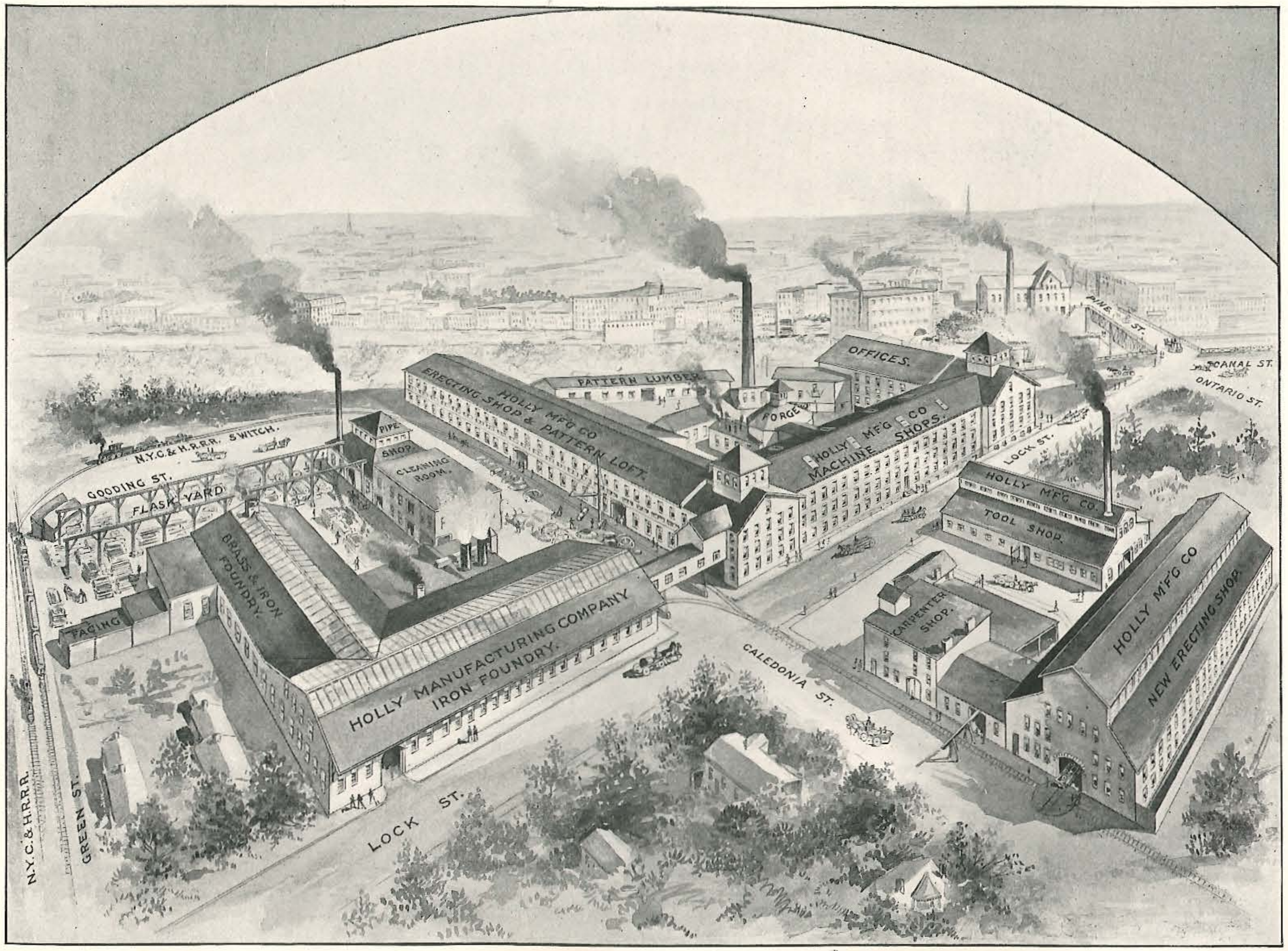
THE HOLLY MANUFACTURING COMPANY'S

1895

HIGH DUTY PUMPING ENGINES

1895

LOCKPORT, N.Y.


HOLLY MFG CO
ERECTING SHOP & PATTERN LOFT.
PATTERN LUMBER
OFFICES.
FORGE
HOLLY MFG CO
MACHINE SHOPS.
PINE ST.
CANAL ST.
ONTARIO ST.
LOCK ST.
HOLLY MFG CO.
TOOL SHOP.
HOLLY MFG CO
NEW ERECTING SHOP.
CARPENTER SHOP.
CALEDONIA ST.
HOLLY MANUFACTURING COMPANY
IRON FOUNDRY.
BRASS & IRON FOUNDRY.
PIPE SHOP
CLEANING ROOM.
N.Y.C.& H.R.R.R. SWITCH.
GOODING ST.
FLASK YARD
FACING
LOCK ST.
GREEN ST.
N.Y.C.& H.R.R.R.

· 1895. ·

ILLUSTRATED AND DESCRIPTIVE CATALOGUE

OF

The Holly Manufacturing Company's High Duty Pumping Engines

Horizontal and Vertical,

Compound and Triple Expansion,

and Water Power Pumps.

Holly manufacturing co., Lockport, N.Y.

Principal Office and Manufacturing Plant,

Lockport, New York.

Branch Offices:

Chicago, New York City, Portland, Oregon.

A REASONABLE CLAIM.

The Holly Manufacturing Company is the only concern building machinery for water-works exclusively, and can with reason claim that it builds better pumping engines than manufacturers that do not make a specialty of machinery for water-works service.

THE MATTHEWS-NORTHRUP CO.
COMPLETE ART-PRINTING WORKS
BUFFALO N.Y.
15686

ILLUSTRATIONS.

PAGE

CONTENTS.

THE HOLLY MANUFACTURING COMPANY was incorporated in 1859, under the laws of the State of New York, with $20,000 capital, which has been increased from time to time to $1,000,000. During the entire period of its incorporation the Company has constantly manufactured pumps and pumping engines, and has been for many years the only established concern exclusively devoted to designing and constructing pumping machinery for water works.

In 1862 attention was drawn to the need of better protection of property against fire in Lockport, and in the following year The Holly Manufacturing Company constructed the first water-works plant — consisting of a rotary pump, a turbine water wheel, about one mile of water mains, and twelve fire hydrants — under what has since become known throughout the civilized world as the Holly System of Water Supply and Fire Protection for Cities and Villages, commonly called "Holly Water-Works."

This system is the invention of Birdsill Holly, whose purpose in planning the Lockport works was to provide fire protection without the use of portable engines. Success in that led to the combination of domestic supply with fire protection through the same system of pipes, by the addition of suitable pumping apparatus and regulators. The feasibility of the combined service was first demonstrated in the Auburn, New York, water-works in 1866, from which time the system has grown in popular favor until now it is in successful operation in over 470 cities and towns. For a full description of this system of water-works, send for a pamphlet entitled: "The Holly System of Water Supply and Fire Protection."

Experience enabled the inventor to make important improvements in the mechanism of the system, and to secure great economy and efficiency in the regular pumping service. The first of these improvements was a combination of six single-acting reciprocating pumps arranged to operate in regular succession, each pump having the lead of the next by one-sixth the length of the stroke, so as to give a continuous flow of water into the mains. The second important improvement was made in 1871–2, when the Holly Quadruplex Engine was brought out. This engine was especially adapted to both domestic and fire service, and superseded both the rotary and the reciprocating pumps. The third improvement was an addition to the Quadruplex engine of suitable apparatus for using steam on the compound principle, and was first applied at Rochester, N. Y., in 1874.

Following the Quadruplex engine, the Company brought out the Horizontal Compound Condensing Crank and Fly Wheel Pumping Engine designed and patented by the late Harvey F. Gaskill, for several years Engineer and Superintendent of the Company's works, and successor to Mr. Birdsill Holly. In designing this engine the inventor had in view the production of a pumping engine that would combine low first cost and high economy with the utmost simplicity of construction. How well he succeeded a perusal of the following pages will demonstrate.

The first Holly Pumping Engine of the Gaskill type was sold to the Village of Saratoga Springs, New York, in 1882, under condition that: "Said pumping engine shall have capacity "to deliver four million gallons of water in twenty-four hours, against eighty pounds domestic "pressure, at eighteen revolutions per minute, and shall run at thirty revolutions per minute "with safety to all its parts under a fire pressure of one hundred and forty pounds to the "square inch; and develop a duty equal to raising eighty million pounds of water one foot "high with one hundred pounds of best coal, and an average daily duty of sixty-five million "foot pounds with good merchantable anthracite coal reasonably free from dirt and slate."

The results of two trials made by three disinterested experts, were duties of 106,838,000 to 127,170,000 foot pounds for each 100 pounds of coal; and the daily records of the operating engineers show an average duty for six years of 105,910,739 foot pounds for each 100 pounds of coal consumed, without deductions for ashes, steam for heating or other purposes.

Since this first Horizontal Engine was designed, 181 have been sold, ranging in daily capacity from 1,000,000 to 20,000,000 gallons each, and aggregating in nominal capacity, 960,000,000 gallons daily, which largely exceeds, both in number and capacity, the high duty pumping engines erected by any other engineer or manufacturer.

Following the Horizontal Engine, the Company produced vertical pumping engines, of the compound condensing and of the triple expansion types, of the highest order of merit. These engines are also illustrated and described in the following pages.

The Company, besides increasing its capital to $1,000,000 as before stated, has recently enlarged and improved its manufacturing facilities by introducing full lines of the best modern machinery and tools; and not only maintains its unexcelled reputation for the finest workmanship, but is prepared to promptly meet all demands for High Duty Pumping Engines of any capacity.

Correspondence is solicited with engineers and officials desiring to improve or increase the pumping facilities of their water-works plants.

TO CORRESPONDENTS.

Prices for pumping engines for water-works can not be satisfactorily listed, because the physical conditions and peculiarities of service in different localities are so various that an estimate of cost for one place would not answer for another place. Correspondents desiring to know the price of a pumping engine should, therefore, when making inquiries give replies to the questions on the following page. If a preliminary estimate only is desired, the replies may be approximate; but if a careful estimate is wanted, the replies should be full and exact.

QUESTIONS.

What is:—

1. The name and population of the town or city for which the engine is wanted?

2. The present consumption of water? Give the minimum and maximum quantities in gallons per 24 hours.

3. The maximum capacity, in gallons per 24 hours, of the proposed new pumping engine?

4. The required water pressure, in pounds or feet, upon the pumps for the regular daily service?

5. The required extra water pressure, if any, for fire hydrant service?

6. The height of suction lift, measuring from extreme low to extreme high water marks in the source of supply?

7. The length and diameter of the suction pipe?

8. The length and diameter of the force main?

9. The available steam pressure in pounds at the engine?

10. The source of water supply: from a river, a lake, or a pond; an open well, artesian wells, or driven wells?

11. The character of the water to be pumped?

12. The kind, and cost at the pumping station, of fuel?

13. The approximate distance of the pumping station from the center of population?

14. The approximate distance of the pumping station from the nearest railway station, and name of the railway?

15. The system of water-works; reservoir, standpipe, or direct pumping?

16. The kind of formation upon which the engine foundations will rest?

17. The available floor space in the engine room? If convenient send a plan of the pumping station.

18. Give a written description, and if practicable a sketch, of the locality where the pumping station and source of supply are situated.

If water power will be used to operate the pumps, give answers to the following questions, omitting 9 and 12 in the foregoing list.

19. The number of available horse powers; minimum and maximum.

20. The total head and fall of water on the water wheels, in feet.

Answers to these questions will enable the Company to determine the best type of pumping engine, vertical or horizontal; the power and strength of the engine; the capacity of the pumps; the kind of pump plungers and the manner in which they should be packed; and other details affecting the cost of construction of the engine and the service to be rendered.

DUTY AND EFFICIENCY OF THE HOLLY MANUFACTURING COMPANY'S PUMPING ENGINES.

The word "duty" is used in engineering to express the efficiency of a steam pumping engine as measured by the work done by a certain quantity of fuel; usually the number of pounds of water lifted one foot by one hundred pounds of coal. For example: a pumping engine doing a duty of 100,000,000 foot pounds per 100 pounds of coal, requires the consumption of 8,340 pounds of coal under the steam boilers to raise 10,000,000 gallons of water to the height of 100 feet. The elements entering into the calculation are: weight of water; height of the lift or head of water; and the weight of fuel. Time is not considered as an element: the 10,000,000 gallons of water may have been pumped in one day or two days, more or less.

A gallon of water weighs approximately 8.34 pounds; hence, $\overset{\text{Gallons.}}{10{,}000{,}000} \times \overset{\text{Weight.}}{8.34} \times \overset{\text{Head.}}{100} =$ 8,340,000,000, divided by 8,340 pounds of coal = 1,000,000 foot pounds duty for each pound of coal, or 100,000,000 foot pounds duty for each 100 pounds of coal.

If the duty should be 120,000,000 under the same conditions as to weight of water and head, the quantity of coal used would be 6,950 pounds as shown by the following formula:

$$\frac{10{,}000{,}000 \times 8.34 \times 100}{6{,}950} \times 100 = 120{,}000{,}000 \text{ duty for each 100 pounds of coal.}$$

If the duty should be only 50,000,000 under the same conditions as to weight of water and head, the quantity of coal used would be 16,680 pounds, as shown by the same formula:

$$\frac{10{,}000{,}000 \times 8.34 \times 100}{16{,}680} \times 100 = 50{,}000{,}000.$$

The table or "Duty Diagram" printed on page 76 will be found helpful in making calculations of duty.

From the foregoing comparisons it will be readily understood why a pumping engine that shows low fuel consumption or great economy in the use of steam, is called a high duty pumping engine; and why a pumping engine that shows high fuel consumption or small economy in the use of steam, is called a low duty pumping engine. Pumping engines that show 100,000,000 and more duty are classified as "High Duty Pumping Engines"; and pumping engines that show from 50,000,000 to 70,000,000 duty are classified as "Low Duty Pumping Engines."

Prior to the year 1882, a few pumping engines had been made that gave over 100,000,000 duty; but they were so cumbersome, complicated and expensive that the saving in fuel did not compensate for the high cost of maintenance, repairs, interest and labor. In that year—1882—the first Holly Pumping Engine of the Gaskill design was erected at Saratoga Springs, New York, and developed the extraordinary duties of 106,838,000 to 127,170,000 foot pounds under various conditions, as stated on pages 7 and 8. At that time the most highly favored pumping engines rarely developed a duty of more than 65,000,000 foot pounds, and the remarkable economic work of the Holly-Gaskill Engine at Saratoga Springs, coupled with its simplicity of design, its excellent construction, and its moderate price, immediately made it popular. It fully met a long existing demand for a simple, reliable, and economical pumping engine for water-works service, and soon became the standard of duty and price. There is now no demand for engines of a middle class, for the reason that the cost of a pumping engine that would give 80,000,000 to 90,000,000 duty would be nearly as great as is the cost of the Holly High Duty Pumping Engine.

The money value of the fuel saved by the use of The Holly Manufacturing Company's high duty pumping engines is shown by the following comparison :

Considering that high duty pumping engines as a class show 100,000,000 minimum duty, and that low duty pumping engines as a class show 50,000,000 minimum duty, the difference in duty between the two classes represents a saving in coal of one-half in favor of the high duty pumping engines, other conditions in both cases being alike.

Take the example already cited of a high duty engine pumping 10,000,000 gallons of water 100 feet high, doing 100,000,000 duty, using 8,340 pounds of coal, and assume that the time taken to pump the water is one day. Compare this with a low duty engine of the same capacity, under the same head, doing 50,000,000 duty, and the quantity of coal required is just double, or 16,680 pounds a day. The saving in favor of the high duty engine is, therefore, 8,340 pounds per day. With coal at an average price of $3.00 per ton of 2,000 pounds delivered under the boilers, the result is a saving in money of $4,503 per year of 360 days, to which should be added the saving in boiler capacity, repairs and labor.

The result is the same with a high duty pumping engine of 5,000,000 gallons capacity under 200 feet, instead of 100 feet, head ; and in equal ratio for other quantities of water under different heads.

Estimating the average price of a 5,000,000 gallon high duty pumping engine under 200 feet head at $28,000, the value of the fuel saved equals 16 per cent. per annum on the cost of the high duty pumping engine, and in some cases the rate runs as high as 20 and 25 per cent. per annum.

HOW HIGH DUTY IS OBTAINED.

All steam pumping engines built by The Holly Manufacturing Company are of the rotative or crank and fly wheel type, with automatic steam cut-offs. The superiority of this type over the nonrotative type is generally admitted by steam users, engineers, and experts. Its principal advantages are positive action of steam valves and cut-offs, and absolutely full stroke of steam pistons and pump plungers under varying pressures of steam and water. In these engines, therefore, there can be no increase in the clearance spaces between the steam pistons and cylinder heads causing waste of steam, nor loss of capacity by deficient plunger displacement ; such as occur in nonrotative pumping engines whenever the steam pistons and pump plungers fall short of the full stroke, which they do as often as the steam pressure falls below, or the water pressure rises above, the normal pressures.

The automatic steam cut-offs on the Holly Horizontal High Duty Compound Pumping Engine, are applied to the high-pressure cylinders only. The cut-offs can be adjusted either manually or automatically to close at any point of the stroke of the steam pistons; but as the exact points of cut-off vary as the speed of the engine varies, the adjustment of the cut-off valves of the horizontal engines is effected by an automatic governor, and only sufficient steam is admitted to the cylinders at each stroke of the steam pistons to carry the pumping engine through one revolution. This automatic action of the cut-offs on the high-pressure steam cylinders is repeated for every stroke, and the rate of speed at which the engine must run to do the required pumping is steadily and economically maintained.

The automatic cut-offs on the Holly Triple Expansion Pumping Engine are applied to all of the steam cylinders; and the cut-offs of each cylinder can be adjusted, independently of those of any other cylinder, to close at any point of the stroke of the steam pistons. The action of the cut-offs on the high-pressure steam cylinder of this engine is the same as the action of the cut-offs on the high-pressure steam cylinders of the horizontal compound engine; but the points of cut-off on the intermediate and low-pressure steam cylinders are adjusted by hand, and remain constant while the engine is working under normal conditions.

The application and operation of the automatic steam cut-offs on the Holly Vertical Compound Pumping Engines are the same as they are on the Triple Expansion Pumping Engine.

By cutting off steam automatically, the duty of the pumping engines is greatly increased.

The sides and heads of the steam cylinders of all of the pumping engines made by The Holly Manufacturing Company are thoroughly steam jacketed. The form and position of the steam valves and the size and length of the steam ports and passages, are such that the steam clearance spaces are reduced to the smallest ratios. The condensed steam or water from the jackets, reheaters, and steam traps, is not allowed to waste but is returned to the boilers. The water ways and valve areas of the pumps are ample, and the friction of the water in passing through the pumps is reduced to the lowest degree. Careful attention is given to every detail of design and construction of each pumping engine, with a view to preventing loss of power by friction of the moving parts. These details, added to the more important features before mentioned, contribute to the high duty and remarkable efficiency of the pumping engines manufactured by this Company. While careful attention is given to every detail tending to produce high economy in the use of steam, the strength and durability of the pumping engines are not overlooked.

For further information on these important subjects see pages 30, 31 and 32.

PISTON SPEED OF PUMPING ENGINES.

The speed of the piston of an engine is expressed in feet per minute. In double-acting engines both the forward and backward strokes are taken into account. For example: a double-acting engine having a stroke of three feet and running at the rate of twenty-five revolutions per minute, has a piston speed of (3 x 2 x 25) one hundred and fifty feet per minute.

Stationary steam engines for driving machinery having a rotary motion, locomotive engines, and marine screw engines, are run at piston speeds ranging from 800 to 1,200 feet per minute; but pumping engines for water-works service — in which the speeds of both steam pistons and pump pistons are equal — are run within a much lower range, 120 to 200 feet per minute being the rates of piston speed recommended by engineers and builders that have had the longest and widest experience with this particular class of steam engines.

This great difference between the speeds of steam engines used for pumping water and the speeds of steam engines used for other purposes, is accounted for by the fact that water, because of its incompressibility and specific gravity, cannot be safely moved at high velocities; while steam, because of its great elasticity and rarity, can be safely utilized at very high velocities.

Experimental pumping engines having low speed of pump pistons and high speed of steam pistons have been made from time to time in past years, with a view to obtaining higher duty by increasing the velocity of the steam without increasing the velocity of the water. In all such pumping engines the power of the steam cylinders is transmitted to the pumps through either intermediate revolving gears of different diameters, or through levers or bell cranks having arms of different lengths. Because of increased friction, more complicated mechanism, and greater cost, none of these pumping engines have thus far produced the desired result, and none have been duplicated.

Piston speeds as high as 300 feet per minute have been successfully attained in pumping engines of 10 to 15 feet stroke; but such pumping engines were so expensive, so liable to serious and costly break-downs, so bulky, and so difficult to manipulate, that they were long ago supplanted by the simpler and shorter stroke pumping engines of the present day.

Some of the objections to high speed in modern pumping engines for water-works are that it:—

1. Increases the number of strokes, or revolutions;

2. Causes more frequent reversals of the water current;

3. Makes more friction in the moving mechanism, and more friction in the pumps by the swifter flow of water through the valves, water ways and pipes. It should be remembered that friction increases as the square — 4 to 1 — of the velocity;

4. Augments the danger of breakage;

5. Enhances the risk of damage to the machinery by impact;

6. Necessitates closer attention, when running, of the engineer; more frequent examination and repairs; and

7. Shortens the life, or term of effective service, of the pumping engine.

The only advantages that can be fairly claimed for high speed pumping engines over moderate speed pumping engines are, that because of their smaller dimensions and weight they cost less to build, and can, therefore, be sold at lower prices; and that high piston speed gives higher duty.

A good buyer, observing the rule that: "The best is the cheapest," will not be governed solely by the price of an article intended for substantial service. This rule should apply with greater force to the selection of a pumping engine than to any other thing pertaining to a substantial water-works. The pumping engine is the heart of the system. If it fails, the system fails; and a cheap pumping engine should be looked upon with suspicion by the water-works manager whose duty it is to provide an uninterrupted supply of water to the public.

The claim that high speed materially increases the duty of pumping engines, has not been authenticated by exhaustive experiments; is not proven by actual service; and is not generally supported by practical engineers.

Whatever modicum of success may have attended the use of high piston speeds in stationary steam engines for general purposes, it is a fact worthy of special notice that none of the more experienced and successful builders and users of pumping engines, advocate high speed of pistons for pumping water; for the reasons already stated, which, summarized, amount to this: it is unnecessary; unsafe; dangerous: and further, because high speed is incompatible with the chief qualities that a pumping engine, more than other kinds of engines, should possess in the highest degree: capability for effective service; stability for continuous service; durability for permanent service.

THE HORIZONTAL TYPE OF PUMPING ENGINE.

The horizontal position (in line with the horizon) is the position of rest and repose — the natural position. Nothing is found in a vertical position that is not maintained in that position by force, or that is not supported by some horizontal projection; as roots for a tree, braces for a post, ties for a frame: the vertical position is, therefore, an unnatural position.

It is almost universally the practice of skillful engineers and designers of machinery to lay their plans on horizontal lines, and a departure from this practice is rarely made except under conditions that render such a course necessary. These conditions are usually: limited horizontal space, as in steam ships; and pumping water from deep mines and pits.

Horizontal pumping engines were first introduced for water-works service about thirty-five years ago. Prior to that time only vertical engines and pumps, and horizontal engines with vertical pumps, had been applied to that service. Horizontal pumping engines rapidly superseded those of the vertical type, and more than 90 per cent. of all the pumping water-works in the United States now use horizontal pumping engines. Notwithstanding these facts, which tend to prove that the horizontal type of pumping engine is superior to the vertical type of pumping engine, attempts have been made in recent years to popularize vertical pumping engines for water-works without due regard to the conditions under which they must serve; but these attempts have failed, or to say the least they have not been successful. Attempts to popularize vertical steam engines, in preference to horizontal steam engines, for service in mills, factories, power houses, etc., have also been unsuccessful.

Horizontal pumping engines are preferred to vertical pumping engines for the following reasons:

1. The horizontal position is the natural position in which a pumping engine should be placed for permanent service.

2. A horizontal pumping engine of any given capacity may be of less weight, and requires less expensive foundations, than a vertical pumping engine of the same capacity.

3. A horizontal pumping engine costs less to build, transport, and erect, than a vertical pumping engine.

4. A horizontal pumping engine can be more easily operated than a vertical pumping engine, because its valves, gates, slides, bearings, oil cups, etc., are all manipulated from the main floor of the engine room.

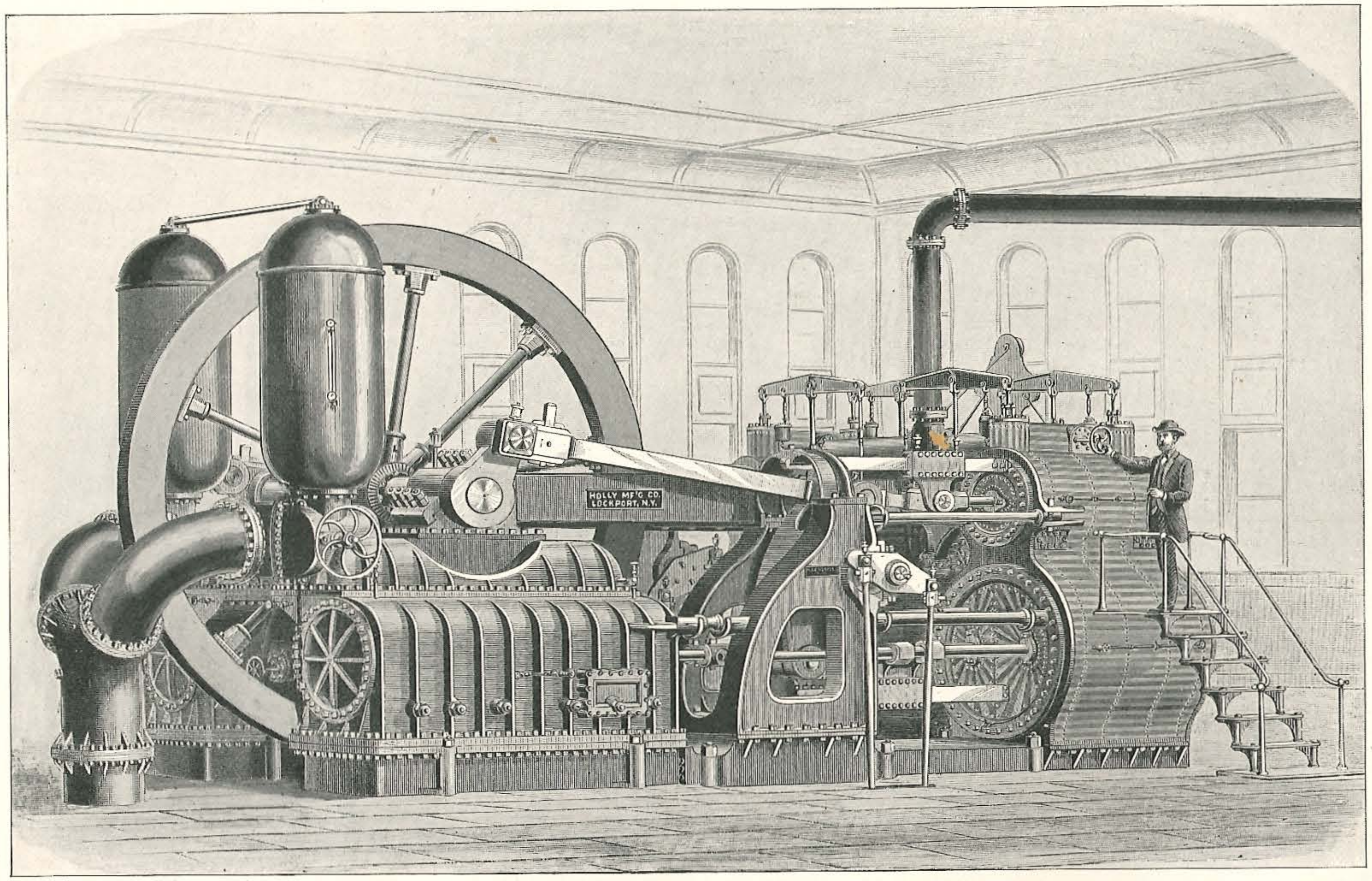
5. A horizontal pumping engine can be more expeditiously and cheaply adjusted and repaired; because all of its parts are wholly accessible from the same floor, and there is no swinging of heavy pieces over head, nor any need of temporary frame work, platforms, or blocking, when parts of the engine or pumps are removed for inspection or repairs.

