6,500.00
1	Pattern shop operator	2,000.00
		$26,000.00

Cost Estimating and Control

Some of the equipment used in the manufacture of sand pumps is indicated in Figure 1. This includes sand piles, other molding materials, pattern assembly of boxes for pouring, cupola and other foundry equipment, pattern shop and tool room.

These are the important items on which to base cost estimates. For this purpose, certain foundry and machine shop estimating data are used, and done on a man-hour basis. However, it should be kept in mind that all foundry items are variable because operations depend upon many qualifying conditions, such as the capacity of the equipment, and the intelligence, skill, ability and experience of labor handling the hot metal. Also, the shopmen's observance of safety and other measures are equally important factors affecting final costs.

Establishing a production standard per man-hour for basing cost estimates for output in pounds of good casting in a small foundry may be made in this case as follows:

Output in the molding area, per man hour	45 pounds
Output in the clearing area, per man hour	45 pounds
Output in the core-making area, per man hour	45 pounds
Average production per man, per hour, in small rough castings	45 pounds

As the average weight of a rough pump casting is figured at 15 pounds, on the estimated 45 pounds basis, the production per man, per hour is 3 pumps.

Working the foundry with five men, this gives a final figure of 15 rough pump bodies produced per hour. Hence:

Labor Wages:

For five men, producing fifteen pumps (Figured on the basis of the wage scale shown above).	$ 6.75
Two mechanics in the machine shop finishing these rough castings, making the pistons and other small parts shown in Figure 1	3.25
Pattern maker	1.25

Material Costs:

Cupola charge, at a rate of $0.06 per pound of iron and scrap, for 15 pumps, at 15 pounds per pump.....$13.50
Additional material for loading cupola, figured at a standard rate of 30 percent of cupola charge..... 4.05
Sand, core sand, nails, patterns, drier, and heating, at a standard rate of 10 percent per cupola charge..... 1.35

Total: Wages and material costs for 15 pumps hourly rate.....$30.15

Markup, standard 100 percent, for such items as salaries, insurance, fuel, power and light, general supplies, advertising and selling, building, tool care and maintenance, taxes, depreciation of building and equipment, postage, telephones, bad debts, administration expenses, and other fixed charges known to each shop.....$30.15

Total for 15 pumps, ready for shipment..... 60.30
Total for one pump..... 4.02

Other Small Foundry Items

A small foundry could and should make, in addition to the hand pumps, other cast iron workpieces. There is no limit, of course, to the great variety. A few possible articles are: Pipes, valves, wheels, stands, troughs and plows. A foundry capable of producing such and similar workpieces would provide a community with a great variety of articles for the regular local market as well as for emergency requirements.

Bibliography:

1. Publications by the American Foundrymen's Society, 616 South Michigan Avenue, Chicago 5, Illinois. Recent publications of the society present new ideas in foundry practices, on the latest developments in research, and ideas advanced by outstanding engineers concerned with the theoretical and practical aspects of founding:

"Alloy Cast Iron Handbook" on the various phases of foundry practice for alloy cast irons. Price $4.50.

"Ferrous Foundry Process Control" No. 11. Various process control procedures are recommended to be used as a possible guide for foundries in controlling production and figuring production costs. Price $2.50.

"Foundry Core Practice" No. 38. Covers the entire field of coremaking. Price $10.00.

"Statistical Quality Control for Foundries" No. 63. Describes the various attempts by foundries to control quality and production, how to train personnel, and the proper ways of figuring and controlling costs. Price $6.75.

"Patternmakers' Manual" No. 61. Includes solutions of simple and difficult pattern making problems. Price $6.75.

2. "Casting and Forming Processes in Manufacturing," by J.S. Campbell, 1950. McGraw Hill Book Company, 330 West 42nd Street, New York, N.Y. Price $7.00. This book of more than 500 pages covers briefly the entire casting technique in addition to various other shop practices.

3. "Pattern Making for Engineers," 1950, by J.G. Horner. The Technical Press, Ltd., Gloucester Road, Kingston Hill, Surrey, London, England. Price $4.50. Latest developments are shown and described in practical and improved pattern making, tools and equipment used, and details of pattern construction, drawings, core making, and patterns for miscellaneous work resembling pump and pipe bodies.

4. "Foundry Practices," 1955, by S.E. Rusinoff. American Technical Society, 616 South Michigan Avenue, Chicago, Illinois. Price $6.50. A practical book treating the various manufacturing processes in metal casting for foundrymen, shop foreman, technicians, and students, with hundreds of illustrations on pattern making, sand preparation, core making, sand molding, use of hand tools, and solutions of hundreds of molding problems.

5. "Pattern Maker's Manual," First edition, 1953. American Foundrymen's Society. Price $6.75. Volume presenting pictures of pattern making equipment, pattern layouts, details in wood pattern construction, split pattern making, and the use of pattern making machinery.