6. A decided advantage of the horizontal pumping engine is, that its pumps being above the engine room floor, in a light and dry place, can be more closely watched, more easily opened, and more readily repacked, than the pumps of a vertical pumping engine, which are below the floor in the dark, and usually in a wet or damp place.

The only objection worthy of notice that is urged against horizontal pumping engines by the few advocates of vertical pumping engines is, that the friction and wear of the horizontal steam pistons and pump plungers all come on the bottom of the cylinders: but this is not by any means a serious matter. It is well known that water is a good lubricant; that instances are numerous of horizontal pumping engines running for many years without wearing away the tool marks in the cylinders; and that instances are rare of horizontal steam cylinders having to be re-bored. For pumping gritty water this objection is sometimes specially urged against horizontal pumps; but the facility with which the horizontal plungers can be packed is an advantage that far outweighs the objection, and justifies the claim that for pumping gritty water the horizontal plungers, when properly packed, are the best.

For the reasons given, the horizontal type of pumping engine is recommended in preference to the vertical type of pumping engine for every service where a deep pump well or pit is not necessary, or where the floor space is not restricted.

PLATE I.



THE HOLLY HIGH DUTY HORIZONTAL COMPOUND PUMPING ENGINE — Original Gaskill Design.

THE HOLLY HIGH DUTY HORIZONTAL COMPOUND PUMPING ENGINE.

PLATE I.

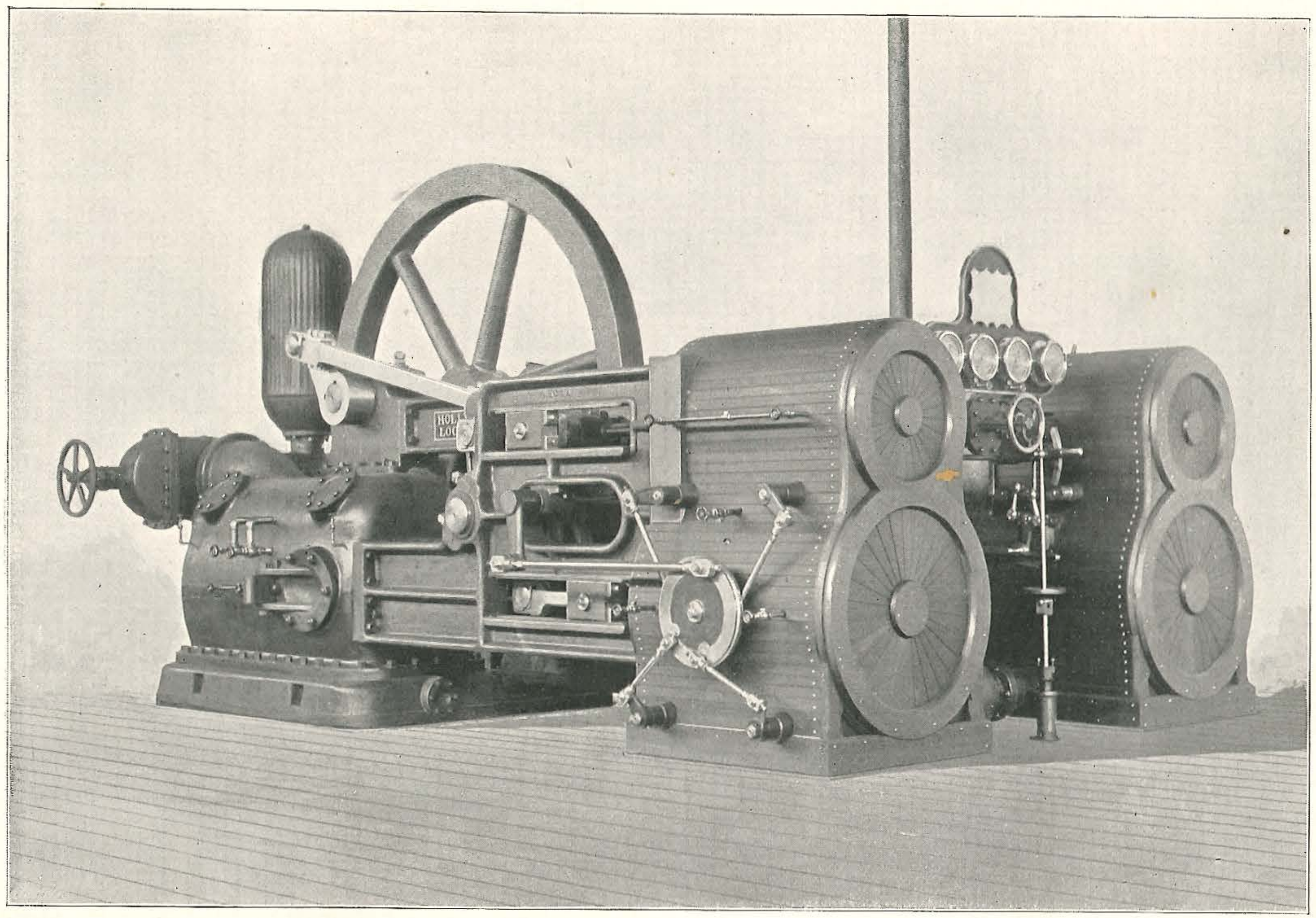
The engraving on the opposite page represents the Horizontal Pumping Engine as originally designed by Mr. Gaskill. A constant study of the engine under the varied conditions of service to which a large number of them have been subjected during the past eleven years, recently led the Company to adopt certain modifications in the form and details of the engine, and to simplify its construction, without, however, abandoning the first principles or eliminating the more valuable features of the original design. For convenient reference and identification, horizontal engines hereafter constructed in this form will be designated by adding the words "Improved Pattern" to the name. The five following engravings represent this Improved Pattern.

The more valuable features of the Gaskill type of pumping engine may be briefly stated as follows:

High Fuel Economy at moderate piston speed and low steam pressure;
Either half of the engine can be operated independently of the other half;
Moderate First Cost;
Simplicity of Design;
Accessibility of Parts;
Equal Steam Distribution;
High Steam Expansion;
Easy Pump Action;
Uniform Length of Stroke; and
Thorough Steam Jacketing.

Repeated comparative tests of the Holly High Duty Pumping Engines with low duty compound pumping engines, have demonstrated that the Holly engines will save from fifty to seventy per cent. of steam in pumping a corresponding quantity of water under equal conditions of service. This saving represents an enormous decrease in cost of fuel and labor; in first cost and repairs of boilers; in floor space and storage capacity of buildings; and consequently increased net revenues and dividends to municipalities and corporations using the Holly Pumping Engines. There is probably not a city in the country consuming more than 1,000,000 gallons of water a day, that can afford to run a low duty pumping engine, unless it be situated where coal is of trifling value and economy in its use a matter of little or no consequence.

PLATE II.



THE HOLLY HIGH DUTY HORIZONTAL COMPOUND PUMPING ENGINE.—Improved Pattern, Gaskill Type.
For Capacities from 2,000,000 to 5,000,000 Gallons per 24 Hours.

DESCRIPTION OF THE HOLLY HIGH DUTY HORIZONTAL PUMPING ENGINE, IMPROVED PATTERN.

PLATES II, III, IV, V, VI.

The engine is of the beam rotative or crank and fly wheel compound condensing type. It has two sets of steam cylinders and pumps connected to one main shaft, with two cranks at quarters, and one fly wheel common to both.

Each engine has two high-pressure steam cylinders, two low-pressure steam cylinders, and two double-acting plunger pumps. The high-pressure steam cylinders are mounted upon and parallel with the low-pressure cylinders. The areas of the latter are usually about four times the areas of the former. The steam pistons move in opposite directions, and are maintained in their proper relative positions by connection with opposite ends of two vertical oscillating beams.

The two pumps are placed parallel to each other, and axially in line with the low-pressure steam cylinders, with which they are directly connected by crossheads hereinafter mentioned. The pump plungers are arranged to work through glands in the center of the pumps, and are, as are also the pump valves, easily accessible through manholes in the pump chambers.

On top of the pumps and in line with the high-pressure steam cylinders, are two pillow blocks that support the main shaft, fly wheel and cranks. The cranks are connected to the oscillating beams by long connecting rods.

There are four heavy cast-iron frames firmly bolted between the inboard ends of the pumps and the steam cylinders so as to hold them rigidly in place, and this combination is further strengthened by heavy cast-iron girders extending from two of the frames to the main pillow blocks. These frames contain bearings for the oscillating beam shafts and guides for the crossheads.

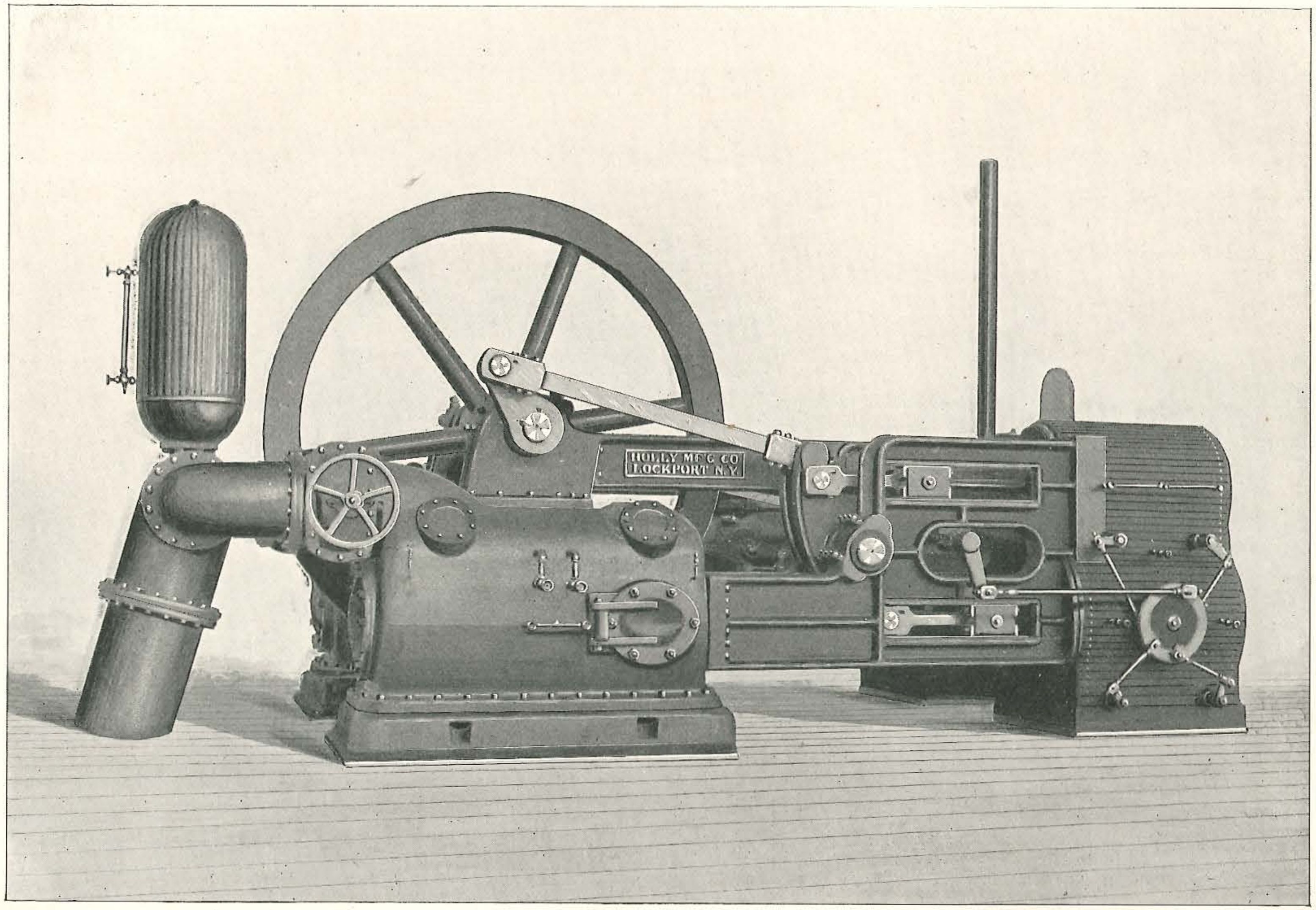
The power of the high-pressure steam cylinders is transmitted to the pumps indirectly through the oscillating beams; and the power of the low-pressure steam cylinders is transmitted to the pumps directly through the crossheads that connect their piston rods with the rods of the pump plungers.

The air pumps are driven from two arms that are keyed on the inner ends of the two oscillating beam shafts.

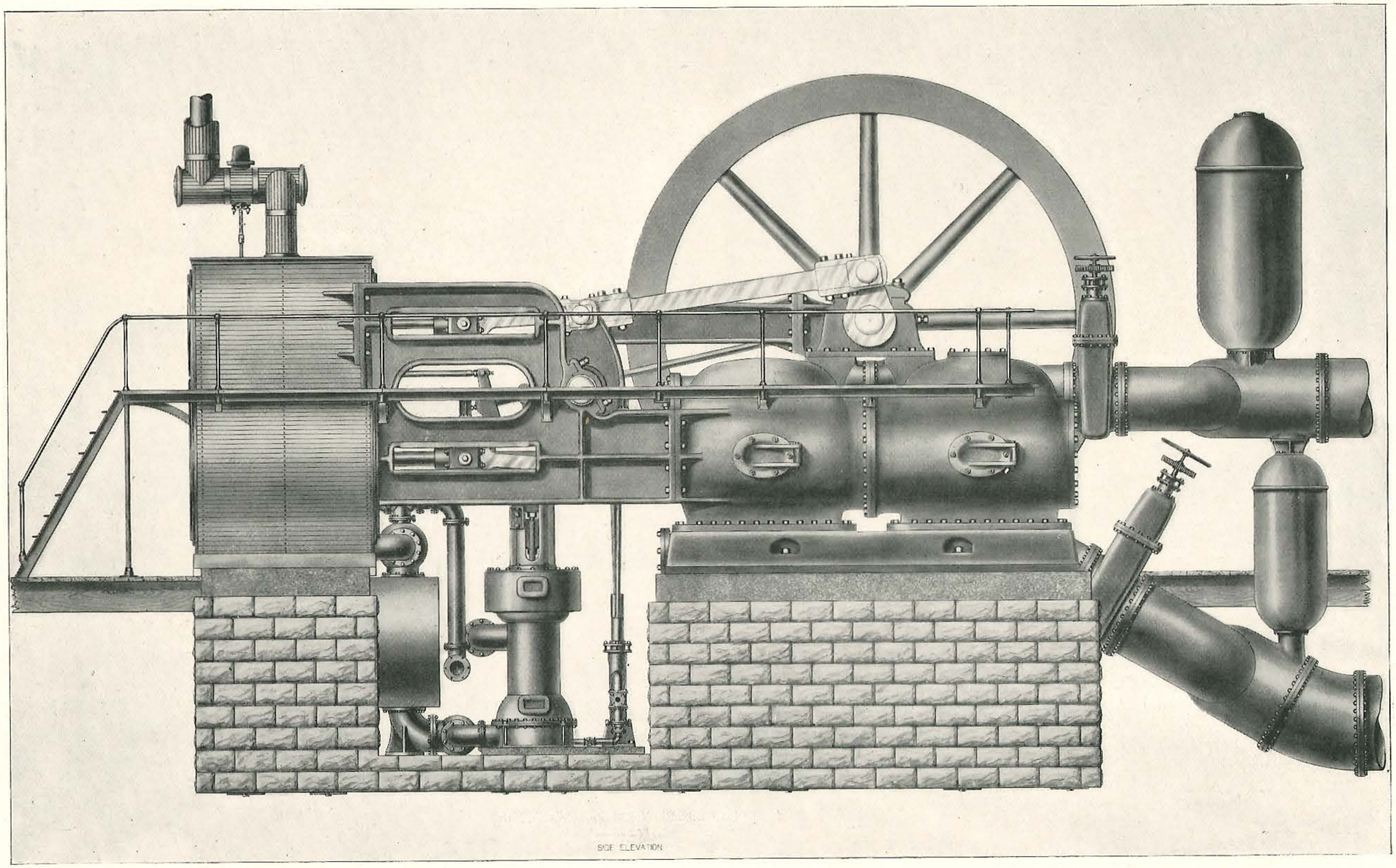
The steam valves are of the Corliss pattern, and are operated from the main shaft by eccentrics connected to wrist plates on the steam cylinders.

The admission valves to the high-pressure steam cylinders open positively at the beginning of every stroke, but in closing they act automatically so as to cut off the steam at any desired point of the stroke.

PLATE III.

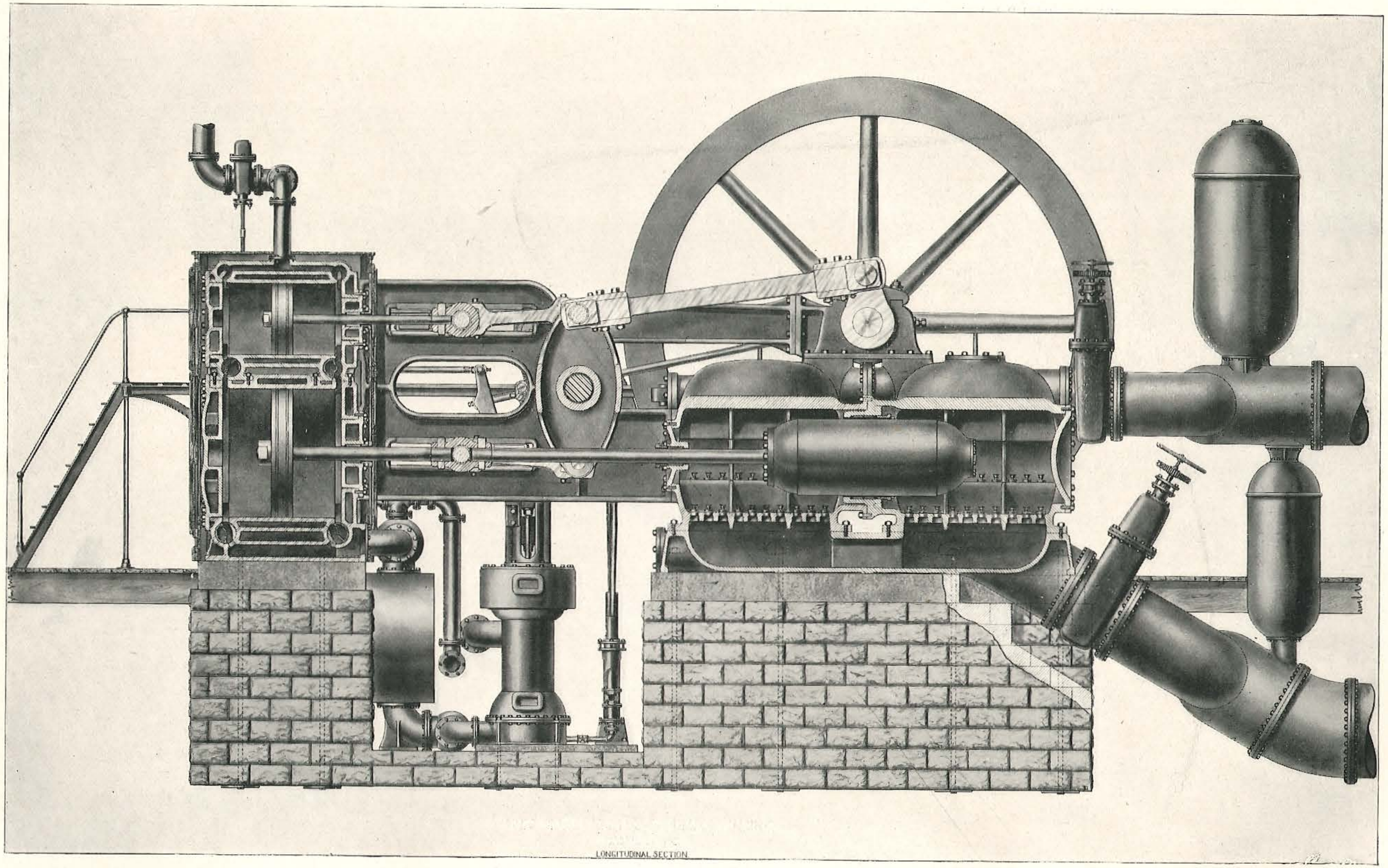


THE HOLLY HIGH DUTY HORIZONTAL COMPOUND PUMPING ENGINE.— Improved Pattern, Gaskill Type.
For Capacities from 2,000,000 to 5,000,000 Gallons per 24 Hours.

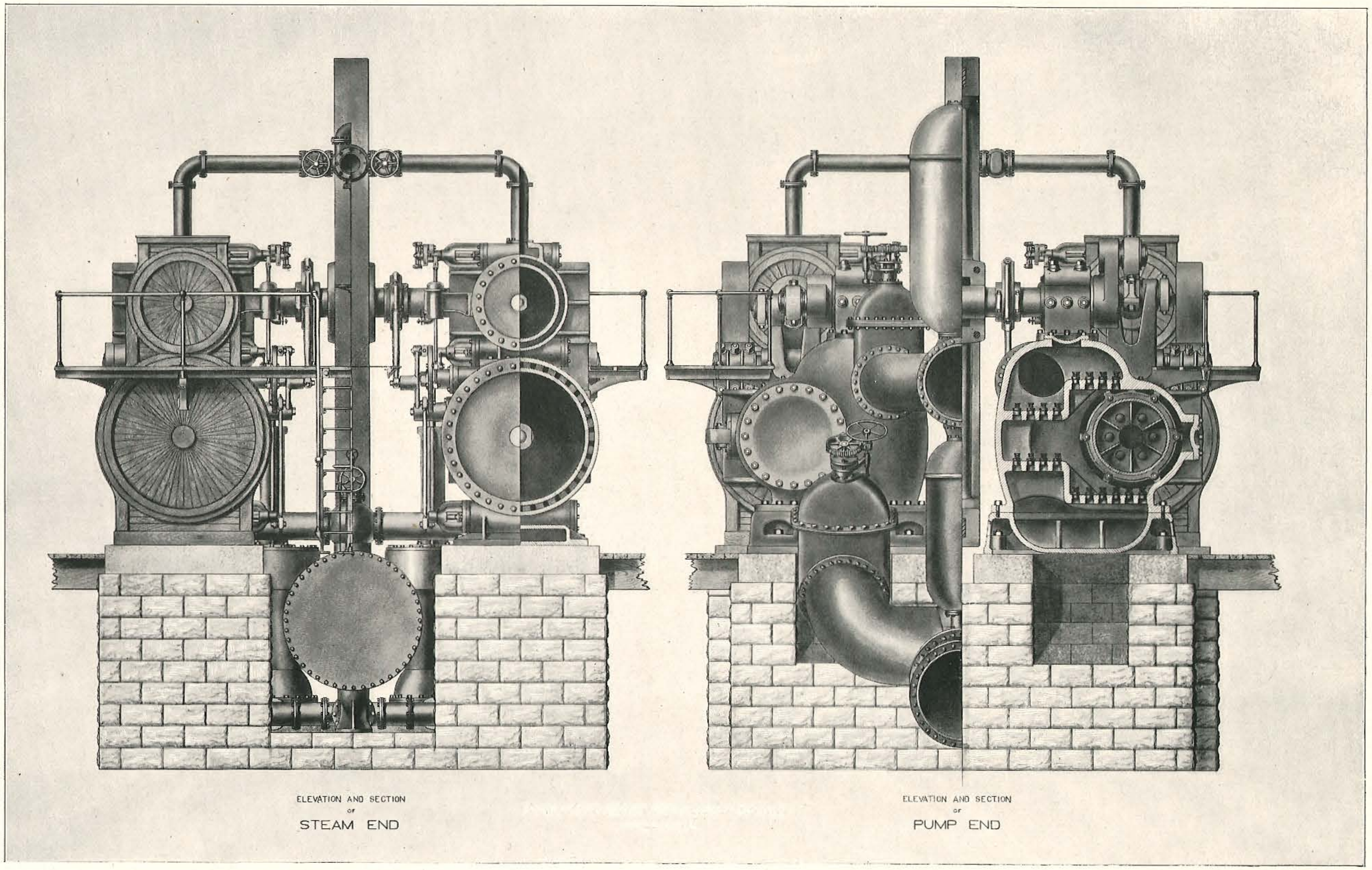


THE HOLLY HIGH DUTY HORIZONTAL COMPOUND PUMPING ENGINE.—Improved Pattern, Gaskill Type.
For Capacities from 5,000,000 to 20,000,000 Gallons per 24 Hours.

PLATE V.



THE HOLLY HIGH DUTY HORIZONTAL COMPOUND PUMPING ENGINE.—Improved Pattern, Gaskill Type.
For Capacities from 5,000,000 to 20,000,000 Gallons per 24 Hours.



THE HOLLY HIGH DUTY HORIZONTAL COMPOUND PUMPING ENGINE—Improved Pattern, Gaskill Type.
For Capacities from 5,000,000 to 20,000,000 Gallons per 24 Hours.

There are intermediate valves between the high and low-pressure steam cylinders that serve as exhaust valves to the former and as admission valves to the latter. These valves remain open a somewhat shorter period of time than is required for a complete stroke.

The exhaust valves of the low-pressure steam cylinders operate in the same manner as the intermediate valves.

Suction and discharge pipes lead to and from the outboard end of each pump chamber, and are respectively connected together by easy bends into one common suction pipe and one common discharge pipe.

Engines of the larger sizes are provided with stairs, galleries, and platforms, for convenient access to such of the working parts as are above, but not accessible from, the engine room floor. See Plates IV, V, VI.

The Operation of the Holly High Duty Horizontal Engine is as follows:

At the beginning of each stroke, steam is admitted to the high-pressure cylinders under full boiler pressure until the point of cut-off is reached, when the admission valves close instantly, and the expansive force of the steam, with the inertia of the fly wheel, carries the pistons on to the end of the stroke. Just before the stroke is completed, however, the intermediate valves open, and the steam not yet fully expanded passes directly into the low-pressure cylinders, is there again used expansively on the return stroke, and is then exhausted into the condenser. This operation is repeated at every stroke by each high and low-pressure steam cylinder alternately.

The passageways between the high and low-pressure steam cylinders are very short, and the clearance spaces are reduced to minimum; which with high steam expansion and thorough jacketing of cylinders insures the most economical use of steam.

Horizontal High Duty Pumping Engines of the Improved Pattern are already in use, and under contract, by the following cities:

Dayton, Ohio, ...	1	Engine,	15,000,000	gallons	daily	capacity.
Columbus, Ohio, ...	1	"	12,000,000	"	"	"
Columbus, Ohio, ...	1	"	12,000,000	"	"	"
Cumberland, Maryland, ...	1	"	4,000 000	"	"	"
Lansing, Michigan, ...	1	"	5,000,000	"	"	"

THE HOLLY HORIZONTAL CROSS COMPOUND PUMPING ENGINE, IMPROVED PATTERN.

PLATES VII, VIII.

The Holly Horizontal Cross Compound Pumping Engine, as illustrated on the two following pages, is a modification of the Holly High Duty Horizontal Pumping Engine. The difference between the two engines is in the steam ends: the pump ends are alike. The Cross Compound Engine has two steam cylinders — one high-pressure and one low-pressure: the other Engine has four steam cylinders — two high-pressure and two low-pressure. The steam cylinders of the Cross Compound Engine are placed parallel to each other and in horizontal lines with the axes of the two pump cylinders. The piston rod of each steam cylinder is connected by a cross-head directly to the plunger rod of its corresponding pump, so that the power of the steam cylinders is transmitted directly to the pump plungers.

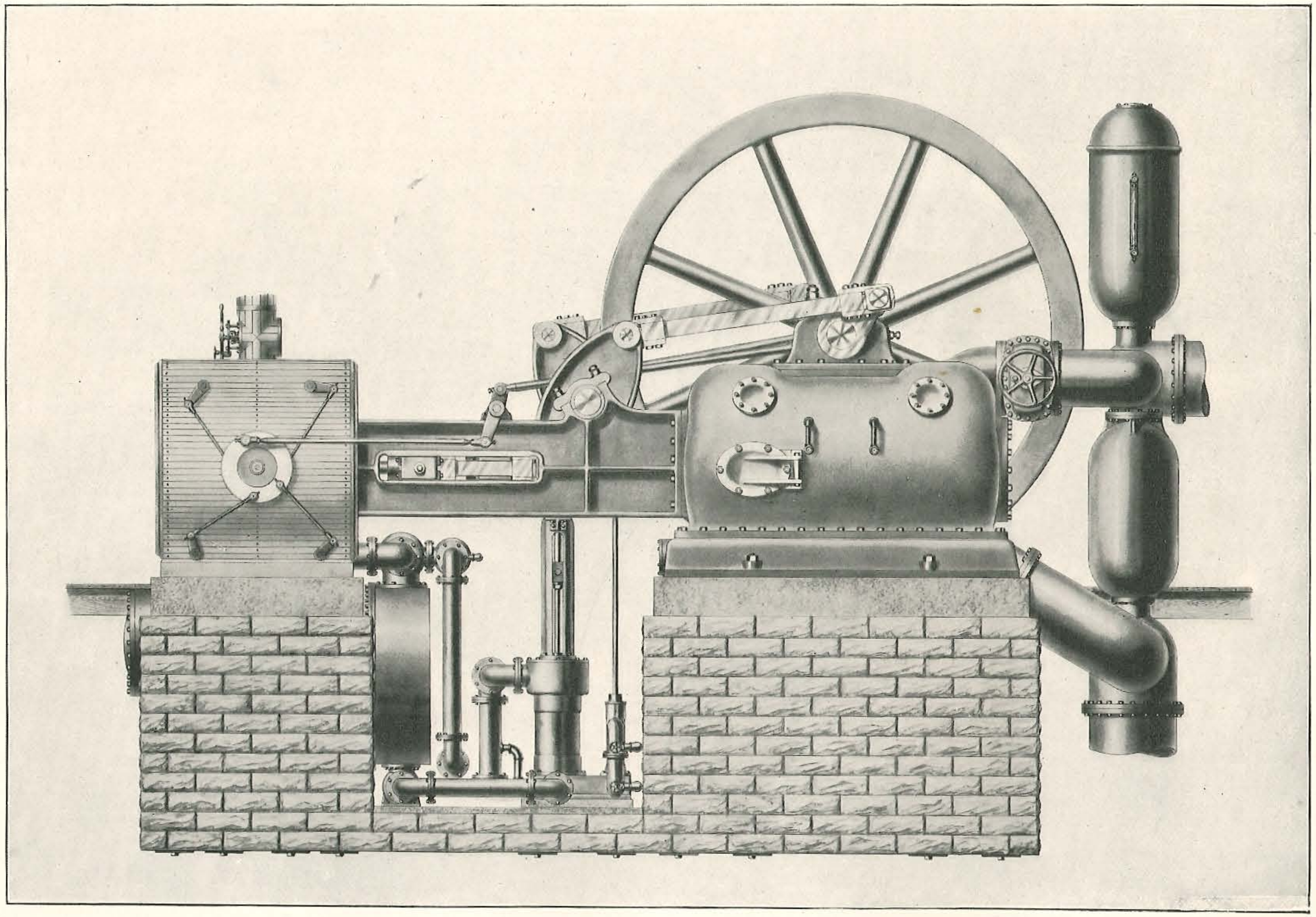
Between the steam cylinders there is a receiver into which steam from the high-pressure steam cylinder is exhausted, and from which steam for the low-pressure steam cylinder is taken. A copper coil that is heated by live steam from the boiler, is placed inside of the receiver, for the purpose of reheating the steam before it enters the low-pressure steam cylinder.

The steam valves are of the Corliss type, and can be controlled automatically in the manner described on pages 11 and 12.

The pumps of this Horizontal Cross Compound Pumping Engine are the same as the pumps of the High Duty Pumping Engine described on page 19.

This type of pumping engine is cheaper than the Holly High Duty Horizontal Compound Pumping Engine, and is recommended for places where the question of first cost is the paramount consideration.

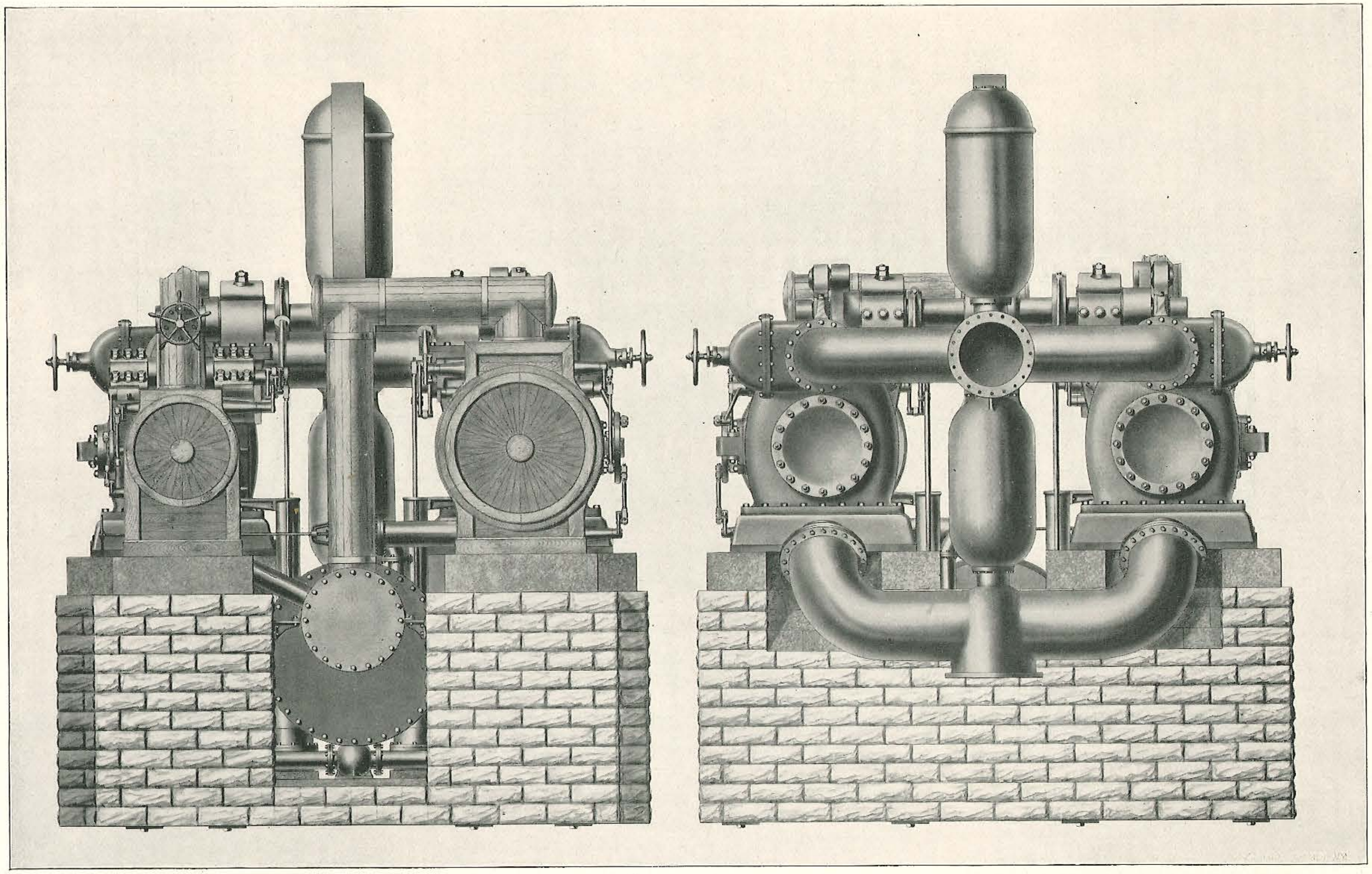
PLATE VII.



THE HOLLY HORIZONTAL CROSS COMPOUND PUMPING ENGINE.—Improved Pattern.

SIDE ELEVATION.

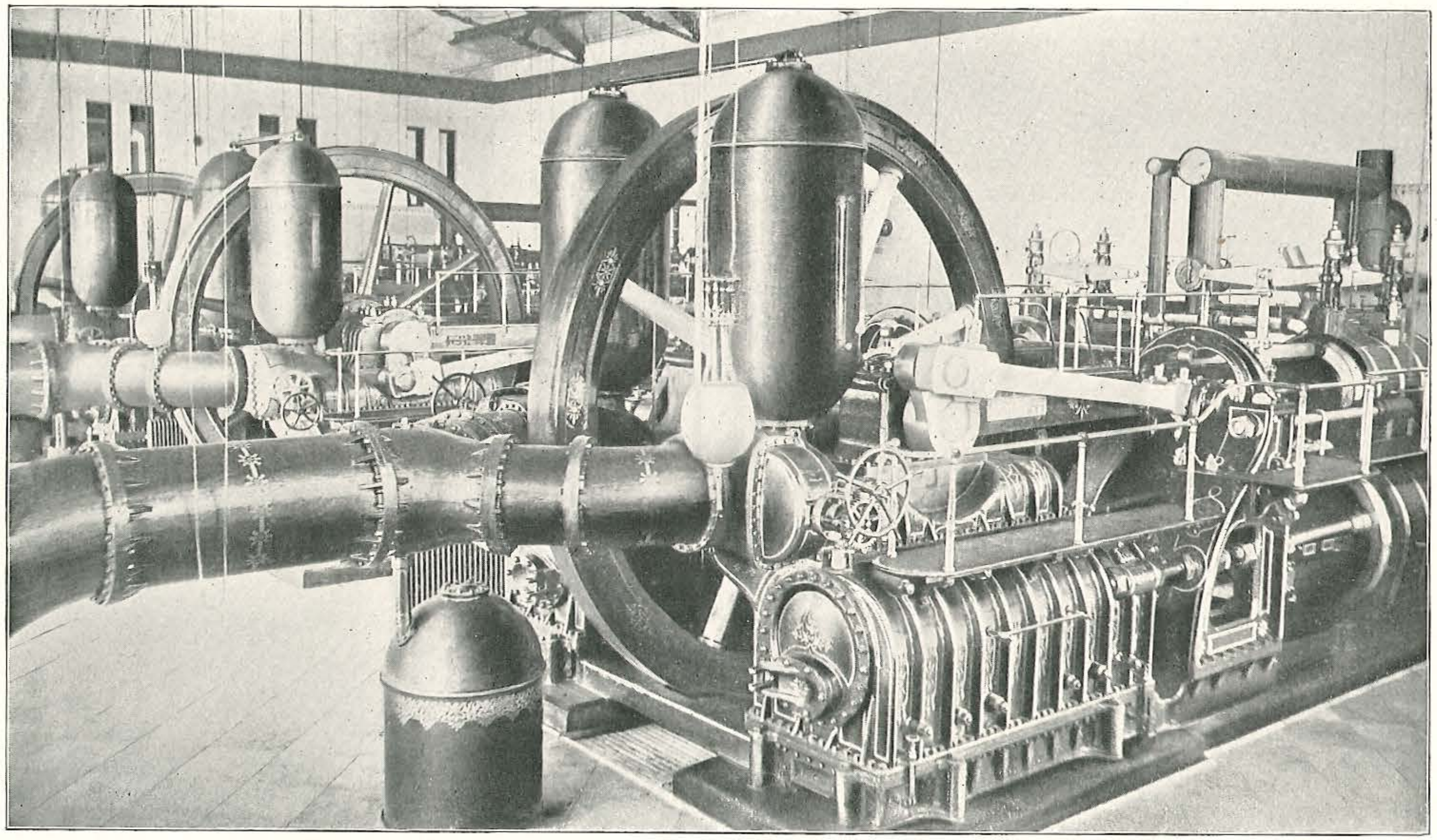
PLATE VIII.



THE HOLLY HORIZONTAL CROSS COMPOUND PUMPING ENGINE.—Improved Pattern.

ELEVATION OF STEAM END. ELEVATION OF PUMP END.

PLATE IX.



THE HOLLY HIGH DUTY PUMPING ENGINES, Gaskill Type,

At 68th Street Pumping Station, Chicago, that Supplied the World's Fair Grounds and Buildings with Water from Lake Michigan.

THE HOLLY HIGH DUTY HORIZONTAL PUMPING ENGINES SUPPLIED THE CHICAGO WORLD'S FAIR GROUNDS AND BUILDINGS WITH WATER FROM LAKE MICHIGAN.

PLATE IX.

When, in 1890, Chicago was selected as the place for holding the World's Columbian Exposition, it became necessary to extend and greatly enlarge its water-works system to provide an adequate supply of water for the enormous transient population that the city must entertain during the Exposition, as well as an abundant supply for the Exposition Grounds and Buildings.

For the latter purpose the Exposition Commissioners entered into an agreement with the City to install additional pumping machinery at the Sixty-Eighth Street Pumping Station, corner of Sixty-Eighth Street and Ogilby Avenue, one block south of the Exposition and near the shore of Lake Michigan. Under that agreement the Commissioners, acting through the City Officials, after careful examination of several competitive plans and proposals, purchased and paid full price for two Holly High Duty Horizontal Pumping Engines of the Gaskill type, each of 12,000,000 gallons daily capacity.

A new tunnel, 7,500 feet in length and six feet in diameter, was driven from a pit in the pumping station out into the Lake; and it was exclusively through this tunnel, these two Holly engines, and a separate system of pipes, that the Exposition was daily supplied with water, independently of the City supply, for all purposes except for the cascades and fountains, water for which was pumped by exhibition engines on the Grounds that took their supply from the lagoons.

The following quotation is from the Eighteenth Annual Report of the Department of Public Works, Chicago, 1893, page 80:

"The thirty-six inch World's Fair main was connected direct to the two new Gaskill engines, Nos. 3 and 4, 12,000,000 each, and after December 11th the World's Fair received its supply direct from these two engines, and at a pressure about twenty-seven pounds greater than the usual pressure in the city mains. The total amount supplied to the World's Columbian Exposition during the year was 2,143,931,616 gallons."

The engraving on the opposite page represents these two special engines after their installation at the Sixty-Eighth Street Pumping Station, where they are now — 1894 — in service on the regular city supply.

There are also at this station two other engines of the same type and size, purchased by the city in 1885 and 1887, making four Holly engines at the Sixty-Eighth Street Station, having a combined capacity of 48,000,000 gallons daily.

THE CITY OF CHICAGO has in operation at its North Side Pumping Station two of these engines, each of 12,000,000 gallons daily capacity, purchased in 1885; also two at the Lake View, or Sulzer Avenue Pumping Station, one of 12,000,000 gallons daily capacity purchased in 1887, and the other of 13,500,000 gallons daily capacity purchased in 1892; making in all eight Holly High Duty Horizontal Pumping Engines of the Gaskill type now in operation in and for the City of Chicago, having a combined capacity of 97,500,000 gallons daily against 125 feet to 207 feet head, the equivalent of about 150,000,000 gallons daily against 100 feet head.

HIGH DUTY RECORD OF THE HOLLY PUMPING ENGINE.

The high economy of the Holly Manufacturing Company's Pumping Engines has been conclusively demonstrated by several of the most eminent engineering experts in the United States, in various duty trials made under the most exacting conditions, the results of which are briefly summarized in the following table:

Place.	Year of Test.	Capacity of Engine Tested.	Duty.	Name of Expert.
Saratoga Springs, N. Y.	1882	5,000,000	112,899,983	Prof. D. M. Greene and Jno. W. Hill, M. E.
Saratoga Springs, N. Y.	1883	5,000,000	127,170,000 106,838,000	Prof. Charles T. Porter.
Columbus, Ohio, ...	1884	10,000,000	115,400,000	Prof. T. C. Mendenhall.
Buffalo, N. Y.	1885	15,000,000	125,907,297	Jno. W. Hill, M. E.
Jackson, Mich.	1886	4,000,000	111,781,072	Chas. Christopher, Ch. Eng.
Leavenworth, Kans.	1886	4,000,000	110,478,000	Thos. J. Whitman, C. E.
Kalamazoo, Mich.	1886	3,000,000	102,728,884	Jno. W. Hill, M. E.
Chicago, Hyde Park, ...	1886	12,000,000	110,632,166	Chas. Hermany, C. E.
Lima, Ohio, ...	1887	3,000,000	110,482,946	J. D. Cook, C. E.
Erie, Pa.	1887	5,000,000	122,309,829	Fred'k A. Scheffler, M. E.
Chicago, N. S. Station, ...	1887	12,000,000	102,583,585	Prof. Robt. H. Thurston. J. S. Coon, C. E. Jas. N. Warrington, C. E.
Philadelphia, Penn.	1888	20,000,000	125,022,730	Jno. E. Codman, C. E.
Washington, D. C. (East Engine) .	1888	2,500,000	101,772,977	G. W. Baird, Passed Ass't Eng. U. S. Navy.
Washington, D. C. (West Engine).	1888	2,500,000	101,183,587	
Boston, Mass.	1888	8,000,000	109,421,100	Wm. Jackson, City Eng.
Port Huron, Mich.	1888	5,000,000	102,638,623	Henry Burton, Asa R. Cole.
Chicago, Town of Lake, ...	1889	12,000,000	108,600,000	Benzette Williams, C. E.
Buffalo, N. Y.	1889	20,000,000	122,255,512	L. H. Knapp, Sup't and Eng.
Springfield, Ohio, ...	1889	5,000,000	113,395,447	Chas. A. Bauer, C. E.
Saratoga Springs, N. Y.	1889	8,000,000	117,936,698	Prof. D. M. Greene.
Dayton, Ohio, ...	1889	10,000,000	124,782,157	Arthur Giesler, M. E.
Nashville, Tenn.	1890	10,000,000	117,829,420	Geo. Reyer, Sup't W. W.
Buffalo, N. Y.	1890	20,000,000	131,120,226	L. H. Knapp, Sup't and Eng.
Schenectady, N. Y.	1890	5,000,000	123,206,684	Richard M. Gifford, M. E.
Terre Haute, Ind.	1891	6,000,000	108,328,984	Prof. C. S. Brown.
Kalamazoo, Mich.	1891	3,000,000	102,289,741	Prof. M. E. Cooley.
Columbus, Ohio, ...	1891	7,500,000	131,205,000	R. B. Collier and S. P. Bush.
Portland, Oregon, ...	1891	2,500,000	104,860,000	Isaac W. Smith, Sup't.
Duluth, Minn.	1891	5,000,000	119,896,258	Tracy Lyon, M. E. H. E. Stevens, C. E.
Rock Island, Ill.	1892	5,000,000	119,906,200	T. N. Hopper. Hiram Shunk. Capt. M. W. Lyon. Frank Robbins.
Sheboygan, Wis.	1892	4,000,000	112,048,909	W. D. Cockburn, Sup't.
Buffalo, N. Y.	1892	20,000,000	136,908,726	L. H. Knapp, Sup't and Eng.
Dallas, Texas, ...	1893	6,000,000	121,110,737	N. Werenskiold, C. E. R. W. Havens, C. E.
Port Huron, Mich.	1893	12,000,000	125,777,598	J. H. Fitzgerald, Eng. Wm. H. Avery, Ch. Eng.
Poughkeepsie, N. Y.	1893	5,000,000	102,343,635	Chas. E. Fowler, C. E.
Clinton, Iowa, ...	1893	5,000,000	110,000,000	S. M. Highlands, Sup't.
East St. Louis, Ill.	1893	8,000,000	119,000,000	F. M. Hormer, Ch. Eng.
Chicopee, Mass.	1893	2,500,000	101,639,763	E. C. & E. E. Davis, C. E.
Grand Rapids, Mich.	1893	14,839,000	114,373,270	Prof. M. E. Cooley.
South Bethlehem, Pa.	1894	5,000,000	110,314,700	Prof. John D. Riggs.

This table is compiled from official reports of various duty trials of pumping engines built by The Holly Manufacturing Company, most of which are published in the second edition of a book of 302 pages, issued by The Holly Manufacturing Company in 1891, containing full and accurate details of expert trials of 37 Holly Pumping Engines. A copy of this valuable work will be mailed free, upon application, to engineers, water-works officials, students in hydraulic engineering, public libraries, and engineering societies, not already supplied.

THE EFFICIENCY AND DURABILITY OF PUMPING ENGINES.

In considering the subject of pumping engines it should be borne in mind that the matter of efficiency and durability is of greater importance than high duty. There would be no economy in sacrificing strength and stability to high duty; because the risks of breakage, interruption of water supply, cost of repairs, and short life of the pumping engine would more than offset the saving in fuel. Long experience in the construction and use of pumping machinery teaches that the factor of safety in steam engines designed for pumping liquids is necessarily much greater than in steam engines designed for other services. There are certain strains, due to the absolute incompressibility of liquids, upon which the power of pumping engines is expended and which must be skillfully equalized, that do not occur in other kinds of engines. For pumping water for supplying towns and cities, a pumping engine should be able to run easily and continuously for an indefinite period of time at its maximum capacity, and in emergencies greatly above its maximum capacity.

In strength, stability, and efficiency, as well as in duty, the pumping engines made by The Holly Manufacturing Company are unequaled. In proof of this statement the Company will send to any applicant a copy of a pamphlet recently issued containing official "Facts and Figures Regarding the Operation and Cost of Repairs of its High Duty Pumping Engines," of which the table on the following page is a summary.

SUMMARY OF THE COST OF REPAIRS ON 103 HOLLY HIGH DUTY PUMPING ENGINES.

Name of Place.	No. of Years' Service.	No. of Engines.	Average Cost of Repairs per Engine per Annum.	Capacity of Engine in 24 Hours. Gallons.	Head, Feet.
Lexington, Ky.	9	2	$15.39	1,500,000 each	100
Urbana, O.	6	1	"Comparatively Nothing,"	2,000,000	160
Burlington, N. J.	10	1	$ 6.77	1,500,000	145
Binghamton, N. Y.	3½	1	18.07	12,000,000	138
Leavenworth, Kan.	9	1	50.73, Sand	5,000,000	369
Auburn, N. Y.	10	1	10.00	7,500,000	138
Lima, O.	7½	2	9.15	3,000,000 each	167
Mankato, Minn.	5	1	24 00	1,500,000	230
Des Moines, Ia.	11	1	"Trifling,"	5,000,000	184
Taunton, Mass.	3½	1	$1.59	4,000,000	127
Marquette, Mich.	2¾	1	"No Repairs,"	3,000,000	230
Ludington, Mich.	1½	1	"No Repairs,"	2,000,000	175
Chicopee, Mass.	⅓	1	"No Repairs,"	2,500,000	182
Beverly, Mass.	8	2	$2.38	2,000,000 each	147
Peekskill, N. Y.	1⅓	1	"No Repairs,"	3,000,000	426
Atlanta, Ga.	$\frac{10}{12}$	4	"No Repairs,"	10,000,000 each	250
Port Huron, Mich.	5½	1	$2.73	5,000,000	115
Port Huron, Mich.	$\frac{8}{12}$	1	"No Repairs,"	12,000,000	115
Wheeling, W. Va.	⅓	2	"No Repairs,"	7,500,000 each	280
Adrian, Mich.	10	2	$10.00	1,500,000 each	100
Batavia, N. Y.	8½	1	"Slight,"	1,500,000	150
Batavia, N. Y.	3	1	"No Repairs,"	2,500,000	150
Valparaiso, Ind.	8	1	$10.25	1,500,000	100
Hutchinson, Kan.	$5\frac{10}{12}$	1	First 2 yrs. 10 mos., $6 83. Last 3 yrs., "Trifling,"	1,500,000	115
Savannah, Ga.	1¼	2	$2.00	12,000,000 each	175
Tonawanda, N. Y.	$\frac{8}{12}$	2	"No Repairs,"	2,000,000 each	120
Wausau, Wis.	9	2	"Almost Nothing,"	3,000,000 each	230
Oshkosh, Wis.	10	2	"Practically Nothing,"	4,000,000 each	150
San Diego, Cal.	5	1	$ 2.40	2,000,000	145
San Diego, Cal.	2½	1	46.20	3,000,000	500
Brantford, Ont.	$4\frac{2}{12}$	1	3.59	2,000,000	161
Rock Island, Ill.	$1\frac{7}{12}$	1	"No Repairs,"	5,000,000	150
Dallas, Texas	$\frac{9}{12}$	1	"No Repairs,"	6,000,000	200
Dallas, Texas	$\frac{9}{12}$	1	"No Repairs,"	10,000,000	45
Erie, Pa.	7½	1	"Very Moderate,"	5,000,000	257
Joliet, Ill.	7½	1	$10 66	3,000,000	150
Fredericton, N. B.	10½	1	16.64	1,500,000	100
Beatrice, Neb.	8	2	First 4 yrs., No Record. Last 4 yrs., $15.93	1,500,000 each	150
Salina, Kan.	11	1	Average for 9 yrs., $15.32. No Record for 1891-2	1,500,000	100
Fort Worth, Tex.	$\frac{10}{12}$	1	"No Repairs,"	8,000,000	285
Fort Worth, Tex.	$\frac{3}{12}$	1	"No Repairs,"	8,000,000	285
Schenectady, N. Y.	6½	1	For 5 yrs., $75.29, Sand	3,000,000	196
Schenectady, N. Y.	3½	1	$75.29, Sand	5,000,000	196
Bay City, Mich.	7½	1	51.76, Sand	5,000,000	100
Anniston, Ala.	$3\frac{7}{12}$	1	1.09	3,000,000	400
Anniston, Ala.	3	1	1.09	3,000,000	400
Bucyrus, O.	4½	1	"No Repairs,"	1,500,000	100
Columbus, Ind.	4¾	1	$ 16.99	3,000,000	100
Norfolk, Va.	3⅔	1	136.61, Sewage	7,000,000	60
Saginaw, Mich., East S.	4¾	1	89.23	12,000,000	130
Albuquerque, N. M.	9	1	36.10, Sand	3,000,000	252
Saratoga Springs, N. Y.	12	1	15.89	5,000,000	230
Saratoga Springs, N. Y.	4	1	9 00	8,000,000	230
Muskegon, Mich.	2½	2	79 00	3,000,000 each	230
Evanston, Ill.	6	1	47.53	5,000,000	138
Fort Wayne, Ind.	4½	1	22.22	6,000,000	120
Poughkeepsie, N. Y.	$\frac{7}{12}$	1	25.68	5,000,000	300
Fond du Lac, Wis.	8	2	5.72	3,000,000 each	115
Cheyenne, Wyo.	$1\frac{8}{12}$	1	14.10	3,000,000	130
Dayton, O.	$4\frac{7}{12}$	1	87.24	10,000,000	138
Norfolk, Va.	8½	1	See Letter	5,000,000	100
Norfolk, Va.	8½	1	See Letter	2,000,000	50
Streator, Ill.	7½	2	$24.99, Sand	1,500,000 each	165
Chester, Pa.	$5\frac{11}{12}$	2	16.14	4,000,000 each	260
Tiffin, Ohio.	8¼	1	13 69	3,000,000	115
Ashland, Wis.	8½	2	12.35	1,500,000 each	115
Kalamazoo, Mich.	8	1	23.08	3,000,000	120
Kalamazoo, Mich.	3¼	1	20.40	3,000,000	120
Paducah, Ky.	8	2	No Record first five yrs. Average last 2¼ yrs., $40 98	2,000,000 each	150
Rockford, Ill.	9	1	$ 37.73, Sand	3,000,000	165
Rockford, Ill.	3	1	163.48, Sand	6,000,000	165
Galesburg, Ill.	$2\frac{5}{12}$	2	9.19	1,500,000 each	150
Portland, Ore.	6½	1	"No Repairs,"	1,500,000	150
Portland, Ore.	4	1	"No Repairs,"	12,000,000	210
Portland, Ore.	$2\frac{9}{12}$	1	"No Repairs,"	2,500,000	127
Doylestown, Pa.	10	1	$6.37	1,500,000	164
Sioux City, Ia.	10	2	No Complete Record, Splendid Service	3,000,000 each	230
Topeka, Kan.	$6\frac{2}{12}$	1	First 3 yrs., $10.80, Last 3 yrs., "Equally as Good,"	4,000,000	207
West New Brighton, S. I.	3	1	$73.94, Sand	5,000,000	350
Fresno, Cal.	3½	1	3.14	4,000,000	100
North Tonawanda, N. Y.	$7\frac{4}{12}$	2	6.84	2,000,000 each	100

The word "Sand" indicates that the water supply contains enough of that material to rapidly wear the pumps internally and make extraordinary repairs necessary.