6. "Cupola and Its Operation," by American Foundrymen's Association, second edition, 1954. Price $9.50. Presents minute calculations for a cupola, methods of applying the lining, use of coke bed, preparation of the charges, control of temperatures, and solutions of problems like front slagging, keeping the tuyeres open, banking the cupola, and other operational techniques.

7. "Equipment and Supplies for Foundrymen," Stevens Catalog No. 30, by F.B. Stevens Company, 510 Third Street, Detroit, Michigan. This is a complete reference book on foundry equipment and supplies.

8. "Foundry Core Binder," IR-12054, and "Measurement of Work in the Foundry Industry," IR-11611. Both obtainable from the U.S. Department of Commerce, Office of Technical Services, Washington 25, D.C.

9. "Pattern Making and Founding," by R.E. Smith, 1954. McKnight and McKnight Publishing Company, Bloomington, Illinois. Price $3.00. Discusses the activities of foundrymen, methods of molding, coremaking, cupola operations and other phases of founding.

10. "The Foundry Industry in Illinois". (HF 5500 13 Bulletin No. 70). By the Bureau of Economic and Business Research, University of Illinois, Urbana, Illinois. Price $.75.

11. "Five Small Gray Iron Foundries," Report No. 85, April 1955. By the Bureau of Labor Statistics, U.S. Department of Labor, Washington 25, D.C. Available from International Cooperation Administration, Washington 25, D.C.

12. "Plant Requirements to Set Up and Operate a Gray Iron Jobbing Foundry," April 1955. International Cooperation Administration, Washington 25, D.C.

Additional information may be obtained from the following sources:

Foundry Equipment Manufacturing Association
Law and Finance Building
Pittsburgh 19, Pennsylvania

Gray Iron Founders Society
National City-E. 6th Building
Cleveland 16, Ohio

Steel Founders Society of America
920 Midland Building
Cleveland 15, Ohio

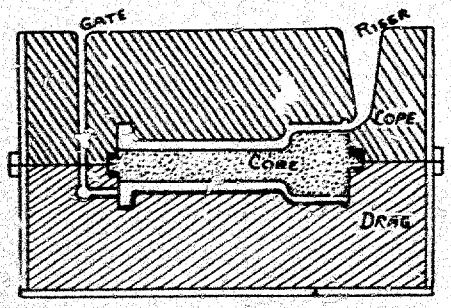
Manufacturers of Equipment:

The Whiting Company, Harvel, Illinois. Manufacturers of all sizes of cupolas.
Spencer Turbine Company, 400 Park Avenue, Hartford 6, Connecticut. Manufacturers of cupola blowers.
Newaygo Engineering Company, Newaygo, Michigan. Sand handling equipment.
E.B. Stevens, Inc., 1820-18th Street, Detroit 16, Michigan. Manufacturers of all kinds of molding and foundry tools.
Leeds and Northrup Manufacturing Company, Rockland and Stenton Street, Philadelphia 44, Pennsylvania. Manufacturers of all kinds of pyrometers.
Hisey-Wolf Machine Company, 2600 Madison Road, Cincinnati 8, Ohio. Manufacturers of electric hand grinders.
Sheldon Machine Company, 4200 North Knox Avenue, Chicago 11, Illinois. Manufacturers of lathes, and lathe tools.
Oster Manufacturing Company, Box 4326-B, Cleveland 32, Ohio. Manufacturers of all kinds of thread cutting tools.
Danly Machine Specialty Company, 2100 South Larramie Avenue, Chicago 50, Illinois. Manufacturers of dies.
Fay and Egan Manufacturing Company, Cincinnati, Ohio. Makers of bandsaws and planers.

Mention of the name of any firm, product or process in this report is not to be construed as a recommendation or endorsement but merely as a citation that is typical in its field. Commercial directories generally list names of additional companies and products.

NOTE: To obtain copies of any catalogs, bulletins and other reference material mentioned in this report, please write direct to the indicated source of issue or supply.

Fig. 1 TYPICAL LAYOUT, EQUIPMENT AND DESIGN



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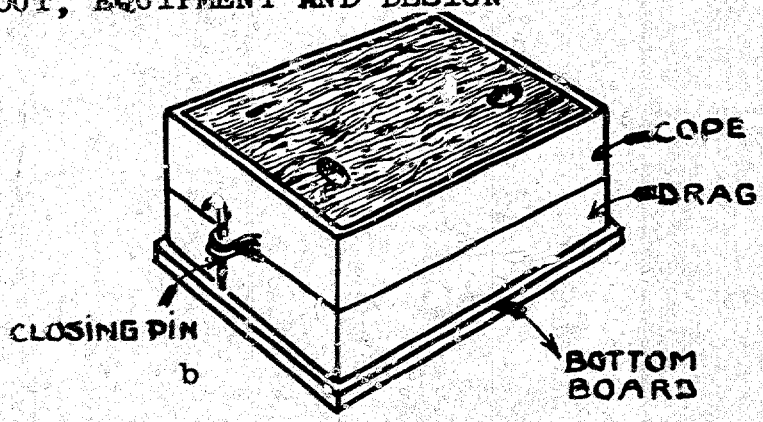