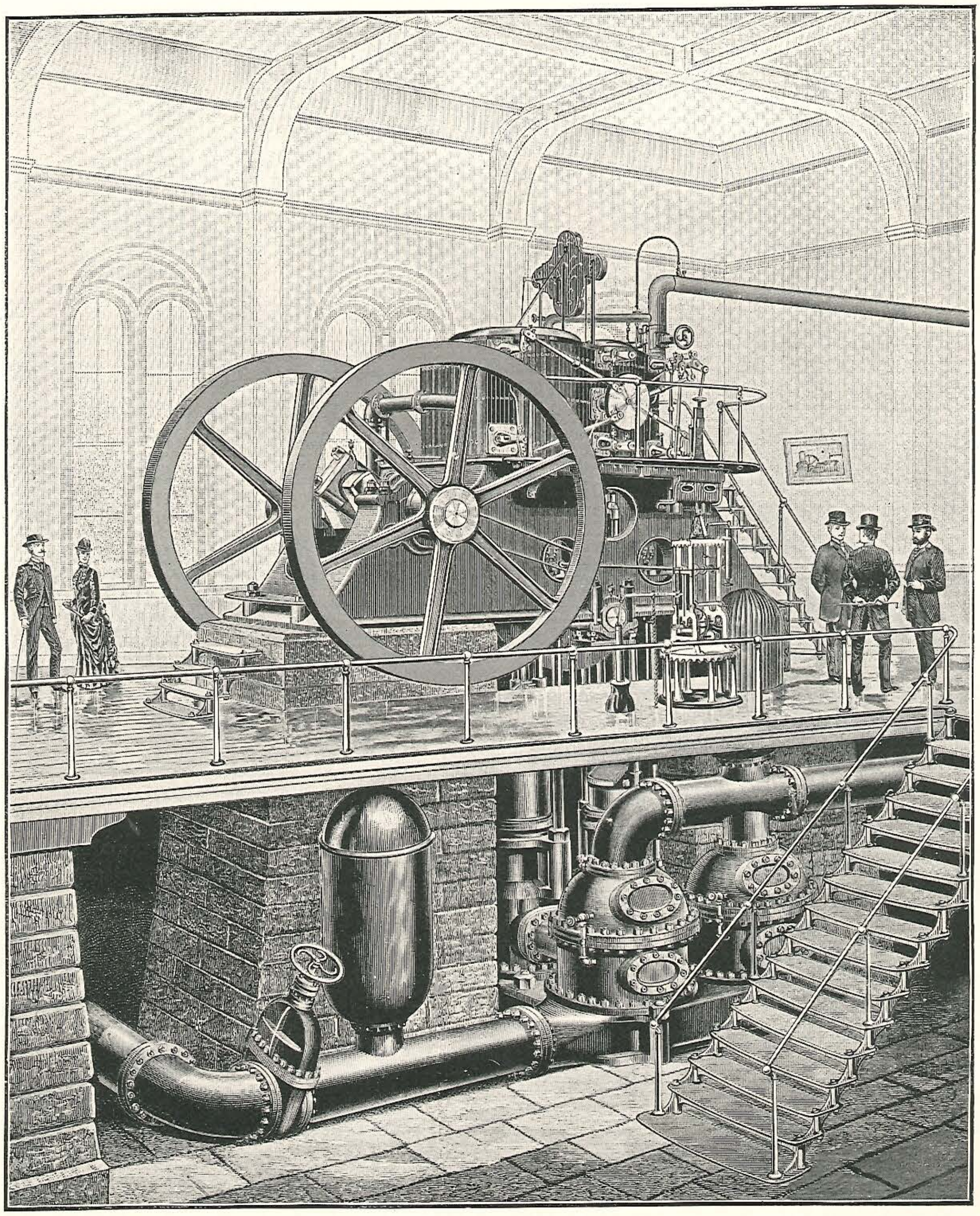
THE VERTICAL TYPE OF PUMPING ENGINE.

There are many situations on our Western rivers, and in other localities where the rise and fall of water at the source of supply is excessive, where a horizontal pumping engine of considerable size can not be placed as advantageously as a vertical pumping engine. It is necessary in such cases to so set a pumping engine that the pumps can take suction at low water, and the steam cylinders not be submerged during high water in the source of supply.

Owing to the fact that the vertical suction lift of any pump is limited by natural laws, and also that a steam engine can not be successfully operated under water, if horizontal pumping engines are used in such situations they must be placed at the bottom of a well or pit of sufficient depth to enable the pumps to take suction at the lowest stage of water, and the well or pit must be of sufficient height to prevent overflow and consequent submersion of the engine during high water. To accommodate a horizontal engine and pumps, the well or pit must be of large dimensions; to resist the external pressure of the soil and the water at its highest mark, it must be of great strength; and to avoid the annoyance and expense of pumping seepage, it must be water tight: all of which involves a large expenditure of money.

Vertical pumping engines, however, can be placed with the pump end only at the bottom of a well or pit of comparatively small dimensions and near low water mark, and with the steam end at the surface of the ground above high water mark, the extreme variations of the water determining the distance and the length of the connections between the two.

PLATE X.



THE HOLLY HIGH DUTY VERTICAL COMPOUND PUMPING ENGINE.—Kalamazoo Pattern.

THE HOLLY HIGH DUTY VERTICAL COMPOUND PUMPING ENGINE, KALAMAZOO PATTERN.

PLATES X, XI.

The vertical pumping engine shown on the opposite page in perspective and on the following page in section, embodies the essential features of the Holly High Duty Horizontal Compound Pumping Engine, and is peculiarly adapted to locations where the horizontal engine could not be advantageously placed.

The steam cylinders are set above the engine room floor, and have direct connections with the pumps below the floor. The steam pistons travel simultaneously in opposite directions, and of course impart the same movement to the pump plungers. The steam valves are a modification of the Corliss valve, and give the same effect in the distribution of steam as the valves of the Holly High Duty Horizontal Compound Engine, Improved Pattern.

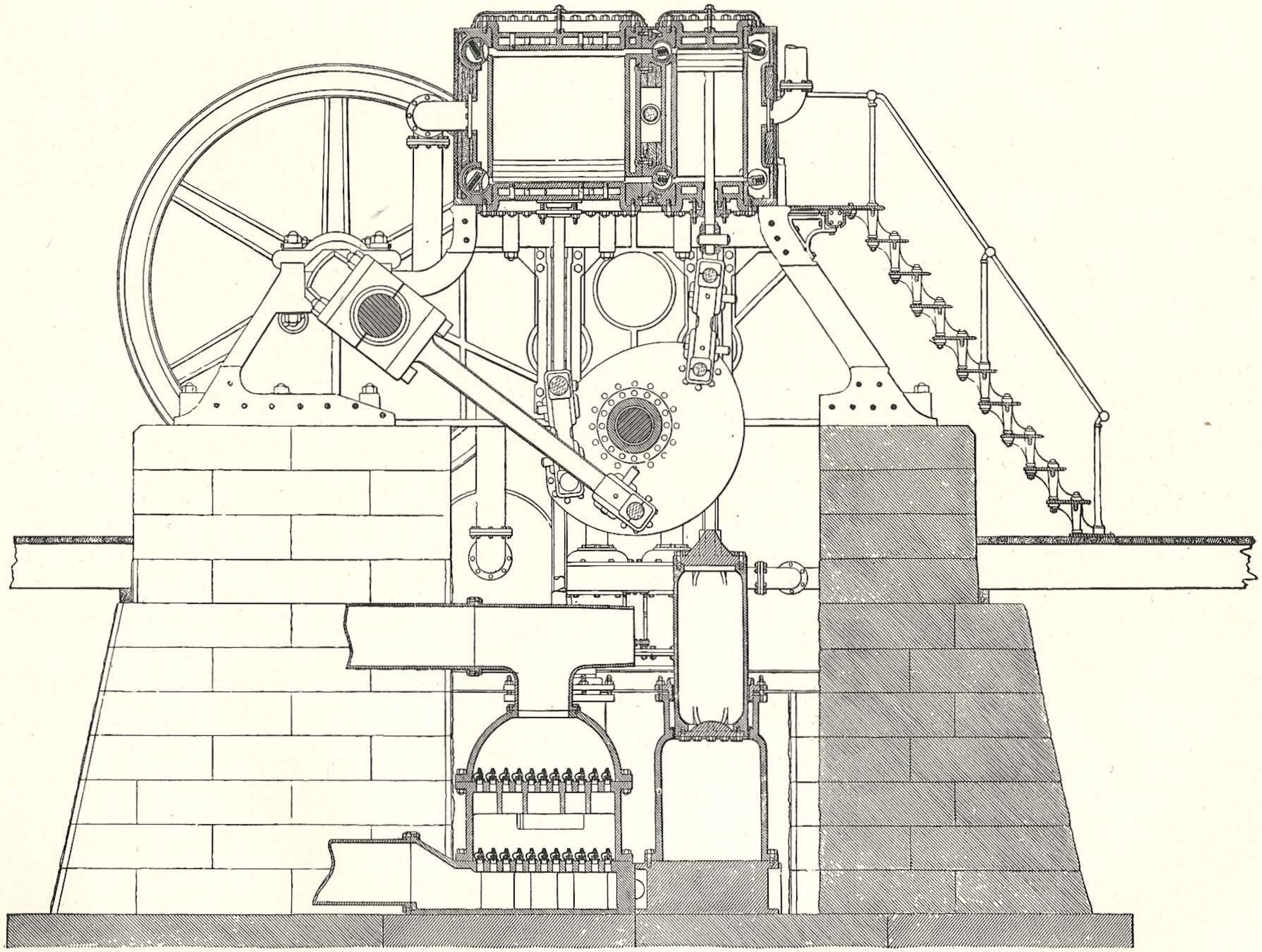
The pumps shown in these engravings have single-acting plungers with outside packing. The pump valves are contained in separate chambers, and by removing the hand hole plates they can be exposed without disturbing the plungers or any of the connections. If preferred, the pumps can be made with double-acting plungers, with either outside or inside packing.

This vertical engine is sometimes doubled, that is with four steam cylinders, instead of two, with two cranks placed at right angles, instead of one crank, and with either two or four pumps. For illustration of the double vertical engine see Plates XVIII and XIX.

This type of Vertical Compound Engine is in use at the water-works of the following cities:

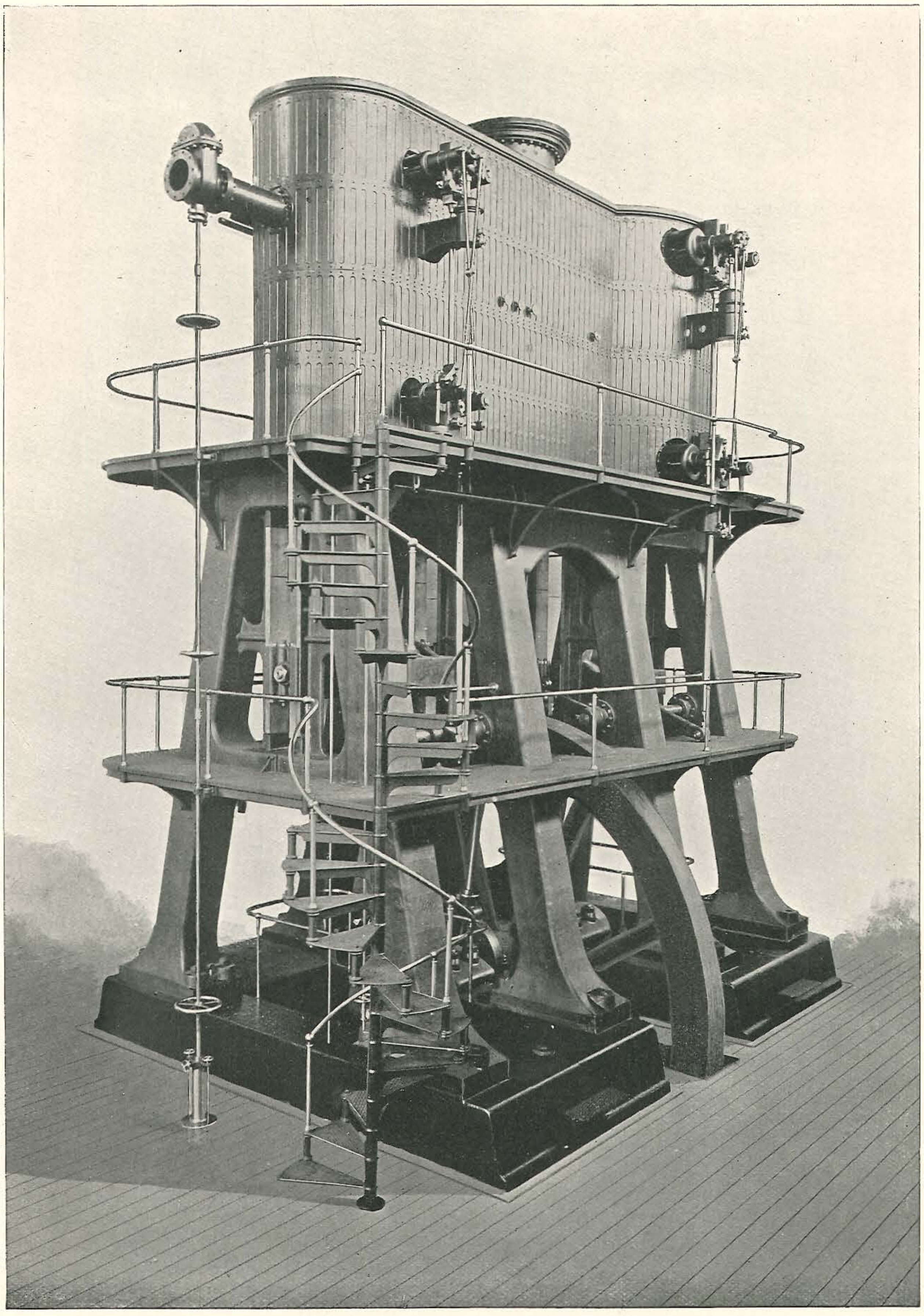
PLACE.	CAPACITY.	HEAD.
Frankfort, Ky.	2,500,000	340 feet.
Paducah, Ky.	2,000,000	220 "
Paducah, Ky.	2,000,000	220 "
Kalamazoo, Mich.	3,000,000	125 "
Kalamazoo, Mich.	3,000,000	125 "
Emporia, Kans.	2,000,000	150 "
Covington, Ky.	5,000,000	378 " (double).
Covington, Ky.	5,000,000	378 " "
Jeffersonville, Ind.	1,500,000	184 "
Jeffersonville, Ind.	1,500,000	184 "
Norfolk, Va.	7,000,000	60 "
Terre Haute, Ind.	6,000,000	138 " (double).
Muskegon, Mich.	3,000,000	230 "
Muskegon, Mich.	3,000,000	230 "
Wheeling, W. Va.	7,500,000	280 " (double).
Wheeling, W. Va.	7,500,000	280 " "

PLATE XI.

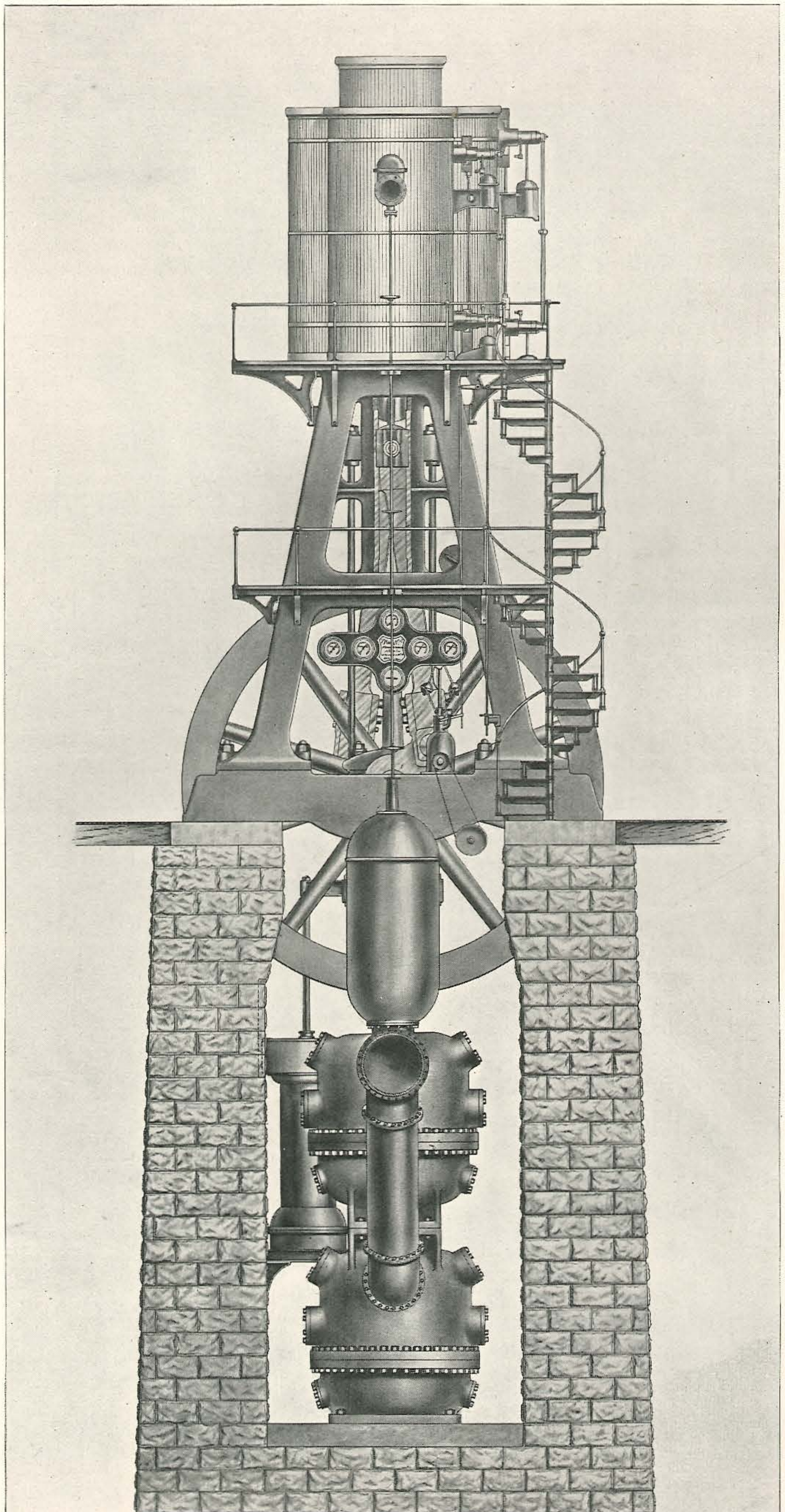


THE HOLLY HIGH DUTY VERTICAL COMPOUND PUMPING ENGINE.— Kalamazoo Pattern.

SECTIONAL ELEVATION.



THE HOLLY HIGH DUTY VERTICAL COMPOUND PUMPING ENGINE
At the Brilliant Pumping Station, Pittsburgh, Pa.

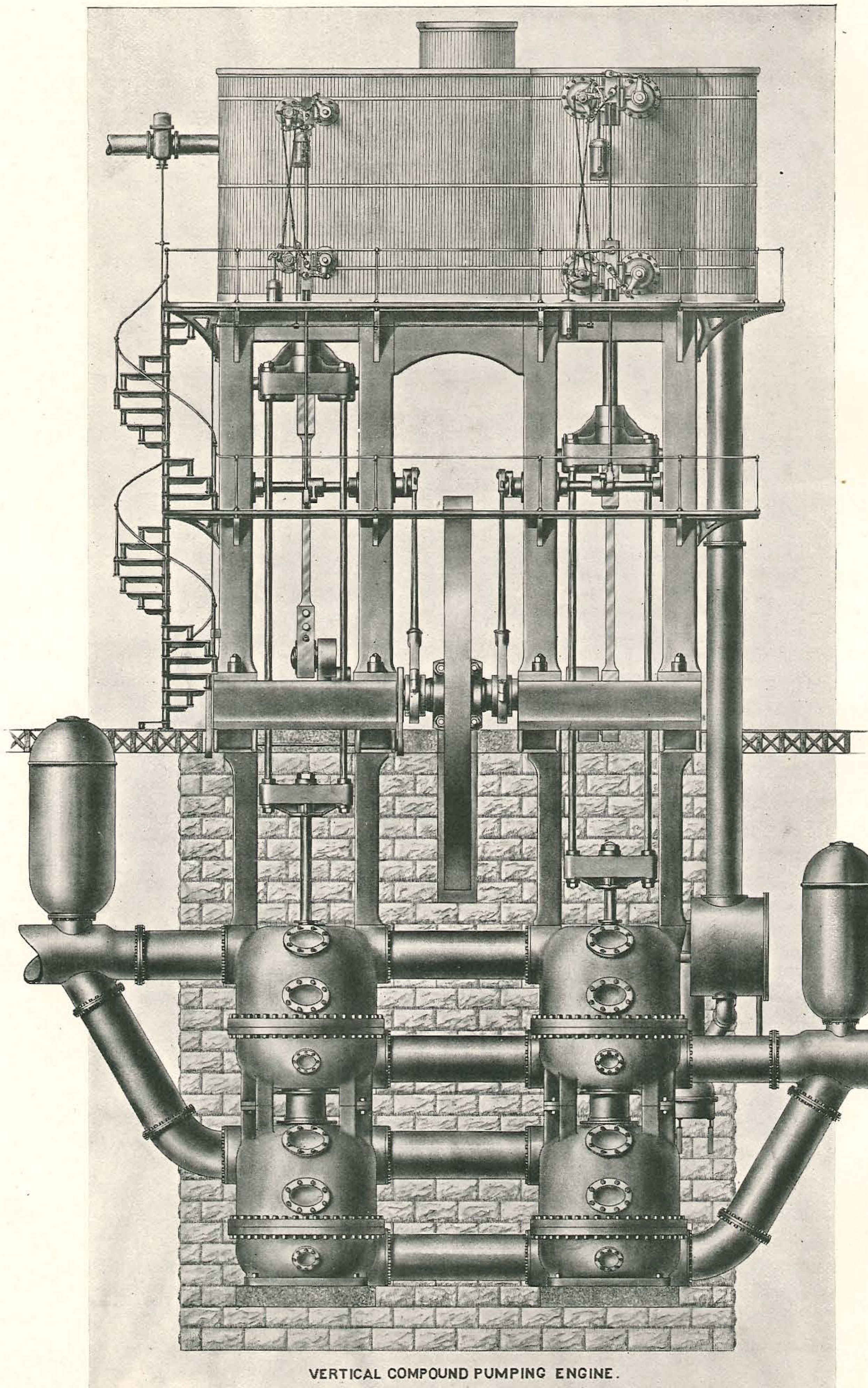


THE HOLLY HIGH DUTY VERTICAL COMPOUND PUMPING ENGINE.
END ELEVATION.

THE HOLLY HIGH DUTY VERTICAL COMPOUND PUMPING ENGINE, PITTSBURGH PATTERN.

Plates XII, XIII, XIV.

In 1893 the City of Pittsburgh bought of The Holly Manufacturing Company two High Duty Vertical Compound Condensing Pumping Engines, to be erected at the "Brilliant Pumping Station." The engines pump 20,000,000 gallons of water per twenty-four hours from the Allegheny River, through a long force main into a reservoir 460 feet above the source of supply. The river frequently rises and falls 35 feet, and carries more or less sand and other earthy substances in suspension most of the time: the available floor space in the engine room is greatly restricted: so that taking these severe conditions into account, it will be readily seen that the service is very difficult. To successfully accomplish the desired results, the engine illustrated on pages 37, 38 and 40, was specially designed by this Company. The engine alone is illustrated in perspective by Plate XII, and the engine and pumps together in end elevation by Plate XIII, and in front elevation by Plate XIV. For description of this engine see page 41.



THE HOLLY HIGH DUTY VERTICAL COMPOUND PUMPING ENGINE.
FRONT ELEVATION.

DESCRIPTION OF THE HOLLY VERTICAL PUMPING ENGINES

AT THE BRILLIANT PUMPING STATION, PITTSBURGH.

Each engine has one high-pressure and one low-pressure steam cylinder, mounted vertically, and parallel with each other, upon a heavy "A" frame of cast-iron resting upon two cast-iron bedplates that extend across a deep pump pit and are supported at both ends by stone masonry built up from bed rock as shown on page 38.

Two double-acting plunger pumps are placed below the bedplates, in direct vertical lines with the steam cylinders, and rest on foundations at the bottom of the pump pit, as shown by Plates XIII and XIV. Each pump is firmly connected to one of the bedplates above by two heavy iron struts.

Each pump plunger is connected with the piston of the corresponding steam cylinder by two crossheads — one upper and one lower — and four steel distance-rods. The upper cross-heads carry the wrist pins and slide plates, which latter are guided in ways formed for them in the engine frames.

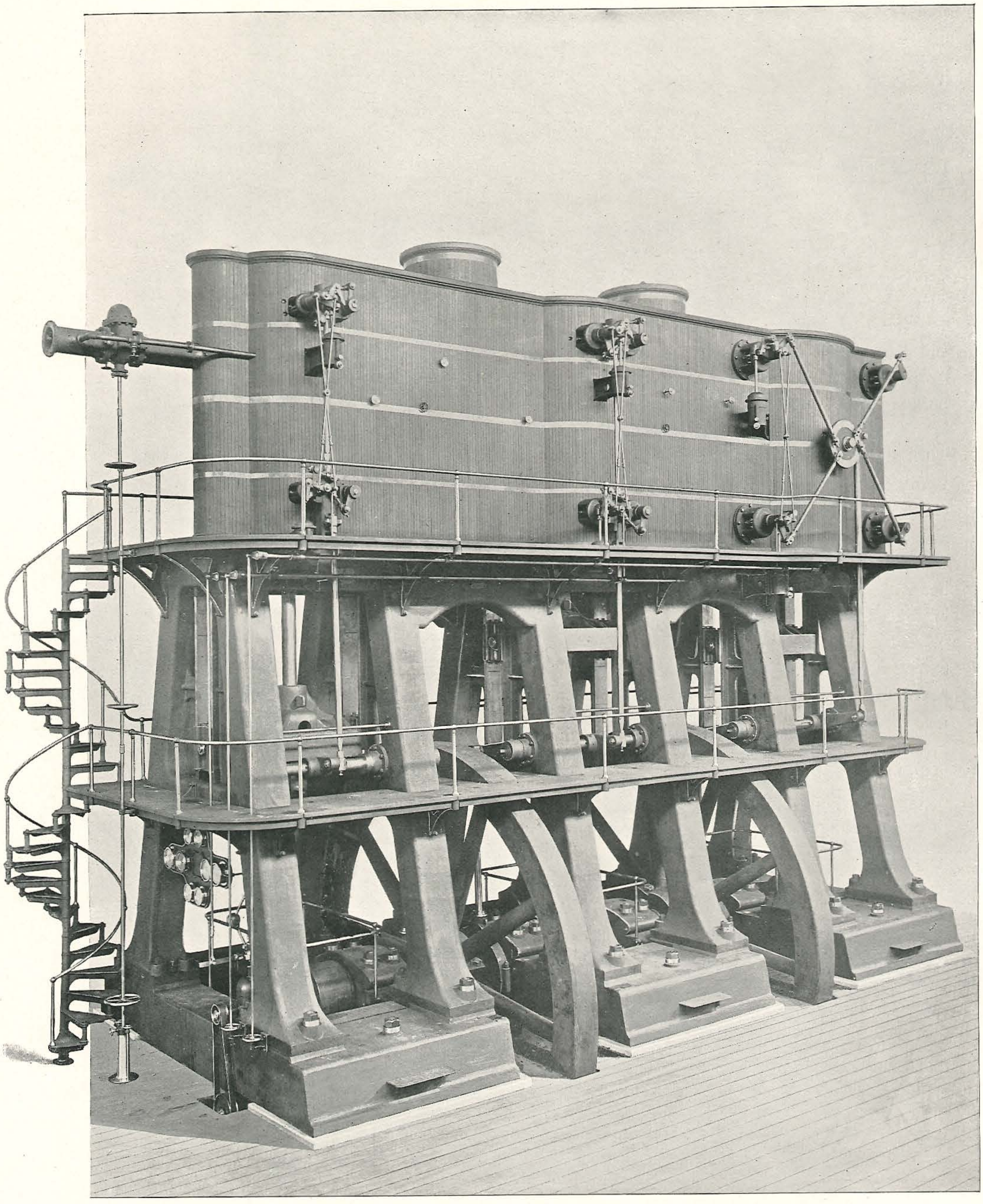
There is one main shaft placed in broad bearings on top of the bedplates. This shaft carries a fly wheel in the middle, and a crank set at quarters on each of its ends. The cranks have steel pins connected with the wrist pins of the upper crossheads by two long connecting rods that work between the upper and lower crossheads and the distance-rods.

Between the steam cylinders there is a receiver, into which steam from the high-pressure cylinder is exhausted and from which steam for the low-pressure cylinder is taken. The receiver contains a copper coil that is heated with live steam from the boilers. In its passage through the receiver the exhaust steam from the high-pressure cylinder comes in contact with the heated coil, and is converted into dry steam before entering the low-pressure cylinder.

An improved air pump and jet condenser are placed below the engine room floor, and take their supply of cold water from the suction pipe of the main pump.

The steam valves are of the Corliss pattern, and are set in the cylinder heads so as to reduce the clearance spaces to minimum. The valve motion includes a new and simple device, which is illustrated and described on pages 48 and 49, whereby the cut-off valves may be released at any point of the stroke.

For strength, compactness, simplicity, convenience and efficiency, this arrangement and combination of parts is unequaled by any vertical rotative pumping engine.



THE HOLLY HIGH DUTY VERTICAL TRIPLE EXPANSION PUMPING ENGINE.

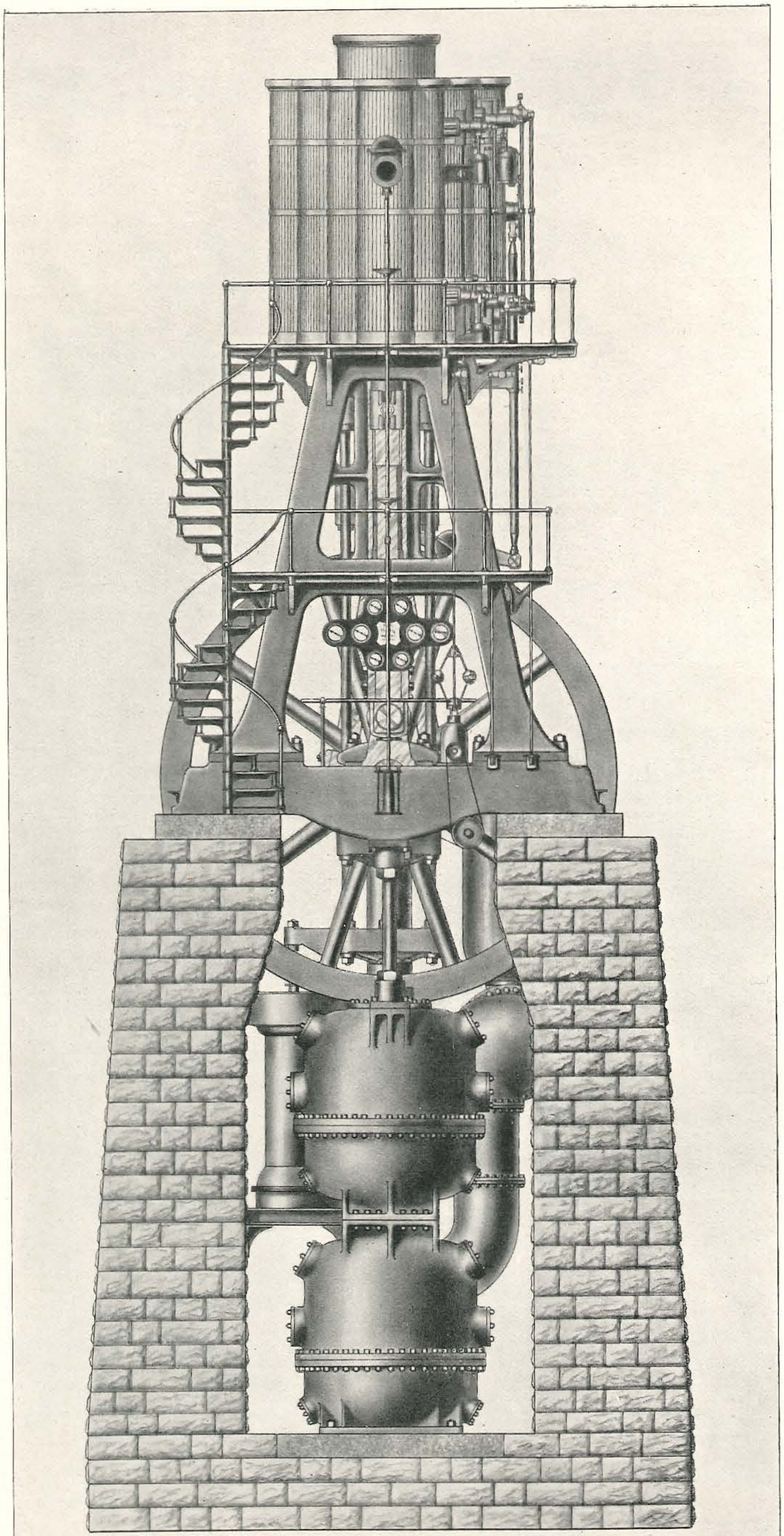
At the Spring Garden Pumping Station, Philadelphia.—Capacity, 30,000,000 Gallons per 24 Hours.

THE HOLLY VERTICAL TRIPLE EXPANSION PUMPING ENGINE.

PLATES XV, XVI, XVII.

Within the past few years a demand has prevailed for greater fuel economy in machinery, especially in steam pumping engines of large capacity; and in maintaining its high place in that branch of engineering, The Holly Manufacturing Company has produced vertical triple expansion pumping engines of superior design and construction.

The triple expansion pumping engine illustrated in perspective on the opposite page, in end elevation by Plate XVI, and in front elevation by Plate XVII; is one of two just completed for the City of Philadelphia, the combined nominal capacity of which is 60,000,000 gallons of water a day, but they are capable of safely pumping 70,000,000 to 80,000,000 gallons a day. For description of this engine see pages 45 and 47.



THE HOLLY HIGH DUTY VERTICAL TRIPLE EXPANSION PUMPING ENGINE.

DESCRIPTION OF THE HOLLY TRIPLE EXPANSION PUMPING ENGINES

At the Spring Garden Pumping Station, Philadelphia.

Each pumping engine has three steam cylinders — designated the high-pressure cylinder, the intermediate cylinder, and the low-pressure cylinder — mounted vertically, in parallel lines, upon a heavy "A" frame of cast-iron resting on three cast-iron bedplates, as shown on page 42. The bedplates extend across the pump pit and are supported by stone masonry, as shown by Plate XVI on the opposite page.

There are three pumps with double-acting outside packed plungers, placed below the bedplates in direct lines vertically with the steam cylinders, and resting on rock foundations at the bottom of the pump pit. Each pump is firmly connected to one of the bedplates above by two heavy iron struts.

Each pump plunger and corresponding steam piston are connected by two crossheads — one upper and one lower — and four steel distance-rods. The upper crossheads carry the wrist pins and slide plates, and the latter are guided in ways formed for them in the engine frames.

There are two main shafts placed axially in line in broad bearings on top of the bedplates. Each shaft carries one of the two fly wheels, and has a crank on each end; but the two inboard cranks are rigidly connected together by a heavy steel pin, so that the two shafts and four cranks when in place on the engine, become practically one shaft with three cranks.

The cranks have three steel pins, which are connected with the wrist pins of the three upper crossheads by long connecting rods that work between the upper and lower crossheads.

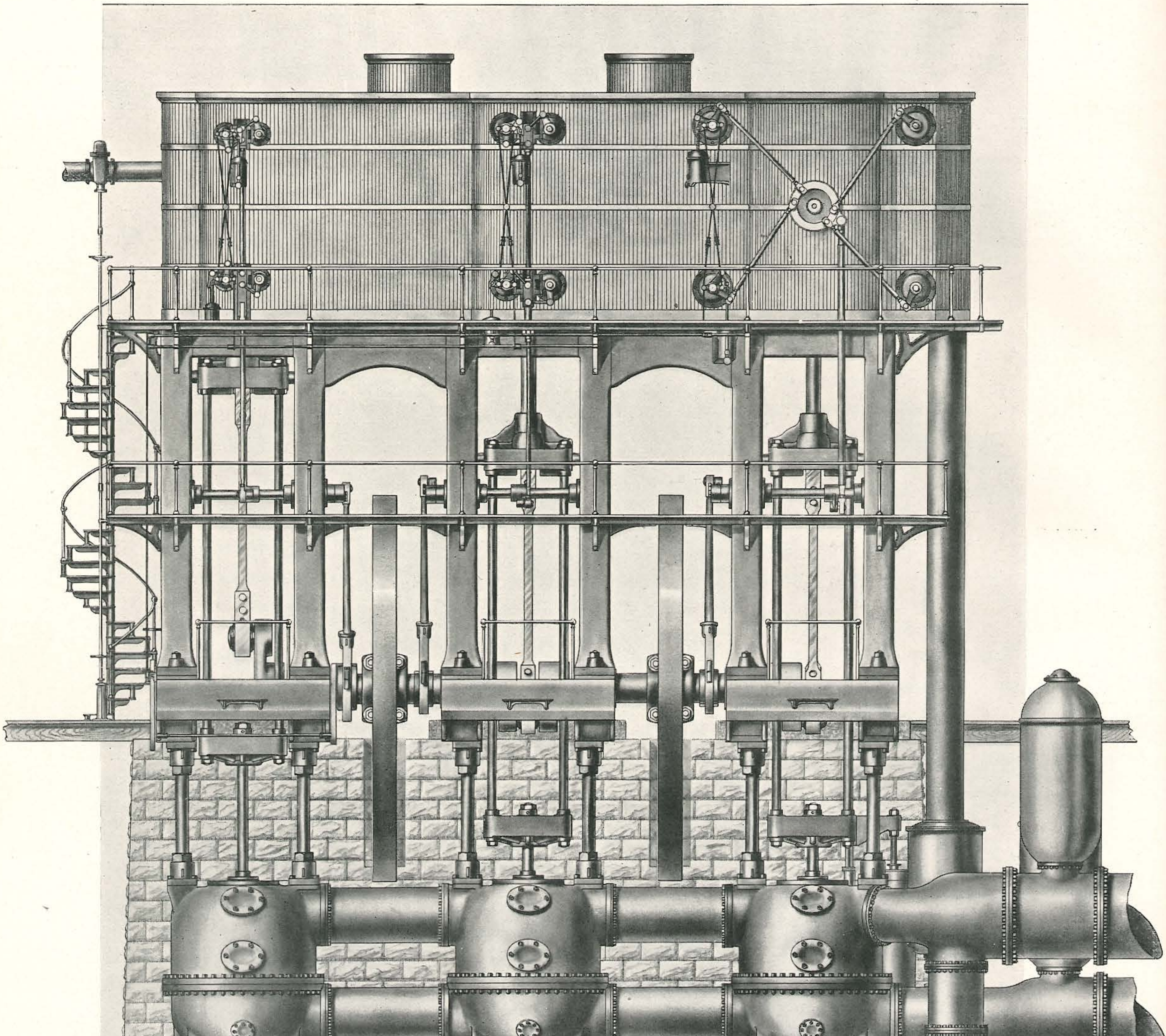
The cranks are set so as to carry each steam piston and pump plunger one-third of a revolution in advance of the next, equally balancing the moving parts, evenly distributing the strains, and producing a very uniform flow of water through the suction and discharge mains.

This engine, unlike the Holly High Duty Horizontal Compound Engine, is provided with receivers and reheating steam coils placed between the steam cylinders. The coils — of which there are two — are supplied with live steam from the boilers. In this engine steam is used expansively in three cylinders, instead of two as in the Horizontal Compound Engine.

The steam is admitted from the boilers to, and first expanded in, the high-pressure cylinder; it is again expanded in the intermediate cylinder; and is finally expanded in the low-pressure cylinder, whence it is exhausted into the condenser.

From the high-pressure and intermediate cylinders the steam passes through the receivers and around the reheating coils, so that high degrees of temperature and extreme dryness of steam are maintained throughout.

The low-pressure steam cylinder has an area about six and one-half times the area of the high-pressure cylinder, and ratios of steam expansion ranging from 18 to 25 are obtained, the exact ratio depending upon the points where steam is cut off in the cylinders.



THE HOLLY HIGH DUTY VERTICAL TRIPLE EXPANSION PUMPING ENGINE.

For this type of engine a higher steam pressure is recommended than is ordinarily used for a compound engine, because a greater range of expansion can be utilized and consequently increased duty obtained.

The steam valves are of the Corliss pattern, and are so placed in the cylinder heads that the clearance spaces are reduced to less than one and one-half per cent. The valves of each cylinder cut off the steam at any point of the stroke, and the point of cut-off on any cylinder may be adjusted independently of the others. The cut-offs can be controlled automatically either by a pressure regulator for pumping directly into the mains, or by a speed governor for reservoir service. In the former case a variable speed is necessary, in order that the engines shall exactly meet the daily demands for water: in the latter case uniform speed is preferable. For description of the automatic cut-offs see pages 48 and 49.

The steam cylinders, receivers, and connections, are thoroughly covered with the best non-conducting material, and are housed in neat black walnut lagging. The steam cylinders are completely steam jacketed.

An improved air pump and jet condenser are placed below the floor of the engine room so that injection water can be raised by suction from the main source of supply.

The pumps for Philadelphia, illustrated by Plates XVI and XVII, have double-acting outside packed plungers; but wherever the local conditions require or purchasers prefer a different kind, they will be made with single-acting outside packed plungers, or with double-acting inside packed plungers, or with differential plungers.

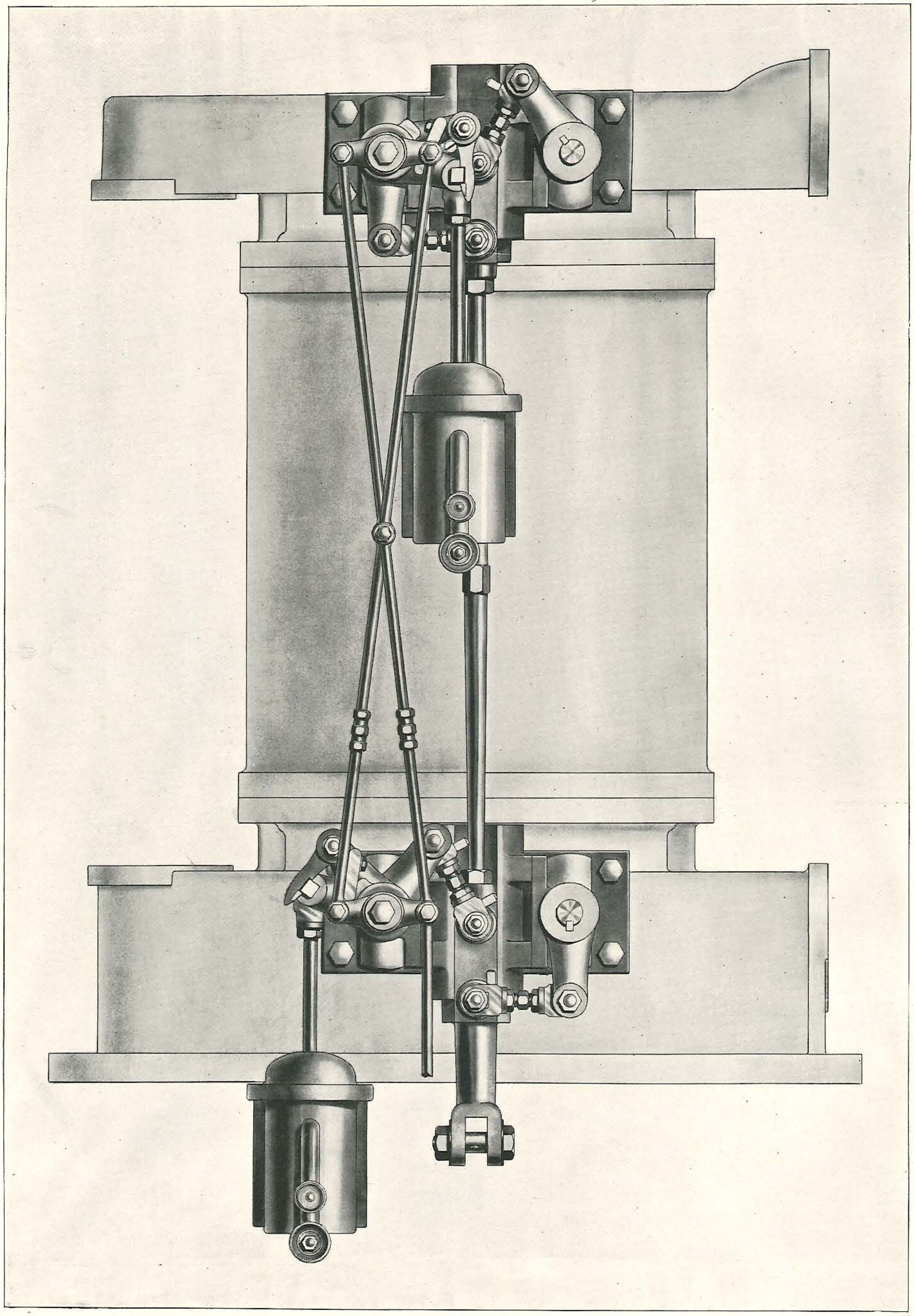
The platforms and stairs shown in the engravings are guarded by finished brass hand rails in polished wrought-iron columns.

The Company is prepared to furnish this engine of any size up to 50,000,000 gallons daily, for any service, and to guarantee the most economical results.

LIST OF VERTICAL TRIPLE EXPANSION PUMPING ENGINES BUILT BY THE HOLLY MANUFACTURING COMPANY.

PLACE.	CAPACITY.	HEAD.
Columbus, Ohio.	7,500,000	185 feet.
Columbus, Ohio.	7,500,000	185 "
Omaha, Neb.	8,000,000	100 "
Fort Wayne, Ind.	6,000,000	120 "
Fort Worth, Texas.	10,000,000	285 "
Fort Worth, Texas.	10,000,000	285 "
Philadelphia, Pa.	30,000,000	145 "
Philadelphia, Pa.	30,000,000	145 "
Providence, R. I., Sewerage,	36,000,000	34 "
Providence, R. I., Sewerage,	36.000,000	34 "
Providence, R. I., Sewerage,	36,000,000	34 "

Total, 217,000,000 gallons daily, or 212,070,000 gallons daily against 100 feet head. Representing 3,804 Horse powers.



NEW VARIABLE STEAM CUT-OFF.

NEW VARIABLE STEAM CUT-OFF VALVES.

Experience in operating pumping engines having variable steam cut-off valves, has shown that a wider range of the points of cut-off than has heretofore been attained is particularly desirable as a matter of safety, economy and convenience.

The range of cut-offs in most of the releasing valve motions in general use, is limited to the first half of the stroke of the steam pistons; but a few inventors have, by using various combinations of gear wheels, cams, eccentrics, etc., extended the range of cut-off— or points of release—somewhat beyond the half stroke.

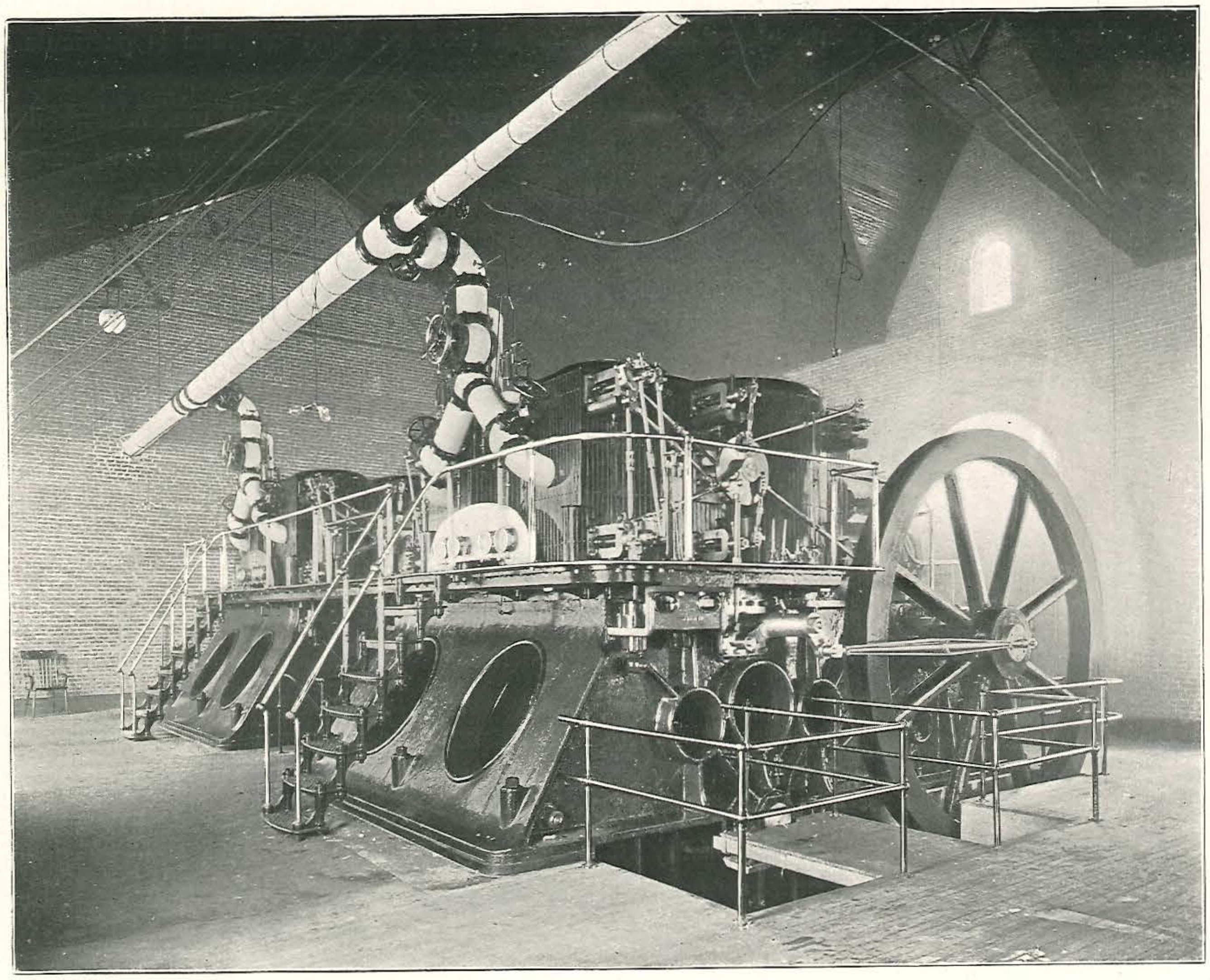
In the well known Corliss valve motion especially, the limitation of points of cut-off within the half stroke has been almost universal; though of late several complex devices for extending the limit have been applied to pumping engines and are more or less satisfactory in their operation, but none of them fully accomplish the desired results.

The engraving on the opposite page, Plate XVIIB, illustrates a simple and effective attachment for the Corliss valve motion that gives a range of cut-off throughout the entire stroke of the steam pistons. This device is fully protected by Letters Patent controlled by this Company.

The point of release of each of the cut-off valves is determined by two *knock-off* arms, a primary and a secondary, at each end of the steam cylinder. The primary *knock-off* arms fulfill the same function as the "trip" of an ordinary Corliss cut-off, i. e., release the valve at any point previous to the half stroke of the engine; but when it is desired to release the valve beyond the half stroke, the primary *knock-off* arms can be freed from contact, either by hand or by an automatic governor, and the secondary *knock-off* arms brought into position to produce the desired result, *i. e.*, to release the valve beyond the half stroke. The secondary *knock-off* arms perform identically the same service when the engine is cutting off later than half stroke that the primary *knock-off* arms perform when the engine is cutting off before the half stroke.

This cut-off is applied to the Holly Vertical Compound and the Holly Vertical Triple Expansion Pumping Engines, with the addition of a ball governor for pumping services requiring a uniform water supply, or a hydrostatic regulator for pumping services requiring a variable water supply; either of which will control the movements of the cut-off mechanism and the speed of the engines automatically.

PLATE XVIII.



THE HOLLY HIGH DUTY VERTICAL COMPOUND DOUBLE PUMPING ENGINES
At the Holly Pumping Station, Wheeling, West Virginia.

THE HOLLY HIGH DUTY VERTICAL COMPOUND DOUBLE PUMPING ENGINES

AT WHEELING, WEST VIRGINIA

PLATES XVIII, XIX, XX.

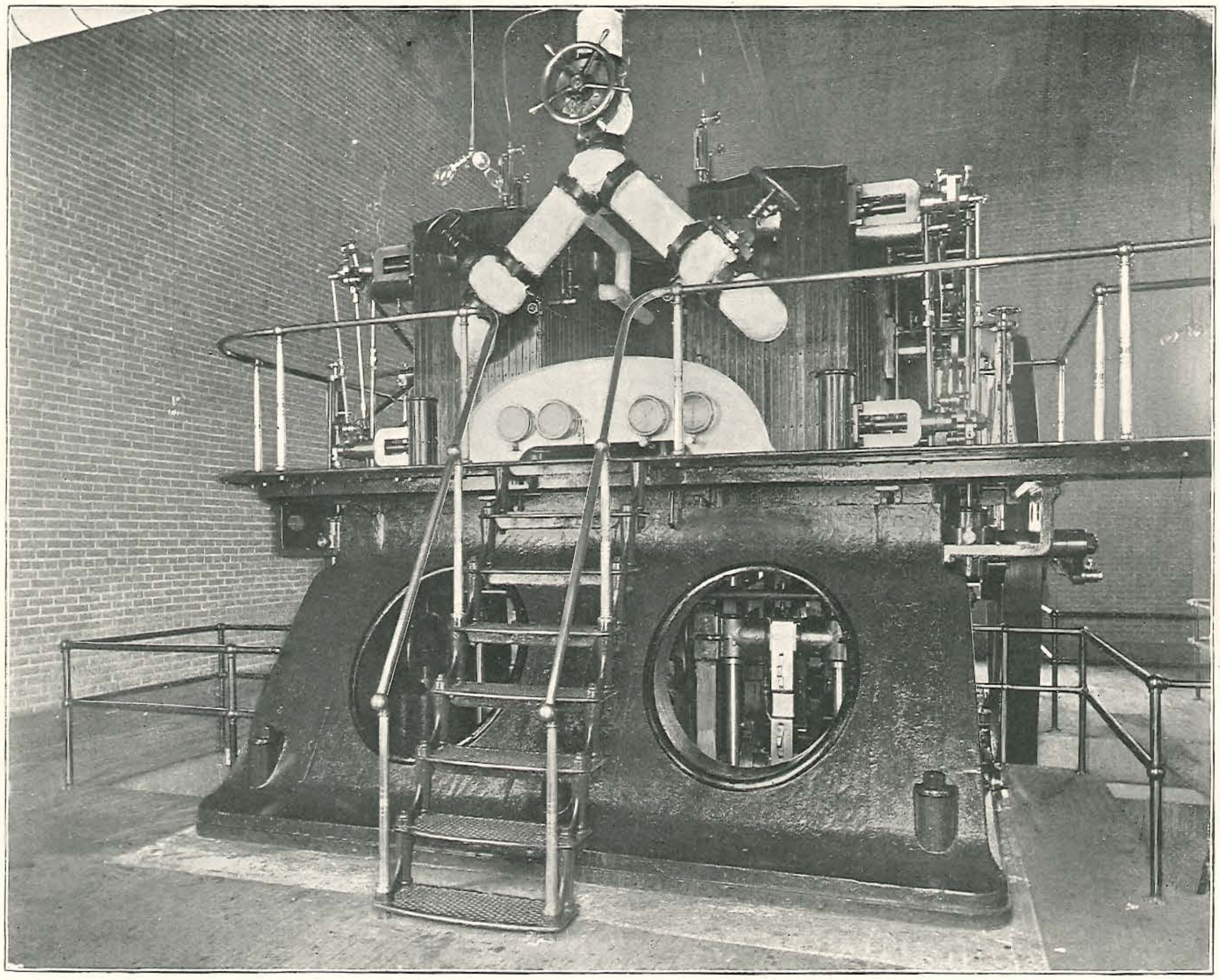
The engraving on the opposite page represents two Holly High Duty Vertical Compound Double Pumping Engines at the new water-works station of the City of Wheeling, W. Va. A front view of one of the engines is given on page 52.

About the year 1834 the township, now city, of Wheeling established one of the first water-works in the United States. The money to pay for their construction was borrowed of the Rothschilds of England, and for a long time they were known as the "Rothschilds works." The works were enlarged from time to time as the city increased in population and wealth, but not until the year 1892 were any radical changes made. In that year the city entered into a special agreement with The Holly Manufacturing Company whereby the latter, at its own charges, erected a new pumping plant two miles further up the Ohio River. The new plant included a 30 inch cast-iron water main 9,000 feet long, leading from the pumping station to the upper distributing reservoir; a brick engine and boiler house; a brick smoke stack; two Holly High Duty Vertical Compound Pumping Engines as hereafter described, of a combined capacity of 15,000,000 gallons a day; six tubular steam boilers; a block-stone pump pit fifty feet deep; two 24 inch intake pipes from the river; and all connections necessary to make a complete outfit. This plant The Holly Manufacturing Company owns and leases to the city at an annual rental, the city having the option to purchase the plant at any time upon paying a stipulated price. The engine and boiler house and smoke stack are illustrated on page 53.

Under this arrangement the city assumed no risk in the construction and testing of the new works, and was relieved of the necessity of incurring a debt by an issue of bonds.