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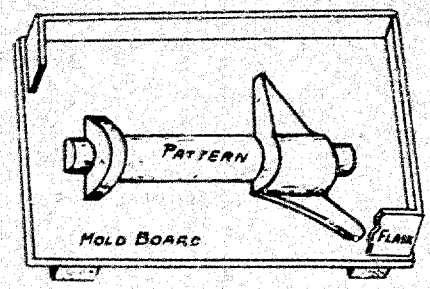
ASSEMBLY READY FOR POURING



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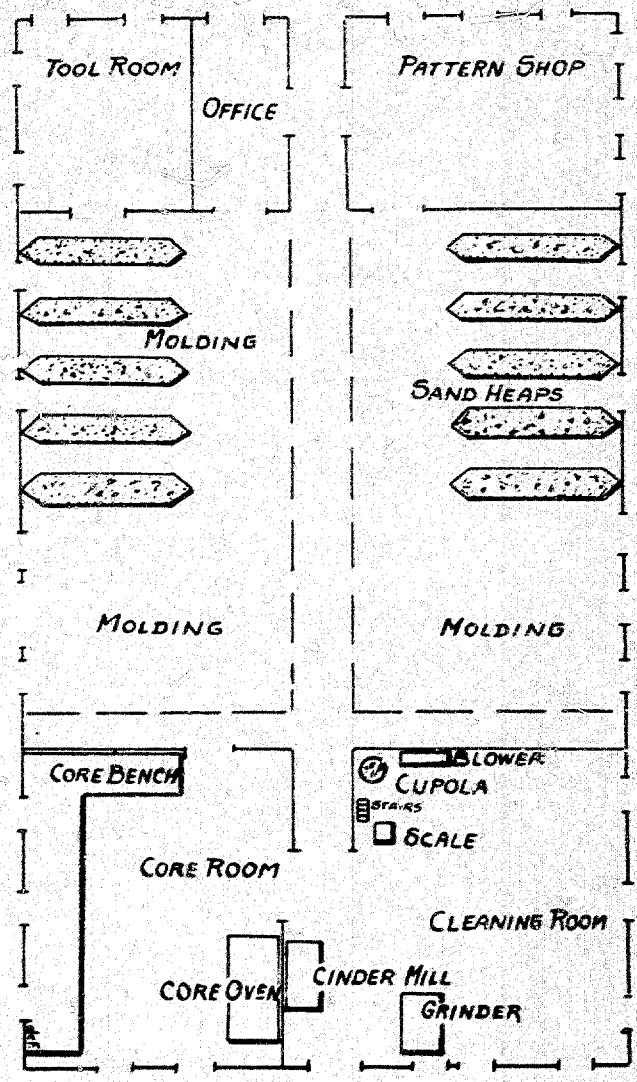

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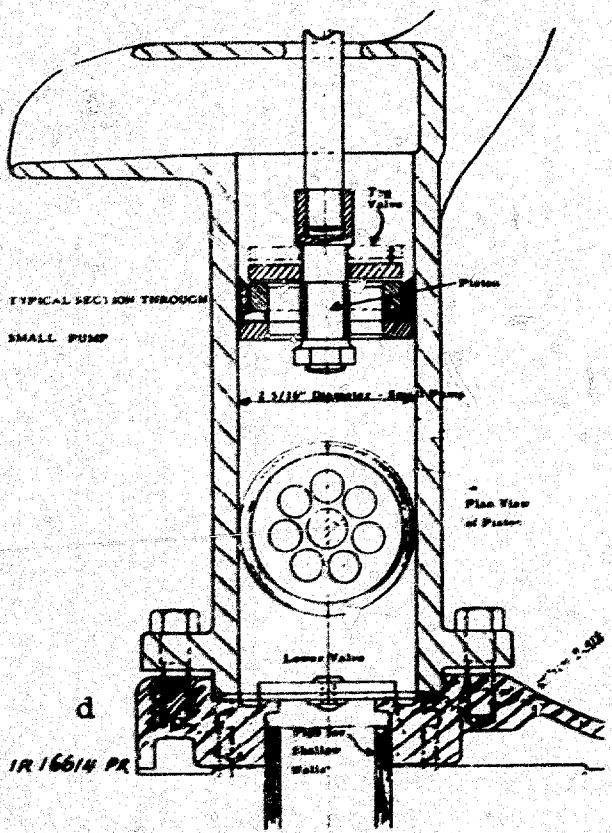

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Fig. 2 TYPICAL CAST IRON ARTICLES PRODUCED IN A SMALL FOUNDRY