Each of the Wheeling engines has two high-pressure steam cylinders each 27 inches in diameter, two low-pressure steam cylinders each 48 inches in diameter, four double-acting plunger pumps each 23 inches in diameter, and is of 36 inches stroke. The pumps are set in the bottom, and the engines at the top, of the stone pit, the pumps being 50 feet below the engines, that distance representing approximately the difference between low and high water marks in the river. Ever since the engines were put into service they have shown high economy in fuel, have run smoothly under full reservoir pressure, and are in every particular satisfactory to the users as well as to the builders.

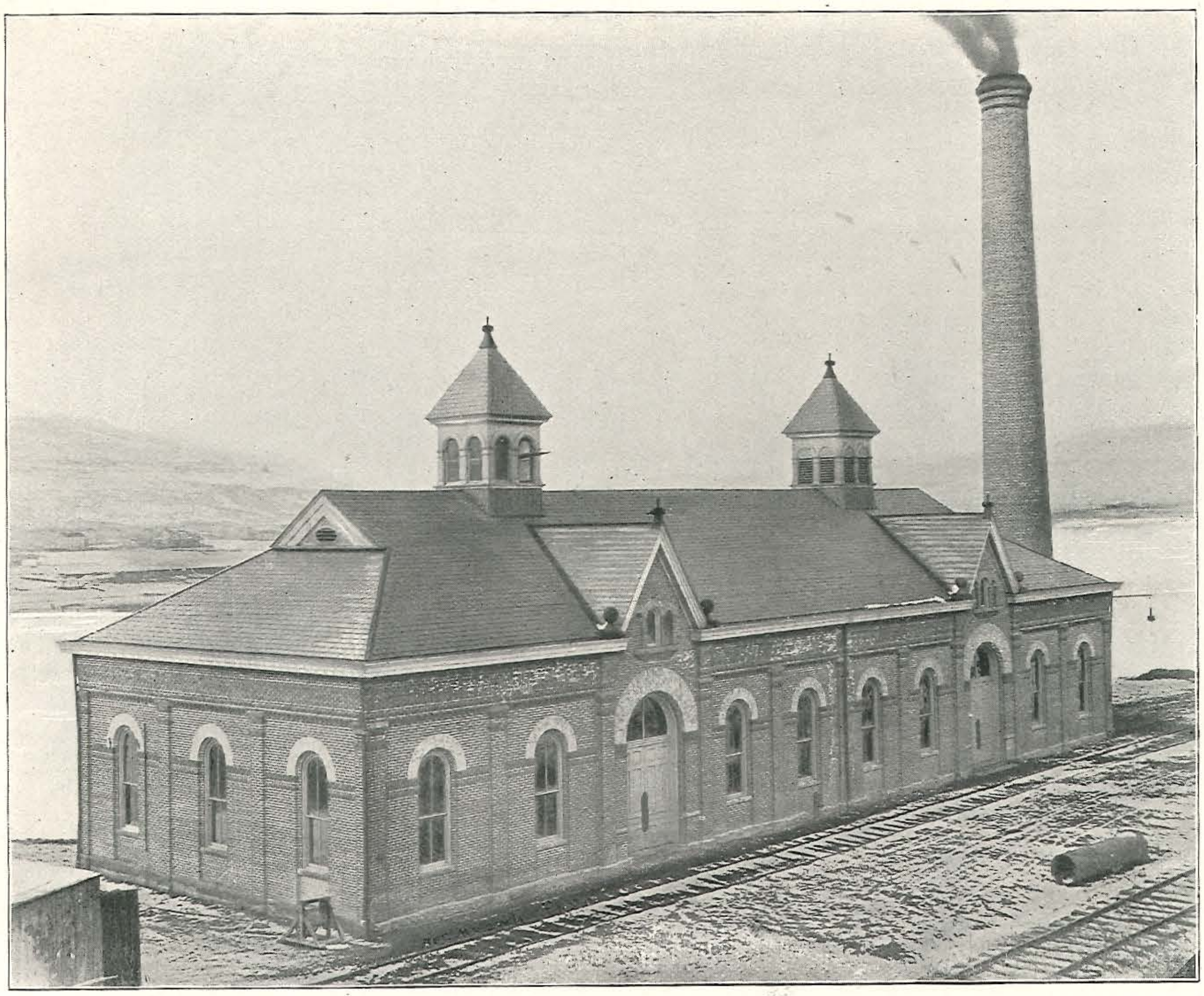
The Holly Manufacturing Company is prepared to construct water-works pumping plants, or pumping engines alone, for other prosperous cities under similar terms and conditions.



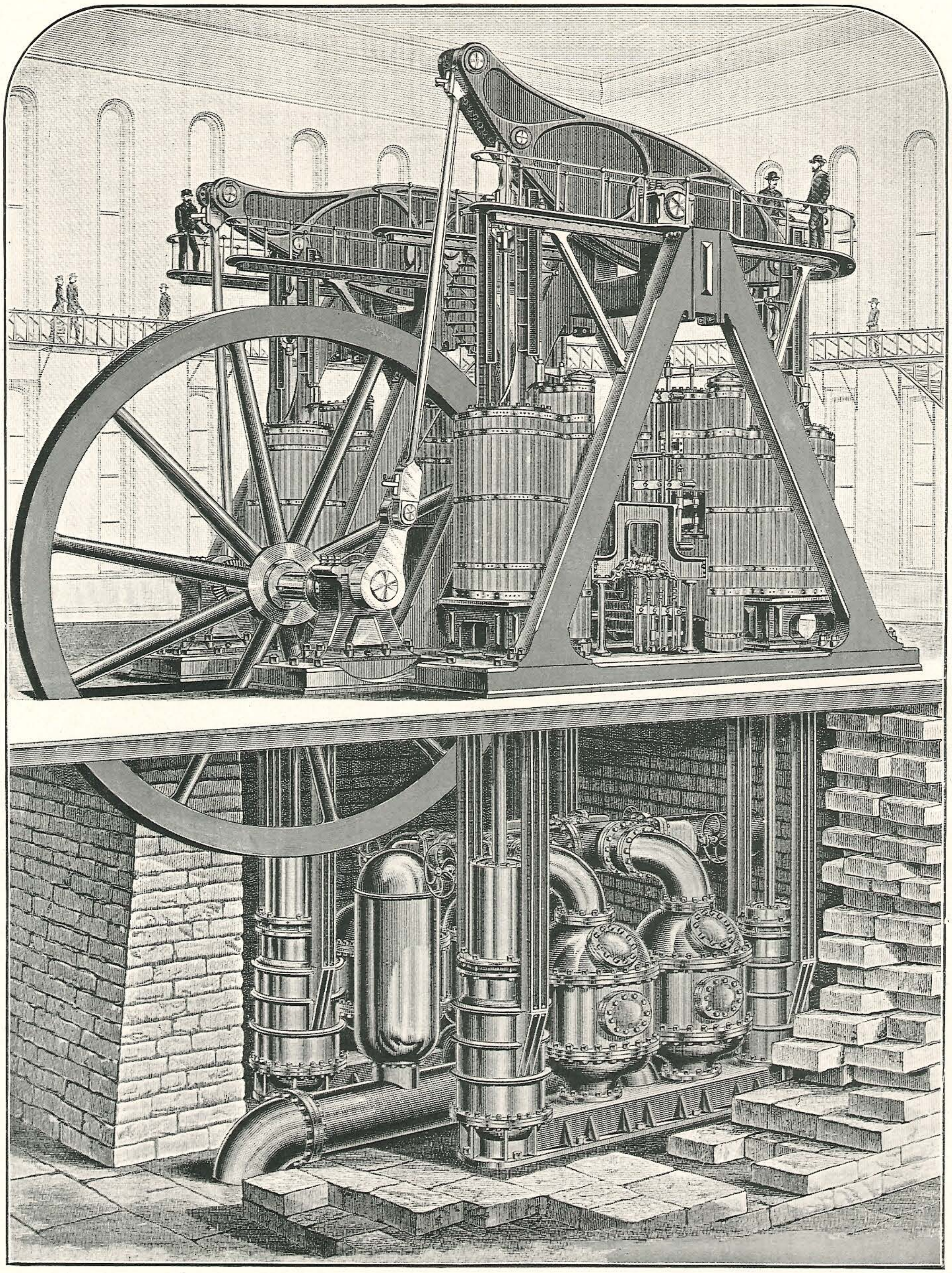
FRONT VIEW OF ONE OF THE

HOLLY HIGH DUTY VERTICAL COMPOUND DOUBLE PUMPING ENGINES
At the Holly Pumping Station, Wheeling, West Virginia.

PLATE XX.



THE HOLLY PUMPING STATION OF THE CITY WATER-WORKS,
Ohio River, Wheeling, West Virginia.



THE HOLLY HIGH DUTY COMPOUND OVERHEAD BEAM PUMPING ENGINE.

THE HOLLY HIGH DUTY COMPOUND OVERHEAD BEAM PUMPING ENGINE.

PLATE XXI.

The engraving on the opposite page illustrates a 10,000,000 gallon pumping engine built for the City of Nashville, Tenn., to operate against a head of 300 feet.

It is a massive structure, weighing over 400 tons. The extreme height from the bottom of the pump bases to the top of the beams is over 80 feet. The engraving shows the pumps near the engine room floor, but at Nashville they are set 60 feet below and are connected to the engine by long piston rods and heavy cast-iron struts.

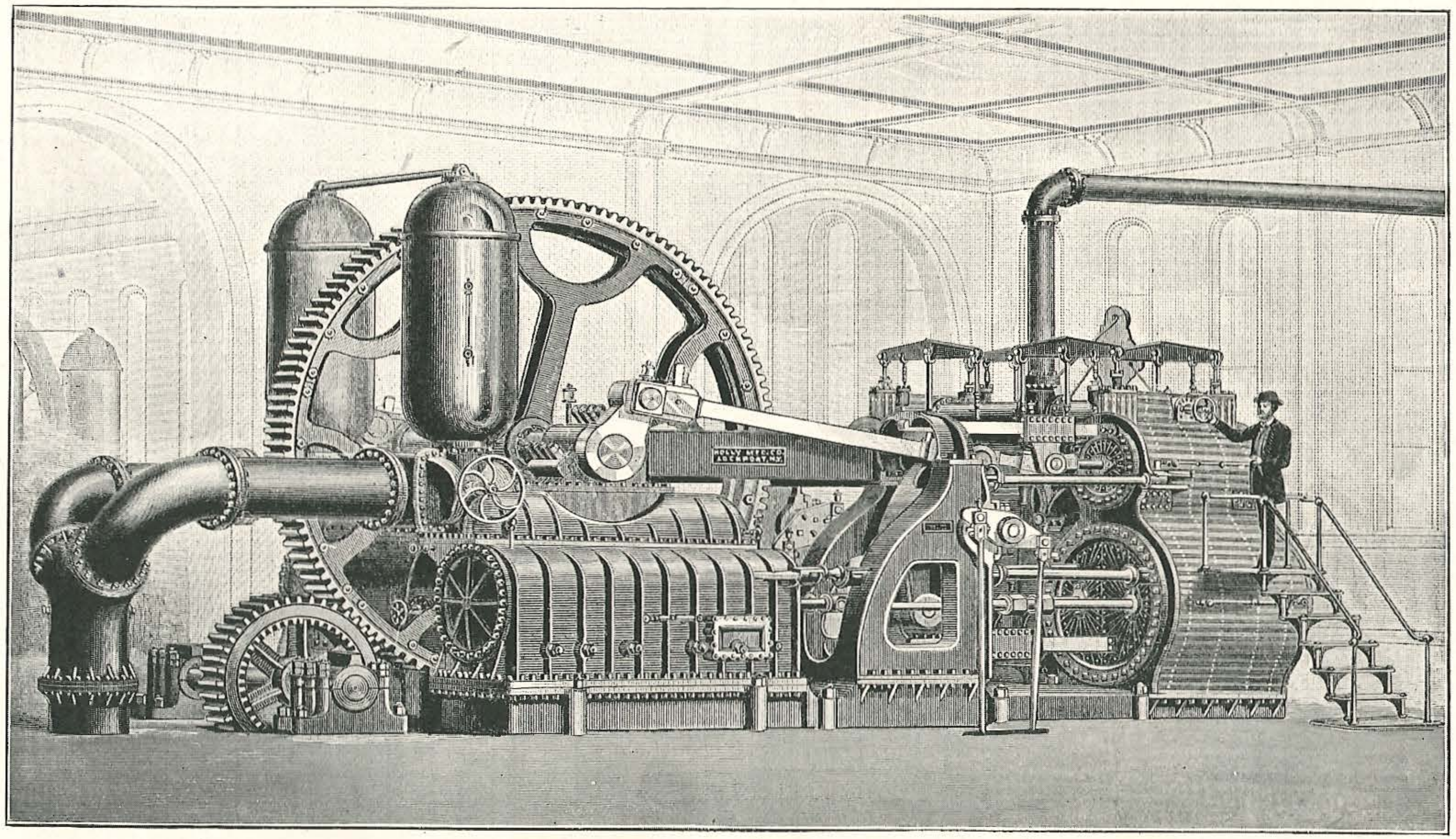
The engine has two high-pressure steam cylinders each 33 inches in diameter, two low-pressure steam cylinders each 66 inches in diameter, four single-acting plunger pumps each 27 inches in diameter, and is of 60 inches stroke.

The beams are each made of two steel plates, 1½ inches thick, with cast-iron ribs. The steam pistons are connected to the beams by links. The crank ends of the beams are prolonged so that the connecting rods swing clear of the high-pressure steam cylinders. The two cranks are set at an angle to each other of 90 degrees. The fly wheel is 24 feet in diameter, and weighs 30 tons.

All of the steam valves are of the double-beat puppet type, but the admission valves only have the Gaskill patent cut-off gear.

At the official test in February 1890, this engine gave a duty of 117,829,420 foot pounds per 1,000 pounds of steam. The test was very thorough and continued until 50,000,000 gallons of water had been delivered into the reservoir — a run of about four and a quarter days. These results were about 20 per cent. in excess of the Company's guarantees for duty and capacity, and the engine has since given excellent service in pumping the regular water supply for the city.

PLATE XXII.



THE HOLLY HIGH DUTY COMBINED STEAM AND WATER POWER PUMPING ENGINE.—Gaskill Type.

THE HOLLY HIGH DUTY COMBINED STEAM AND WATER POWER PUMPING ENGINE.

PLATES XXII, XXIII.

The object of this combination is to supplement water power or steam power by each other.

The perspective engraving on the opposite page illustrates a Holly High Duty Horizontal Compound Pumping Engine, Gaskill type, of 7,500,000 gallons daily capacity, with gearing for water power attachment; and the line engraving on the following page shows the water wheels and connections as applied to an engine of this kind at the Auburn, New York, water-works.

When water power alone is to be used, the steam cylinders are disconnected at the cross-heads, the pinion *F* is thrown into mesh with the large gear wheel *E*, and the pump end operated by the water wheels independently of the steam end.

Whenever the water power is insufficient, the pumps may be operated partially by steam and partially by water, thereby utilizing the latter to whatever extent it may be available from time to time.

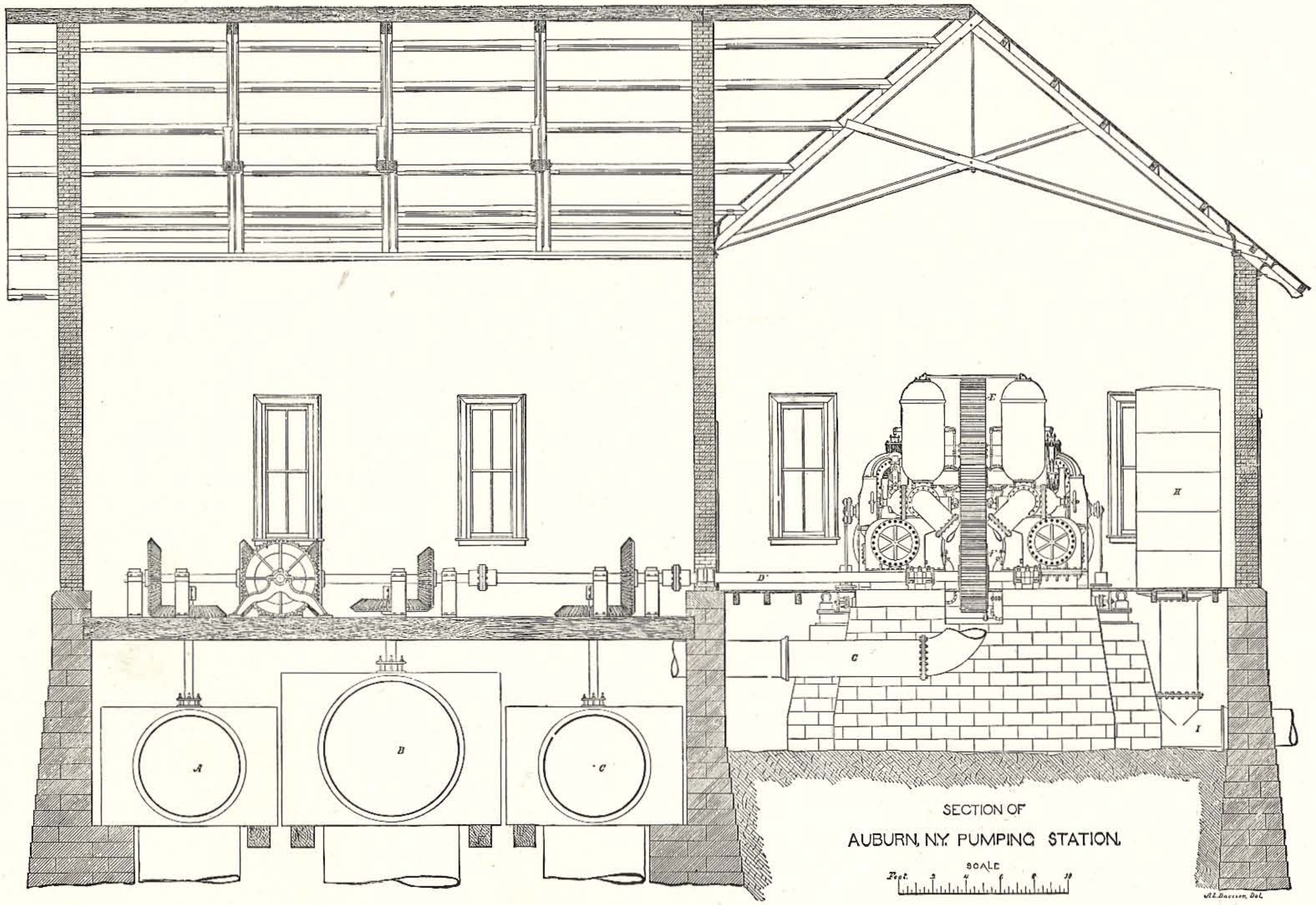
When no water power is available, the water wheel connection is severed, by throwing the pinion *F* out of mesh with the large gear wheel, and the pumps are operated by steam alone. When the engine is run in this way the large gear wheel serves as a fly wheel.

This special feature or combination of the Holly Steam Pumping Engine is of great value in places where the available water power is unequal to the maximum service required of the pumps.

When the engine at Auburn is run by steam alone, one horizontal tubular boiler five feet in diameter and fifteen feet long operates it to its full capacity of 7,500,000 gallons daily against 100 feet head.

An engine of this type but of 2,000,000 gallons daily capacity, is in successful operation at the pumping station of the South Denver, Colorado, water-works.

PLATE XXIII.



THE HOLLY COMBINED STEAM AND WATER POWER PUMPING ENGINE AND TURBINES

At the Owasco Lake Pumping Station, Auburn, New York.

CONDENSERS AND AIR PUMPS.

Where condensers are shown in the engravings of pumping engines in this catalogue, it will be noticed that they are jet condensers; but many of the engines that have been built by this Company are furnished with surface condensers, and this kind can be applied to any of the pumping engines illustrated herein if they are preferred to the jet condensers.

Surface condensers are usually preferred wherever the water is unfit for use in steam boilers, as the condensed steam or water from a surface condenser can be advantageously used for that purpose. And they are of special value where the water supply is not abundant, as by placing a surface condenser in either the suction or the discharge main, the water used for condensing the steam can be saved by returning it to the main after it has passed through the condenser. In a jet condenser this water would be wasted. The surface condensers are made in different forms to suit the places where they are to be installed.

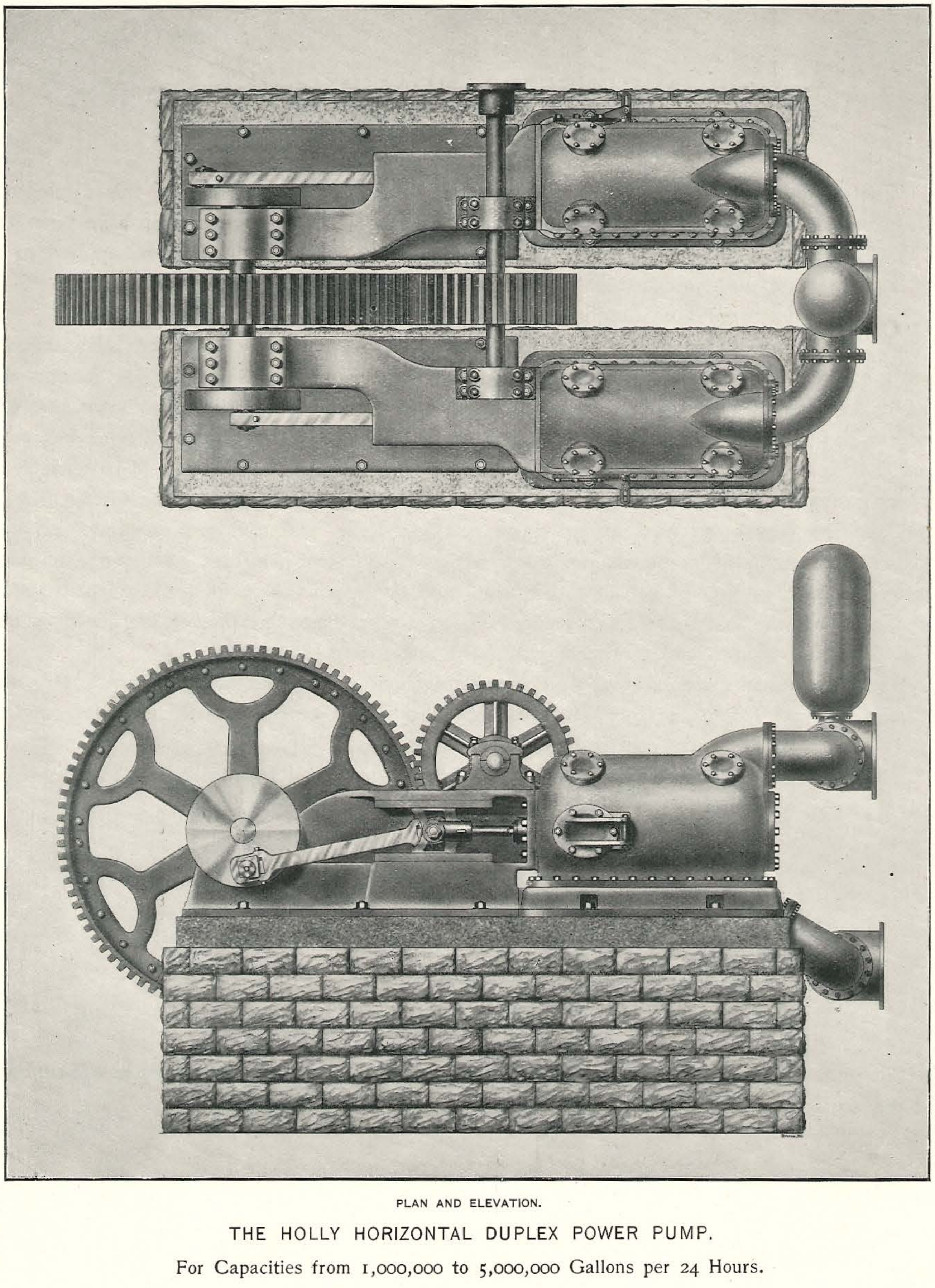
This Company owns a right to make and use Hill's patented surface condenser, which is expressly designed for use in the water mains of pumping engines. Its most important feature is a combination of valves with a side pipe or by-pass, by which the quantity of cold water entering the condenser is regulated so as to produce the proper degree of vacuum under different volumes and temperatures of the steam and water.

Surface condensers cost somewhat more to manufacture than jet condensers, but where the water is unfit for use in the boilers, or where the saving of the water used for condensation is an object, the extra cost is of little consequence.

The kind and dimensions of the air pumps are determined by the service to be rendered by the pumping engine.

FOUNDATIONS FOR HOLLY PUMPING ENGINES.

All pumping engines constructed by The Holly Manufacturing Company are self-contained, and require foundations sufficient only to support their weight.



PLAN AND ELEVATION.

THE HOLLY HORIZONTAL DUPLEX POWER PUMP.

For Capacities from 1,000,000 to 5,000,000 Gallons per 24 Hours.

WATER POWER PUMPING MACHINERY.

THE HOLLY HORIZONTAL DUPLEX POWER PUMP.

PLATE XXIV.

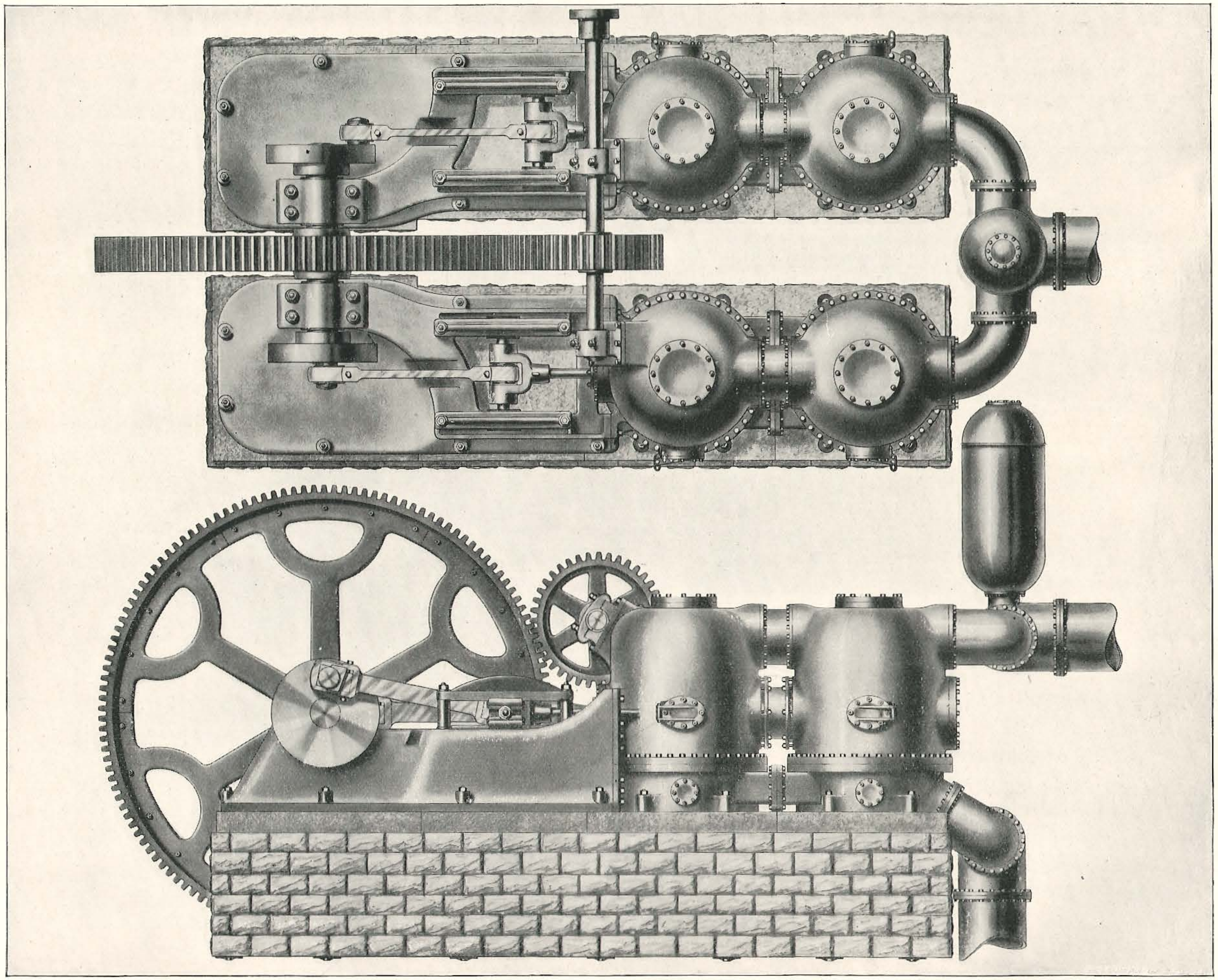
The power pump illustrated in plan and elevation on the opposite page is recommended for any service requiring from 1,000,000 to 5.000,000 gallons of water per 24 hours. The pump has two double-acting plungers working within horizontal cylindrical chambers that are set upon two cast-iron bedplates. The chambers and bedplates are firmly bolted at their inboard ends to two heavy cast-iron frames, making a combination of principal parts of extraordinary strength and stiffness, qualities that are necessary to any pump driven by power extraneously applied, as from a water wheel, a separate steam engine, electric or other motor. Power is applied to the pump at the flanged coupling on the long end of the intermediate shaft shown in the plan, and is transmitted through the pinion and wheel to the crank shaft, thence through the connecting rods, crossheads and piston rods to the pump plungers.

The cogs of the pinion and wheel are machine cut, and they work closely, evenly and noiselessly. The diameters of the pinion and wheel are made of such relative proportions as the speeds of the motor and the pump plungers may require in each case.

The crank discs are tightly fitted to the main shaft and keyed thereto with steel keys. The crank and crosshead pins are made of steel; the sliding gibs of bronze; the connecting rods of the best forged wrought-iron; the piston rods of steel; the shafts of either best forged or cold rolled iron; the crossheads of steel castings; the connecting rod boxes of bronze; all bolts of selected scrap iron turned and threaded to standard gauges.

The workmanship on the Power Pumps made by The Holly Manufacturing Company is equal in every respect to that on the pumps of its High Duty Steam Pumping Engines.

PLATE XXV.



PLAN AND ELEVATION OF

THE HOLLY SPECIAL HORIZONTAL POWER PUMP.

For Capacities from 5,000,0co to 50,000,000 Gallons per 24 Hours.

THE HOLLY SPECIAL HORIZONTAL POWER PUMP.

Plate XXV.

The engraving on the opposite page illustrates the Holly Horizontal Power Pump specially designed for capacities from 5,000,000 to 50,000,000 gallons of water per 24 hours.

The pump is composed of four upright, circular, double valve chambers, joined by flanged pipes that serve both as intermediate water passages and as connections for holding the four chambers together. The chambers are arranged in two pairs, and each pair has one plunger extending through outside glands from one chamber to the other. This arrangement is equivalent to a combination of four single-acting pumps with outside packed plungers. The two inboard chambers are rigidly bolted to the ends of two curvelinear triangular frames that have broad flanges and large surface on the bottom.

This combination of principal parts and the broad base for foundations, gives the extraordinary strength and stiffness that are requisite for a power pump of large capacity under heavy water pressure.

The frames support two wide pillow blocks that carry the crank shaft and large gear wheel, also two double slides that guide the crossheads.

Power is applied from water wheels, separate steam engines or other motors, at the flanged coupling on the long end of the intermediate shaft shown in the plan, and is transmitted through the pinion and wheel to the crank shaft, thence through the connecting rods, crossheads and piston rods to the pump plungers.

The cogs of the pinion and wheel are machine cut, and they work closely, evenly and noiselessly. The diameters of the pinion and wheel are made of such relative proportions as the speed of the motor and the pump plungers may require in each case.

The crank discs are tightly fitted to the main shaft and keyed thereto with steel keys. The crank and crosshead pins are made of steel; the sliding gibs of bronze; the connecting rods of the best forged wrought-iron; the piston rods of steel; the shafts of either best forged or cold rolled iron; the crosshead of steel castings; the connecting rod boxes of bronze; all bolts of selected scrap iron turned and threaded to standard gauges.

The water ways of this pump are exceptionally large, and it is highly recommended for irrigating extensive areas of land where water for power is available.

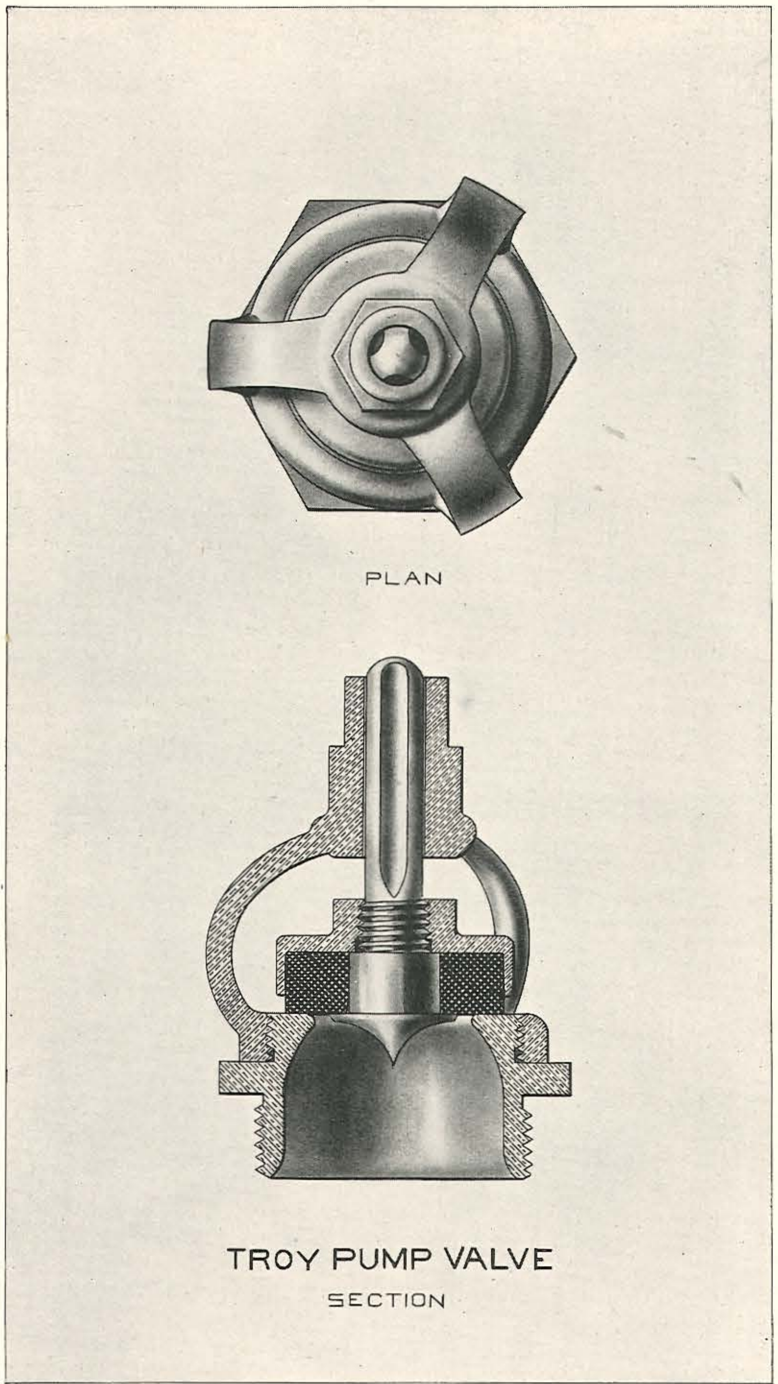
This Company has constructed pumping machinery to be driven by water power for the following places:

Allegan, Mich,	One set of	1,000,000	gallons	daily.
Alpena, Mich.,	"	2,000,000	"	"
Auburn, N. Y.,	"	4,000,000	"	"
Auburn, N. Y.,	"	7,500,000	"	"
Augusta, Me.,	"	3,000,000	"	"
Bangor, Me.,	"	4,000,000	"	"
Bangor, Me.,	"	5,000,000	"	"

Beaver Falls, Pa.,	One set of	1,500,000	gallons	daily.
Beaver Falls, Pa.,	"	2,000,000	"	"
Beaver Falls, Pa.,	"	2,000,000	"	"
Big Rapids, Mich.,	"	1,500,000	"	"
Big Rapids, Mich.,	"	1,500,000	"	"
Cohoes, N. Y.,	"	3,500,000	"	"
Denver, Colo.,	"	2,500,000	"	"
Denver, Colo.,	"	2,500,000	"	"
Denver, Colo.,	"	5,000,000	"	"
East Aurora, N. Y.,	"	700,000	"	"
Enterprise, Ore.,	"	700,000	"	"
Fort Collins, Colo.,	"	750,000	"	"
Fort Collins, Colo.,	"	750,000	"	"
Gouverneur, N. Y.,	"	1,500,000	"	"
Indianapolis, Ind.,	"	5,000,000	"	"
Indianapolis, Ind.,	"	5,000,000	"	"
Lockport, N. Y.,	"	2,000,000	"	"
Lockport, N. Y.,	"	3,000,000	"	"
Lockport, N. Y.,	"	5,000,000	"	"
Lynchburg, Va.,	"	3,000,000	"	"
Mamaroneck, N. Y.,	"	250,000	"	"
Marquette, Mich.,	"	1,500,000	"	"
Middletown, N. Y.,	"	2,000,000	"	"
Nashua, N. H.,	"	3,000,000	"	"
Nelson Knitting Co., Rockford, Ill.,	"	1,250,000	"	"
New Tacoma, Wash.,	"	1,000,000	"	"
North Yakima, Wash.,	"	1,250,000	"	"
North Yakima, Wash.,	"	1,250,000	"	"
Ogdensburgh, N. Y.,	"	2,000,000	"	"
Portsmouth, Va.,	"	1,750,000	"	"
Portsmouth, Va.,	"	600,000	"	"
Potsdam, N. Y.,	"	1,500,000	"	"
Pulaski, N. Y.,	"	1,000,000	"	"
Rochester, N. Y.,	"	2,000,000	"	"
Rochester, N. Y.,	"	2,000,000	"	"
Rockland, Me.,	"	1,000,000	"	"
Saratoga Springs, N. Y.,	"	2,000,000	"	"
Spokane, Wash.,	"	750,000	"	"
Spokane, Wash.,	"	750,000	"	"
Spokane, Wash.,	"	4,600,000	"	"
Spokane, Wash.,	"	3,200,000	"	"
Spokane, Wash.,	"	2,500,000	"	"
Spokane, Wash.,	"	2,500,000	"	"
Spokane, Wash.,	"	2,500,000	"	"
Spokane, Wash.,	"	2,500,000	"	"
Springville, N. Y.,	"	1,000,000	"	"
Suspension Bridge, N. Y.,	"	1,500,000	"	"
Suspension Bridge, N. Y.,	"	5,000,000	"	"
Tacoma, Wash.,	"	1,500,000	"	"
Tiffin, Ohio,	"	1,500,000	"	"
Vergennes, Vt.,	"	1,000,000	"	"

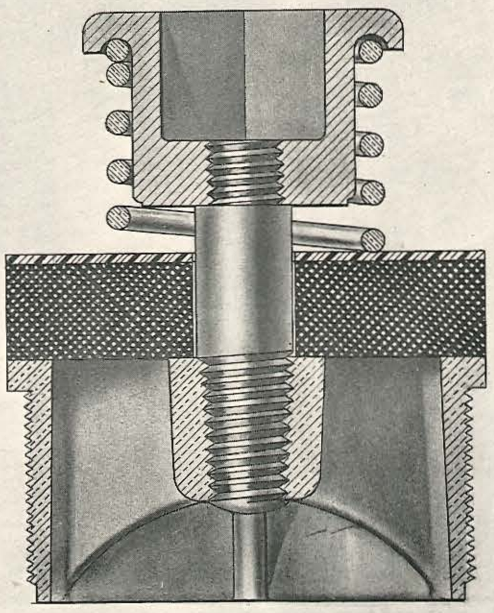
Total number of Water Power Pumps built by The Holly Manufacturing Co., 58. Total daily capacity, 131,050,000 gallons.

Plate XXVI.



The above engravings are about two-thirds full size of a pump valve used in many of the pumping engines of this Company. It is patented, and known as the "Troy Valve," having been first used at Troy, N. Y., in two 6,000,000 gallon pumping engines built by this Company for that city. The lift of the valve is equal to the area of the opening in the seat, so that the water passes through with uniform velocity. The low lift and elastic rubber face of the valve make its action noiseless at all speeds and pressures. A sufficient number of valves are placed in the pumps to insure the free passage of the maximum quantity of water to be delivered.

PLATE XXVII.



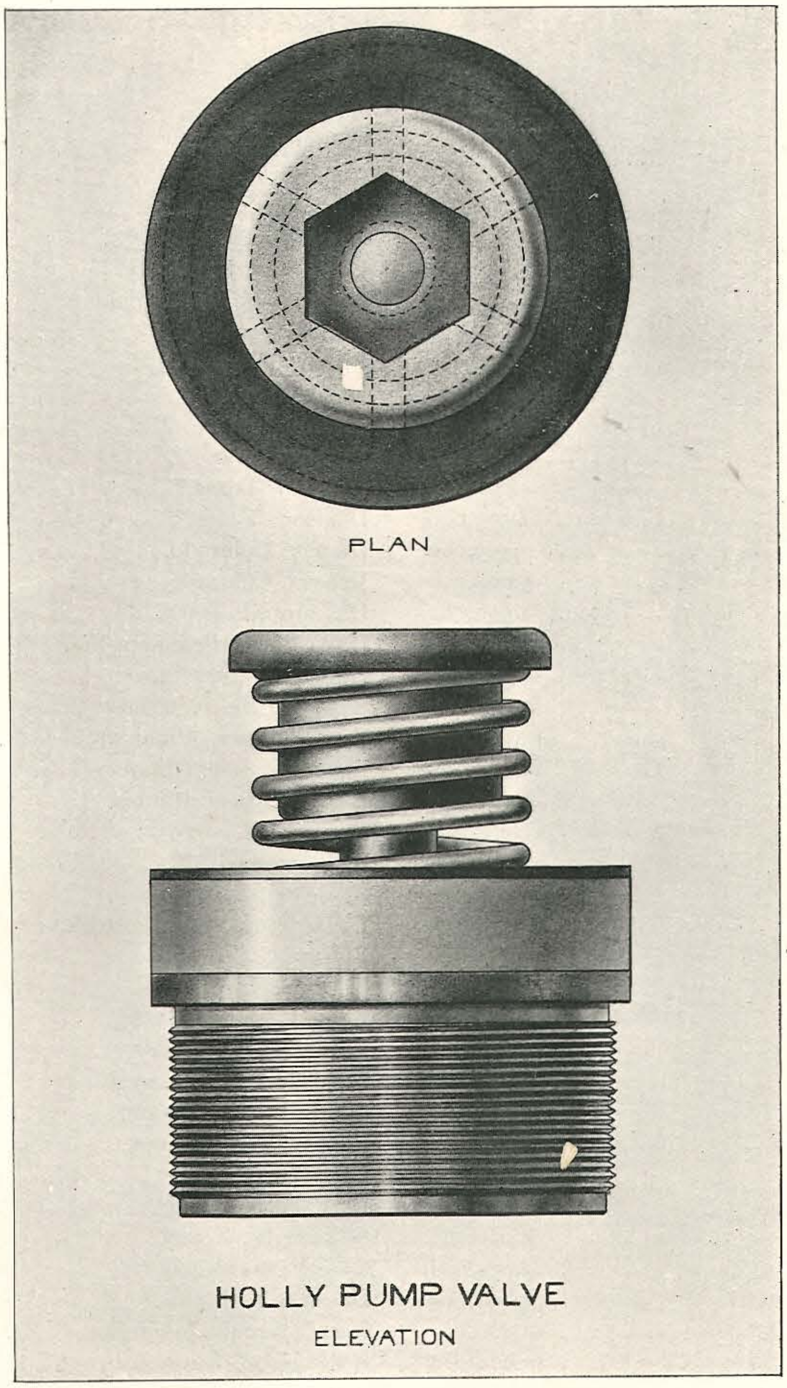
HOLLY PUMP VALVE

SECTION

The above and opposite engravings are about two-thirds full size of a new pump valve recently adopted by this Company for its large pumping engines.

The seat or body of the valve is of cast bronze of our own composition; the stem is of Tobin bronze; the spring is of the best drawn brass wire; and the disc is of fine vulcanized rubber, protected on top by a metal plate. The head or nut is cup shaped, with hexagon sides within so that a plug wrench can be used to remove it. When the nut is removed, the disc, spring, stem, and seat are all exposed for adjustment or repairs. Both sides of the disc are alike, and when worn on one side it can be turned over and the other side used so as to get double wearing surface.

The main features of the "Troy" valve—low lift and free water way—are retained in this new form. The increased size of this valve, however, gives larger valve area, while the addition of the spring insures quicker action and reduces to the lowest ratio the percentage of loss of water by slip.



HOLLY PUMP VALVE
ELEVATION

LIST OF

HIGH DUTY PUMPING ENGINES

BUILT BY THE HOLLY MANUFACTURING COMPANY.

Adrian, Michigan,	1,500,000
Adrian, Michigan,	1,500,000
Albuquerque, New Mexico,	3,000,000
Anniston, Alabama,	3,000,000
Anniston, Alabama,	3,000,000
Ashland, Wisconsin,	1,500,000
Ashland, Wisconsin,	1,500,000
Atlanta, Georgia,	10,000,000
Atlanta, Georgia,	10,000,000
Atlanta, Georgia,	10,000,000
Atlanta, Georgia,	10,000,000
Auburn, New York,	7,500,000
Austin, Texas,	5,000,000
Batavia, New York,*	1,500,000
Batavia, New York,	2,500,000
Bay City, Michigan,	5,000,000
Beatrice, Nebraska,	1,500,000
Beatrice, Nebraska,*	1,500,000
Beverly, Massachusetts,	2,000,000
Beverly, Massachusetts,	2,000,000
Binghamton, New York,	12,000,000
Boston, Massachusetts,	8,000,000
Boston, Massachusetts,	8,000,000
Brantford, Canada,	2,000,000
Brockville, Ontario,	1,500,000
Brockville, Ontario,	1,500,000
Bucyrus, Ohio,*	1,500,000
Buffalo, New York,	15,000,000
Buffalo, New York,	20,000,000
Buffalo, New York,	20,000,000
Buffalo, New York,	20,000,000
Burlington, Iowa,	3,000,000
Burlington, Iowa,	6,000,000
Burlington, New Jersey,	1,500,000
Canton, Ohio,	8,000,000
Chester, Pennsylvania,	4,000,000
Chester, Pennsylvania,	4,000,000
Cheyenne, Wyoming,	3,000,000
Chicago, Illinois,	12,000,000
Chicago, Illinois,	12,000,000
Chicago, Illinois,	12,000,000
Chicago, Illinois,	12,000,000
Chicago, Illinois,	12,000,000
Chicago, Illinois,	13,500,000
Chicopee, Massachusetts,	2,500,000
Cincinnati, Ohio,	6,000,000
Cincinnati, Ohio,	6,000,000
Clinton, Iowa,	5,000,000
Columbus, Indiana,	3,000,000
Columbus, Ohio,	10,000,000
Columbus, Ohio,	7,500,000
Columbus, Ohio,	7,500,000
Columbus, Ohio,	12,000,000
Columbus, Ohio,	12,000,000
Covington, Kentucky,	5,000,000
Covington, Kentucky,	5,000,000
Cumberland, Maryland,	4,000,000
Dallas, Texas,	8,000,000
Dallas, Texas,	6,000,000
Dallas, Texas,	10,000,000
Dayton, Ohio,	10,000,000
Dayton, Ohio,	15,000,000
Denison, Texas,*	1,500,000
Denison, Texas,*	1,500,000
Denver, Colorado,	6,000,000
Denver, Colorado,	6,000,000
Des Moines, Iowa,	5,000,000
Doylestown, Pennsylvania,	1,500,000
Duluth, Minnesota,	5,000,000
East Orange, New Jersey,	1,500,000
East Saginaw, Michigan,	12,000,000
East St. Louis, Illinois,	6,000,000
East St. Louis, Illinois,	8,000,000
Emporia, Kansas,	3,000,000
Erie, Pennsylvania,	5,000,000
Evanston, Illinois,	5,000,000
Fredericton, New Brunswick,	1,500,000
Fresno, California,	4,000,000
Flint, Michigan,	1,500,000
Flint, Michigan,	1,500,000
Frankfort, Kentucky,	2,000,000
Fond du Lac, Wisconsin,	3,000,000
Fond du Lac, Wisconsin,	3,000,000
Fort Wayne, Indiana,	6,000,000
Fort Worth, Texas,	8,000,000
Fort Worth, Texas,	8,000,000
Gainesville, Texas,	1,500,000
Galesburg, Illinois,*	1,500,000
Galesburg, Illinois,*	1,500,000
Grand Rapids, Michigan,	13,000,000
Hutchinson, Kansas,	1,500,000
Indianapolis, Indiana,	12,000,000
Jackson, Michigan,	4,000,000
Jackson, Michigan,	8,000,000
Jamestown, New York,	4,000,000
Joliet, Illinois,*	3,000,000
Kalamazoo, Michigan,	3,000,000
Kalamazoo, Michigan,	3,000,000
Kansas City, Missouri,	4,000,000
Kansas City, Missouri,	9,000,000

Kansas City, Missouri,	10,000,000
Kansas City, Missouri,	10,000,000
Keokuk, Iowa,	4,000,000
Lansing, Michigan,	5,000,000
La Salle, Illinois,	2,000,000
Leavenworth, Kansas,	5,000,000
Lexington, Kentucky,	1,500,000
Lexington, Kentucky,	1,500,000
Lima, Ohio,	3,000,000
Lima, Ohio,	3,000,000
Ludington, Michigan,	2,000,000
Manistee, Michigan,	4,000,000
Mankato, Minnesota,	1,500,000
Marquette, Michigan,	3,000,000
Mobile, Alabama,	6,000,000
Mobile, Alabama,	6,000,000
Muskegon, Michigan,	3,000,000
Muskegon, Michigan,	3,000,000
Nashville, Tennessee,	10,000,000
Norfolk, Virginia,*	2,000,000
Norfolk, Virginia,	5,000,000
Norfolk, Virginia,	7,000,000
Olean, New York,	2,000,000
Omaha, Nebraska,	5,000,000
Omaha, Nebraska,	14,000,000
Omaha, Nebraska,	3,000,000
Omaha, Nebraska,	8,000,000
Oshkosh, Wisconsin,	4,000,000
Oshkosh, Wisconsin,	4,000,000
Paducah, Kentucky,	2,000,000
Peekskill, New York,	3,000,000
Philadelphia, Pennsylvania,	20,000,000
Philadelphia, Pennsylvania,	30,000,000
Philadelphia, Pennsylvania,	30,000,000
Pittsburgh, Pennsylvania,	10,000,000
Pittsburgh, Pennsylvania,	10,000,000
Pittston, Pennsylvania,*	5,000,000
Port Huron, Michigan,	5,000,000
Port Huron, Michigan,	12,000,000
Portland, Oregon,	1,500,000
Portland, Oregon,	12,000,000
Portland, Oregon,	2,500,000
Poughkeepsie, New York,	5,000,000
Providence, Rhode Island,	36,000,000
Providence, Rhode Island,	36,000,000
Providence, Rhode Island,	36,000,000
Pueblo, Colorado,*	1,500,000
Pueblo, Colorado,	5,500,000
Pueblo, Colorado,	5,500,000
Richmond, Indiana,	4,000,000
Richmond, Indiana,	6,000,000
Rochester, New York,*	2,000,000
Rockford, Illinois,	3,000,000
Rockford, Illinois,	6,000,000
Rock Island, Illinois,	5,000,000
Saginaw, Michigan,	4,000,000
Salina, Kansas,	1,500,000
San Diego, California,	2,000,000
San Diego, California,	3,000,000
Saratoga Springs, New York,	5,000,000
Saratoga Springs, New York,	8,000,000
Savannah, Georgia,	12,000,000
Savannah, Georgia,	12,000,000
Seattle, Washington,	5,000,000
Schenectady, New York,	3,000,000
Schenectady, New York,	5,000,000
Sheboygan, Wisconsin,	4,000,000
Sioux City, Iowa,	3,000,000
Sioux City, Iowa,	3,000,000
South Bethlehem, Pennsylvania,	5,000,000
South Denver, Colorado,	2,000,000
Springfield, Ohio,	5,000,000
St. Joseph, Missouri,	6,000,000
Stockton, California,	5,000,000
Streator, Illinois,*	1,500,000
Streator, Illinois,*	1,500,000
Taunton, Massachusetts,	4,000,000
Terre Haute, Indiana,	6,000,000
Tiffin, Ohio,*	3,000,000
Tonawanda, New York,	2,000,000
Tonawanda, New York,	2,000,000
Tonawanda, New York,	2,000,000
Tonawanda, New York,	2,000,000
Topeka, Kansas,	4,000,000
Urbana, Ohio,	2,000,000
Valparaiso, Indiana,*	1,500,000
Washington, D. C.,	2,500,000
Washington, D. C.,	2,500,000
Wausau, Wisconsin,	3,000,000
Wausau, Wisconsin,	3,000,000
West Bay City, Michigan,	1,500,000
West Bay City, Michigan,	1,500,000
West New Brighton, New York,	5,000,000
Wheeling, West Virginia,	7,500,000
Wheeling, West Virginia,	7,500,000
Wichita, Kansas,	5,000,000
WORLD'S FAIR, Chicago,†	12,000,000
WORLD'S FAIR, Chicago,†	12,000,000
Zanesville, Ohio,	5,000,000

* High-pressure cylinders omitted.
† Now in use by the city.

Total number of High Duty Pumping Engines,	199
Total capacity in gallons per 24 hours, nominal head,	1,240,000,000
Total capacity in gallons per 24 hours, at an average head of 100 feet,	2,245,135,000
Average capacity, nominal head, of each engine,	6,231,155
Average capacity under mean head of 100 feet,	11,282,085

In addition to the High Duty Engines, the Company has built 255 Pumping Engines of other types, making a grand total of 454, to any and all of which reference is made as having fully met or exceeded every requirement and condition of the contracts under which they were constructed.

Complete List of Pumping Engines

BUILT BY

THE HOLLY MANUFACTURING COMPANY.

ALABAMA.

Name of Place.	*Style of Machinery.*	*Capacity.*
Anniston,	Horizontal High Duty,	3,000,000
Anniston,	Horizontal High Duty,	3,000,000
Mobile,	Horizontal High Duty,	6,000,000
Mobile,	Horizontal High Duty,	6,000,000

CALIFORNIA.

Fresno,	Horizontal High Duty,	4,000,000
Fresno,	Horizontal Duplex,	1,000,000
Sacramento,	Quadruplex,	3,000,000
San Diego,	Horizontal High Duty,	2,000,000
San Diego,	Horizontal High Duty,	3,000,000
Stockton,	Horizontal High Duty,	5,000,000

COLORADO.

Colorado Springs,	Quadruplex,	1,000,000
Denver,	Horizontal Water Power,	2,000,000
Denver,	Horizontal Water Power,	2,000,000
Denver,	Horizontal Water Power,	5,000,000
Denver,	Quarter Crank,	2,000,000
Denver,	Horizontal High Duty,	6,000,000
Denver,	Horizontal High Duty,	6,000,000
Denver,	Steam Power Engine,	....
Denver,	Horizontal Duplex,	4,000,000
Fort Collins,	Horizontal Water Power,	750,000
Fort Collins,	Horizontal Water Power,	750,000
Golden,	Quadruplex,	1,500,000
Greeley,	Horizontal Duplex,	1,000,000
Highlands,	Horizontal Duplex,	700,000
Pueblo,	Quadruplex,	1,500,000
Pueblo,	Horizontal High Duty,	1,500,000
Pueblo,	Horizontal High Duty,	5,500,000
Pueblo,	Horizontal High Duty,	5,500,000
Silver Cliff,	Quadruplex,	1,500,000
South Denver,	Horizontal High Duty,	2,000,000

DAKOTA.

Fargo,	Quadruplex,	1,500,000
Fargo,	Horizontal Duplex,	750,000
Fort Yates,	Horizontal Duplex.	200,000

DELAWARE.

Dover,	Horizontal Duplex,	1,000,000
Newark,	Horizontal Duplex,	500,000
Newark,	Horizontal Duplex,	500,000

DISTRICT OF COLUMBIA.

Washington,	Horizontal High Duty,	2,500,000
Washington,	Horizontal High Duty,	2,500,000

GEORGIA.

Name of Place.	*Style of Machinery.*	*Capacity.*
Atlanta,	Quadruplex,	3,000,000
Atlanta,	Quadruplex,	4,000,000
Atlanta,	Horizontal High Duty,	10,000,000
Atlanta,	Horizontal High Duty,	10,000,000
Atlanta,	Horizontal High Duty,	10,000,000
Atlanta,	Horizontal High Duty,	10,000,000
Savannah,	Horizontal High Duty,	12,000,000
Savannah,	Horizontal High Duty,	12,000,000

ILLINOIS.

Chicago,	Horizontal High Duty,	12,000,000
Chicago,	Horizontal High Duty,	12,000,000
Chicago,	Horizontal High Duty,	13,500,000
Chicago,	Quadruplex,	2,000,000
Chicago,	Horizontal High Duty,	12,000,000
Chicago,	Horizontal High Duty,	12,000,000
Chicago,	Horizontal High Duty,	12,000,000
Chicago,	Vertical Rotative,	4,000,000
Chicago,	Vertical Rotative,	4,000,000
Columb'n World's Exposition,	Horizontal High Duty,	12,000,000
Columb'n World's Exposition,	Horizontal High Duty,	12,000,000
Decatur,	Quadruplex,	1,000,000
East St. Louis,	Horizontal High Duty,	6,000,000
East St. Louis,	Horizontal High Duty,	8,000,000
Evanston,	Quadruplex,	2,000,000
Evanston,	Horizontal High Duty,	5,000,000
Galesburg,	Horizontal Rotative,	1,500,000
Galesburg,	Horizontal Rotative,	1,500,000
Joliet,	Horizontal Rotative,	3,000,000
LaSalle,	Horizontal High Duty,	2,000,000
Litchfield,	Quadruplex,	750,000
McCormick Harvester Co., Chicago, Ill.,	Horizontal Duplex,	1,800,000
McCormick Harvester Co., Chicago, Ill.,	Horizontal Duplex,	1,800,000
Monmouth,	Horizontal Duplex,	1,000,000
Nelson Knitting Co.,	Horizontal Water Power,	1,250,000
Rock Island,	Quadruplex,	2,000,000
Rock Island,	Quadruplex,	3,000,000
Rock Island,	Horizontal High Duty,	5,000,000
Rockford,	Quadruplex,	2,000,000
Rockford,	Horizontal High Duty,	3,000,000
Rockford,	Horizontal High Duty,	6,000,000
Streator,	Horizontal Rotative,	1,500,000
Streator,	Horizontal Rotative,	1,500,000
Taylorville,	Horizontal Duplex,	750,000

COMPLETE LIST OF PUMPING ENGINES — CONTINUED.

INDIANA.

Name of Place.	*Style of Machinery.*	*Capacity.*
Bluffton,	Horizontal Duplex,	1,000,000
Columbus,	Quadruplex,	1,500,000
Columbus,	Horizontal High Duty,	3,000,000
Connersville,	Quadruplex,	1,000,000
Evansville,	Vertical Rotative,	4,000,000
Evansville,	Vertical Rotative,	4,000,000
Fort Wayne,	Quadruplex,	3,000,000
Fort Wayne,	Horizontal Duplex,	2,000,000
Fort Wayne,	Vertical Triple Expansion,	6,000,000
Indianapolis,	Quadruplex,	6,000,000
Indianapolis,	Horizontal Water Power,	5,000,000
Indianapolis,	Horizontal Water Power,	5,000,000
Indianapolis,	Horizontal High Duty,	12,000,000
Jeffersonville,	Vertical Rotative,	1,500,000
Jeffersonville,	Vertical Rotative,	1,500,000
Laporte,		2,000,000
Michigan City,	Horizontal Duplex,	2,000,000
New Castle,	Horizontal Duplex,	750,000
New Castle,	Horizontal Duplex,	750,000
Plymouth,	Horizontal Duplex,	750,000
Plymouth,	Horizontal Duplex,	750,000
Richmond,	Horizontal High Duty,	4,000,000
Richmond,	Horizontal High Duty,	6,000,000
Terre Haute,	Vertical High Duty,	6,000,000
Valparaiso,	Horizontal Rotative,	1,500,000
Wabash,	Horizontal Duplex,	1,500,000
Wabash,	Horizontal Duplex,	1,500,000
Washington,	Horizontal Duplex,	1,500,000
Washington,	Horizontal Duplex,	1,000,000

IOWA.

Name of Place.	*Style of Machinery.*	*Capacity.*
Atlantic,	Quadruplex,	1,500,000
Atlantic,	Quadruplex,	1,000,000
Burlington,	Quadruplex,	3,000,000
Burlington,	Horizontal High Duty,	3,500,000
Burlington,	Horizontal High Duty,	6,000,000
Clinton,	Horizontal High Duty,	5,000,000
Des Moines,	Horizontal High Duty,	5,000,000
Fairfield,	Horizontal Duplex,	1,500,000
Iowa City,	Quadruplex,	1,500,000
Iowa City,	Horizontal Duplex,	1,000,000
Keokuk,	Quadruplex,	1,500,000
Keokuk,	Horizontal High Duty,	4,000,000
Le Mars,	Horizontal Duplex,	500,000
Le Mars,	Horizontal Duplex,	500,000
Oskaloosa,	Quadruplex,	1,500,000
Oskaloosa,	Quadruplex,	1,000,000
Sioux City,	Horizontal High Duty,	3,000,000
Sioux City,	Horizontal High Duty,	3,000,000

KANSAS.

Name of Place.	*Style of Machinery.*	*Capacity.*
Abilene,	Horizontal Duplex,	1,000,000
Clay Center,	Horizontal Duplex,	1,500,000
Emporia,	Quadruplex,	1,500,000
Emporia,	Vertical High Duty,	2,000,000
Hutchinson,	Horizontal Duplex,	1,500,000
Hutchinson,	Horizontal High Duty,	1,500,000
Leavenworth,	Horizontal High Duty,	5,000,000
Olathe,	Horizontal Duplex,	750,000
Salina,	Horizontal High Duty,	1,500,000
Topeka,	Quadruplex,	1,500,000
Topeka,	Quadruplex,	1,500,000
Topeka,	Horizontal High Duty,	4,000,000
Wichita,	Horizontal High Duty,	5,000,000

KENTUCKY.

Name of Place.	*Style of Machinery.*	*Capacity.*
Covington,	Quarter Crank,	4,000,000
Covington,	Vertical High Duty,	5,000,000
Covington,	Vertical High Duty,	5,000,000
Frankfort,	Vertical High Duty,	2,000,000
Lexington,	Horizontal High Duty,	1,500,000
Lexington,	Horizontal High Duty,	1,500,000
Louisville,	Horizontal Duplex,	3,000,000
Newport,	Vertical Rotative,	4,000,000
Newport,	Vertical Rotative,	4,000,000
Owensboro,	Vertical Duplex,	2,000,000
Paducah,	Vertical High Duty,	2,000,000
Paducah,	Vertical Rotative,	2,000,000

MAINE.

Name of Place.	*Style of Machinery.*	*Capacity.*
Augusta,	Horizontal Water Power,	3,000,000
Bangor,	Horizontal Engine, Quadruplex Pump,	4,000,000
Bangor,	Horizontal Water Power,	5,000,000
Rockland,	Rotary,	1,000,000
Winter Harbor,	Horizontal Duplex,	300,000

MARYLAND.

Name of Place.	*Style of Machinery.*	*Capacity.*
Cumberland,	Quarter Crank,	1,500,000
Cumberland,	Quadruplex,	2,000,000
Cumberland,	Horizontal High Duty, New Pattern,	4,000,000
Easton,	Horizontal Duplex,	500,000
Easton,	Horizontal Duplex,	250,000

MASSACHUSETTS.

Name of Place.	*Style of Machinery.*	*Capacity.*
Beverly,	Horizontal High Duty,	2,000,000
Beverly,	Horizontal High Duty,	2,000,000
Boston,	Horizontal High Duty,	8,000,000
Boston,	Horizontal High Duty,	8,000,000
Chicopee,	Horizontal High Duty,	2,500,000
Milford,	Quadruplex,	1,500,000
Randolph,	Horizontal Duplex,	2,500,000
Taunton,	Quadruplex,	2,000,000
Taunton,	Horizontal,	2,000,000
Taunton,	Horizontal High Duty,	4,000,000

MICHIGAN.

Name of Place.	*Style of Machinery.*	*Capacity.*
Adrian,	Horizontal High Duty,	1,500,000
Adrian,	Horizontal High Duty,	1,500,000
Allegan,	Rotary,	1,000,000
Alpena,	Rotary,	2,000,000
Bay City,	Quadruplex,	2,000,000
Bay City,	Horizontal High Duty,	5,000,000
Big Rapids,	Quarter Crank,	1,000,000
Big Rapids,	Horizontal Water Power,	1,500,000
Big Rapids,	Horizontal Water Power,	1,500,000
Cadillac,	Horizontal Duplex,	2,000,000
Dowagiac,	Horizontal Duplex,	1,000,000
Dowagiac,	Horizontal Duplex,	1,000,000
East Saginaw,	Quadruplex,	2,000,000
East Saginaw,	Quadruplex,	6,000,000
East Saginaw,	Horizontal High Duty,	12,000,000
East Tawas,	Horizontal Duplex,	750,000
East Tawas,	Horizontal Duplex,	750,000
Flint,	Horizontal High Duty,	1,500,000
Flint,	Horizontal High Duty,	1,500,000
Flint,	Horizontal Duplex,	4,000,000
Grand Rapids,	Horizontal High Duty,	13,000,000

COMPLETE LIST OF PUMPING ENGINES — CONTINUED.

MICHIGAN — *Continued.*

Name of Place.	*Style of Machinery.*	*Capacity.*
Jackson,	Quadruplex,	1,500,000
Jackson,	Horizontal High Duty,	4,000,000
Jackson,	Horizontal High Duty,	8,000,000
Kalamazoo,	Quadruplex,	2,000,000
Kalamazoo,	Vertical High Duty,	3,000,000
Kalamazoo,	Vertical High Duty,	3,000,000
Lansing,	Horizontal High Duty, New Pattern,	5,000,000
Ludington,	Horizontal Duplex,	3,000,000
Ludington,	Horizontal High Duty,	2,000,000
Marquette,	Quarter Crank,	1,500,000
Marquette,	Horizontal High Duty,	3,000,000
Manistee,	Quadruplex,	2,000,000
Manistee,	Horizontal Duplex,	750,000
Manistee,	Horizontal High Duty, New Pattern,	4,000,000
Muskegon,	Vertical High Duty,	3,000,000
Muskegon,	Vertical High Duty,	3,000,000
Port Huron,	Quadruplex,	2,000,000
Port Huron,	Horizontal High Duty,	5,000,000
Port Huron,	Horizontal High Duty,	12,000,000
Saginaw City,	Quadruplex,	2,000,000
Saginaw City,	Horizontal High Duty,	4,000,000
Vassar,	Horizontal Duplex,	1,500,000
West Bay City,	Horizontal High Duty,	1,500,000
West Bay City,	Horizontal High Duty,	1,500,000

MINNESOTA.

Duluth,	Horizontal High Duty,	5,000,000
Mankato,	Horizontal High Duty,	1,500,000

MISSOURI.

Carrollton,	Horizontal Duplex,	1,000,000
Kansas City,	Quadruplex,	3,000,000
Kansas City,	Horizontal Engine, Quadruplex Pump,	1,500,000
Kansas City,	Low Service,	7,000,000
Kansas City,	Quadruplex,	4,000,000
Kansas City,	Horizontal High Duty,	4,000,000
Kansas City,	High Duty Horizontal Engine, Vertical Pumps,	10,000,000
Kansas City,	High Duty Horizontal Engine, Vertical Pumps,	10,000,000
Kansas City,	Horizontal High Duty,	9,000,000
Sedalia,	Quarter Crank,	1,500,000
St. Joseph,	Horizontal High Duty,	6,000,000

NEBRASKA.

Beatrice,	Horizontal Rotative,	1,500,000
Beatrice,	Horizontal High Duty,	1,500,000
Chadron,	Horizontal Duplex,	1,000,000
Chadron,	Horizontal Duplex,	500,000
Omaha,	Horizontal High Duty,	5,000,000
Omaha,	Horizontal High Duty,	14,000,000
Omaha,	Horizontal High Duty,	3,000,000
Omaha,	Vertical Triple Expansion,	8,000,000
Seward,	Horizontal Duplex,	1,000,000

NEW HAMPSHIRE.

Nashua,	Horizontal Water Power,	3,000,000

NEW JERSEY.

Asbury Park,	Horizontal Duplex,	750,000
Asbury Park,	Horizontal Duplex,	500,000

NEW JERSEY — *Continued.*

Name of Place.	*Style of Machinery.*	*Capacity.*
Asbury Park,	Horizontal Duplex,	500,000
Atlantic City,	Horizontal Duplex, Sewerage,	4,000,000
Burlington,	Horizontal High Duty,	1,500,000
East Orange,	Horizontal High Duty,	1,500,000
Merchantville,	Horizontal Duplex,	500,000
Merchantville,	Horizontal Duplex,	500,000
Salem,	Quadruplex,	1,500,000

NEW MEXICO.

Albuquerque,	Horizontal High Duty,	2,000,000

NEW YORK.

Auburn,	Quadruplex,	4,000,000
Auburn,	Horizontal High Duty,	7,500,000
Auburn,	Horizontal,	7,500,000
Batavia,	Horizontal Duplex,	1,500,000
Batavia,	Horizontal Rotative,	1,500,000
Batavia,	Horizontal High Duty,	2,500,000
Binghamton,	Quadruplex,	2,000,000
Binghamton,	Quadruplex,	6,000,000
Binghamton,	Quadruplex,	1,000,000
Binghamton,	Horizontal High Duty,	12,000,000
Buffalo,	Quadruplex,	4,000,000
Buffalo,	Quadruplex,	6,000,000
Buffalo,	Horizontal High Duty,	15,000,000
Buffalo,	Horizontal High Duty,	20,000,000
Buffalo,	Horizontal High Duty,	20,000,000
Buffalo,	Horizontal High Duty,	20,000,000
Chatham,	Horizontal Duplex,	1,000,000
Cohoes,	Horizontal Water Power,	3,500,000
Dunkirk,	Quadruplex,	2,000,000
East Aurora,	Horizontal Water Power,	700,000
Flushing,	Quadruplex,	1,500,000
Fairport,	Horizontal Duplex,	500,000
Fort Niagara,	Horizontal Duplex,	500,000
Garden City,	Quadruplex,	1,500,000
Geneseo,	Horizontal Duplex,	600,000
Gouverneur,	Quadruplex,	1,500,000
Haverstraw,	Horizontal Duplex,	500,000
Jackson Lumber Co.,	Horizontal Duplex,	320,000
Jamaica,	Horizontal Duplex,	1,000,000
Jamaica,	Horizontal Duplex,	1,000,000
Jamestown,	Horizontal High Duty,	4,000,000
Lockport,	Quadruplex Water Power,	2,000,000
Lockport,	Horizontal Water Power,	3,000,000
Lockport,	Horizontal Water Power,	5,000,000
Long Island City,	Quadruplex,	3,000,000
Mamaroneck,	Horizontal Water Power,	250,000
Middletown,	Horizontal Water Power,	2,000,000
Ogdensburgh,	Horizontal Water Power,	2,000,000
Olean,	Horizontal High Duty,	2,000,000
Patchogue,	Horizontal Duplex,	700,000
Patchogue,	Horizontal Duplex,	700,000
Peekskill,	Horizontal High Duty,	3,000,000
Potsdam,	Horizontal Water Power,	1,500,000
Poughkeepsie,	Horizontal High Duty,	5,000,000
Pulaski,	Horizontal Water Power,	1,000,000
Rochester,	Horizontal Water Power,	2,000,000
Rochester,	Horizontal Water Power,	2,000,000
Rochester,	Quadruplex,	3,000,000
Rochester,	Horizontal Rotative,	2,000,000
Rockaway Beach,	Quadruplex,	1,500,000
Saratoga Springs,	Quadruplex,	2,000,000
Saratoga Springs,	Horizontal High Duty,	5,000,000

COMPLETE LIST OF PUMPING ENGINES — CONTINUED.

NEW YORK — *Continued.*

Name of Place.	*Style of Machinery.*	*Capacity.*
Saratoga Springs, . .	Horizontal High Duty, . . .	8,000 000
Schenectady, ...	Quarter Crank, ...	2,000,000
Schenectady, ...	Horizontal High Duty, . . .	3,000,000
Schenectady, ...	Horizontal High Duty, . . .	5,000,000
Springville, ...	Horizontal Water Power, . .	1,000,000
Suspension Bridge, .	Horizontal Water Power, . .	1,500,000
Suspension Bridge, .	Horizontal Water Power, . .	5,000,000
Tonawanda, ...	Horizontal High Duty, . . .	2,000,000
Tonawanda, ...	Horizontal High Duty, . . .	2,000,000
Tonawanda, ...	Horizontal High Duty, . . .	2,000,000
Tonawanda, ...	Horizontal High Duty, . . .	2,000,000
Troy, ...	Quadruplex, ...	6,000,000
Troy, ...	Quadruplex, ...	6,000,000
West New Brighton, .	Horizontal High Duty, . . .	5,000,000

OHIO.

Name of Place.	*Style of Machinery.*	*Capacity.*
Bucyrus, ...	Horizontal Rotative, ...	1,500,000
Canton, ...	Horizontal Water Power, . .	2,000,000
Canton, ...	Horizontal High Duty, . . .	8,000,000
Cincinnati, ...	Horizontal High Duty, . . .	6,000,000
Cincinnati, ...	Horizontal High Duty, . . .	6,000,000
Circleville, ...	Horizontal Duplex, ...	1,500,000
Circleville, ...	Horizontal Duplex, ...	1,500,000
Columbus, ...	Quadruplex, ...	3,000,000
Columbus, ...	Quadruplex, ...	4,000,000
Columbus, ...	Horizontal High Duty, . . .	10,000,000
Columbus, ...	Vertical Triple Expansion, . .	7,500,000
Columbus, ...	Vertical Triple Expansion, . .	7,500,000
Columbus, . . .	Horizontal High Duty, New Pattern, ...	12,000,000
Columbus, . . .	Horizontal High Duty, New Pattern, ...	12,000 000
Dayton, ...	Quadruplex, ...	4,000,000
Dayton, ...	Quadruplex, ...	4,000,000
Dayton, ...	Horizontal High Duty, . . .	10,000,000
Dayton, ...	Horizontal High Duty, New Pattern, ...	15,000,000
Dennison, ...	Horizontal Duplex, ...	2,000,000
Franklin, ...	Horizontal Duplex, ...	750,000
Franklin, ...	Horizontal Duplex, ...	750,000
Ironton, ...	Quarter Crank, ...	2,000,000
Kent, ...	Horizontal Duplex, ...	1,000,000
Kent, ...	Horizontal Duplex, ...	1,000 000
Kenton, ...	Quadruplex, ...	1,500,000
Kenton, ...	Horizontal Duplex, ...	1,000,000
Lima, ...	Horizontal High Duty, . . .	3,000,000
Lima, ...	Horizontal High Duty, . . .	3,000,000
Mansfield, ...	Quarter Crank, ...	[illegible],000,000
Middletown, ...	Quadruplex, ...	2,000,000
Norwalk, ...	Quarter Crank, ...	2,000,000
Portsmouth, ...	Quarter Crank, ...	2,000,000
Sidney, ...	Quarter Crank, ...	2,000,000
Springfield, ...	Horizontal High Duty, . . .	5,000,000
Tiffin, ...	Quadruplex, ...	1,500,000
Tiffin, ...	Horizontal Rotative, ...	3,000,000
Urbana, ...	Quadruplex, ...	1,500,000
Urbana, ...	Horizontal High Duty, . . .	2,000,000
Van Wert, ...	Horizontal Duplex, ...	1,500,000
Van Wert, ...	Horizontal Duplex, ...	1,500,000
Youngstown, ...	Quarter Crank, ...	2,000,000
Zanesville, ...	Horizontal High Duty, . . .	5,000,000

OREGON.

Name of Place.	*Style of Machinery.*	*Capacity.*
Enterprise, ...	Horizontal Water Power, . .	700,000
Portland, ...	Horizontal High Duty, . . .	1,500,000

PENNSYLVANIA.

Name of Place.	*Style of Machinery.*	*Capacity.*
Portland, ...	Horizontal High Duty, . . .	12,000,000
Portland, ...	Horizontal High Duty, . . .	2,500,000
Beaver Falls, ...	Horizontal Water Power, . .	2,000,000
Beaver Falls, ...	Horizontal Water Power, . .	2,000,000
Beaver Falls, ...	Quadruplex Water Power, . .	1,500,000
Bloomsburg, ...	Horizontal Duplex, ...	2,500,000
Butler, ...	Horizontal Duplex, ...	2,000,000
Chester, ...	Horizontal High Duty, . . .	4,000,000
Chester, ...	Horizontal High Duty, . . .	4,000 000
City Hall, Philadelphia,	Horizontal Duplex, ...	1,000,000
City Hall, Philadelphia,	Horizontal Duplex, ...	200,000
Corry, ...	Horizontal Duplex, ...	1,000 000
Corry, ...	Horizontal Duplex, ...	1,000,000
Danville, ...	Quarter Crank, ...	1,500,000
Doylestown, ...	Horizontal High Duty, . . .	1,500,000
Doylestown, ...	Duplex Compound, ...	1,500,000
Erie, ...	Horizontal High Duty, . . .	5,000,000
Holmesburg, ...	Horizontal Duplex, ...	1,000,000
Monongahela City. .	Horizontal Duplex, ...	1,000 000
Oil City, ...	Horizontal Duplex, ...	1,500,000
Philadelphia, ...	Horizontal High Duty, . . .	20,000,000
Philadelphia, ...	Vertical Triple Expansion, . .	30,000,000
Philadelphia, ...	Vertical Triple Expansion, . .	30,000,000
Philipsburg, ...	Horizontal Duplex, ...	1,000,000
Pittsburgh, ...	Vertical Compound High Duty,	10,000,000
Pittsburgh, ...	Vertical Compound High Duty,	10,000,000
Pittston, ...	Horizontal Rotative, ...	5,000,000
South Bethlehem, . .	Horizontal High Duty, . . .	5,000,000
Titusville, ...	Quadruplex, ...	2,000,000
Towanda, ...	Horizontal Duplex, ...	1,000,000
Union City, ...	Horizontal Duplex, ...	750,000
Union City, ...	Horizontal Duplex, ...	750,000

RHODE ISLAND.

Name of Place.	*Style of Machinery.*	*Capacity.*
Providence, . . .	Vertical Triple Expansion, Sewerage, ...	36,000,000
Providence, . . .	Vertical Triple Expansion, Sewerage, ...	36,000,000
Providence, . . .	Vertical Triple Expansion, Sewerage, . . , . .	36,000,000

TENNESSEE.

Name of Place.	*Style of Machinery.*	*Capacity.*
Memphis, ...	Quarter Crank, ...	4,000,000
Memphis, ...	Vertical, ...	4,000,000
Memphis, ...	Vertical, ...	4,000,000
Nashville, ...	Vertical High Duty, ...	10,000,000

TEXAS.

Name of Place.	*Style of Machinery.*	*Capacity.*
Austin, ...	Quadruplex, ...	3 000,000
Austin, ...	Horizontal High Duty, . . .	5,000,000
Dallas, ...	Horizontal High Duty, . . .	8,000 000
Dallas, ...	Horizontal High Duty, . . .	6,000,000
Dallas, ...	High Duty Horizontal Engine, Vertical Pumps, . .	10,000,000
Denison, ...	Horizontal Rotative, ...	1,500,000
Denison, ...	Horizontal Rotative, ...	1,500,000
Fort Worth, ...	Quadruplex, ...	3,000,000
Fort Worth, ...	Vertical Triple Expansion, . .	8,000,000
Fort Worth, ...	Vertical Triple Expansion, . .	8,000,000
Gainesville, ...	Horizontal High Duty, . . .	1,500 000

VERMONT.

Name of Place.	*Style of Machinery.*	*Capacity.*
Vergennes, ...	Rotary, ...	1,000,000

COMPLETE LIST OF PUMPING ENGINES — CONTINUED.

VIRGINIA.

Name of Place.	*Style of Machinery.*	*Capacity.*
Lynchburg,	Horizontal Water Power,	3,000,000
Norfolk,	Quadruplex,	2 000,000
Norfolk,	Horizontal Rotative,	2,000,000
Norfolk,	Horizontal High Duty,	5,000 000
Norfolk,	Vertical High Duty, Sewerage,	7,000,000
Portsmouth,	Horizontal Water Power,	1,750,000
Portsmouth,	Horizontal Water Power,	600,000
Radford,	Horizontal Duplex,	1,000,000
Richlands,	Horizontal Duplex,	1,000 000
Roanoke,	Horizontal Duplex,	2,000,000
Roanoke,	Horizontal Duplex,	2,000,000

WASHINGTON.

New Tacoma,	Horizontal Water Power,	1,000,000
North Yakima,	Horizontal Water Power,	1,250,000
North Yakima,	Horizontal Water Power,	1,250,000
Spokane Falls,	Horizontal Water Power,	750,000
Spokane Falls,	Horizontal Water Power,	750,000
Spokane Falls,	Horizontal Water Power,	3,200,000
Spokane Falls,	Horizontal Water Power,	4,600,000
Spokane Falls,	Horizontal Water Power,	2,500,000
Spokane Falls,	Horizontal Water Power,	2,500,000
Spokane Falls,	Horizontal Water Power,	2,500,000
Spokane Falls,	Horizontal Water Power,	2,500,000
Seattle,	Horizontal High Duty,	5,000,000
Tacoma,	Horizontal Water Motor,	1,500,000

WEST VIRGINIA.

Martinsburg,	Horizontal,	1,500,000
Wheeling,	Vertical High Duty,	7,500,000
Wheeling,	Vertical High Duty,	7,500,000

WISCONSIN.

Name of Place.	*Style of Machinery.*	*Capacity.*
Ashland,	Horizontal High Duty,	1,500,000
Ashland,	Horizontal High Duty,	1,500,000
Fond du Lac,	Horizontal High Duty,	3,000,000
Fond du Lac,	Horizontal High Duty,	3,000,000
Oshkosh,	Horizontal High Duty,	4,000,000
Oshkosh,	Horizontal High Duty,	4,000,000
Sheboygan,	Horizontal High Duty,	4,000,000
Stevens Point,	Horizontal Duplex,	2,000,000
Stevens Point,	Horizontal Duplex,	2,000,000
Wausau,	Horizontal High Duty,	3,000,000
Wausau,	Horizontal High Duty,	3,000,000

WYOMING.

Cheyenne,	Horizontal High Duty,	3,000,000

CANADA.

Brantford,	Horizontal High Duty,	2,000,000
Brockville,	Horizontal High Duty,	1,500,000
Brockville,	Horizontal High Duty,	1,500,000
Fredericton,	Horizontal High Duty,	1,500,000
Ste. Cunegondo,	Quadruplex,	1,500,000

Total number of Pumping Engines built by The Holly Manufacturing Company to date,	454
Total daily capacity, nominal, gallons,	1,725,120,000
Average daily capacity, nominal, gallons,	3,800,000
Total daily capacity, 100 feet head, gallons,	3,090,940,100
Average daily capacity, 100 feet head, gallons,	6,808,238

The above Pumping Engines represent about 54,588 net horse powers.

WATER.

Pure water consists of two parts hydrogen and one part oxygen. Chemical name Hydrogen oxyde, chemical symbol H_2O. Pure water is a colorless, odorless, tasteless, transparent liquid, and is practically incompressible. Water freezes at 32° F., and boils at 212° F. At its maximum density — 39.1° F. — it is the standard for specific gravities and 1 cubic centimeter weighs 1 gram.

1 United States gallon	=	231 cubic inches,
		.13369 cubic feet,
		8.3311 pounds — distilled water,
		8.34 pounds — in ordinary practice.
1 Cubic Foot . . .	=	62.425 pounds at 39.1° F., maximum density,
		62.418 pounds at 32° F., freezing point,
		62.355 pounds at 62° F., standard temperature,
		59.64 pounds at 212° F., boiling point,
		57.5 pounds at ice.
1 Cubic Foot . . .	=	7.485 U. S. gallons.
1 Pound	=	27.7 cubic inches.
1 Cubic Inch . . .	=	.03612 pounds.

A column of water one inch square and 2.31 feet high weighs one pound.

A column of water one inch square and one foot high weighs .433 pounds.

A column of water 33.947 feet high equals the pressure of the atmosphere at the sea level.

One pound per square inch equals a column of water 2.31 feet in height.

.433 pounds per square inch equals a column of water one foot in height.

Water is an almost universal solvent; consequently pure water does not occur in nature. Sea water contains nearly every known substance in solution.

The latent heat of water is 79 thermal units. When water freezes it gives off its latent heat. The latent heat of steam is 536 thermal units. When steam condenses into water it gives off its latent heat.

TABLE OF HORSE POWERS REQUIRED TO PUMP 1,000,000 GALLONS OF WATER AGAINST HEADS FROM 10 TO 400 FEET.

	10	20	30	40	50	70	90	100	125	150	175	200	225	250	275	300	325	350	375	400
	1.75	3.51	5.26	7.02	8.77	12.28	15.79	17.55	21.93	26.32	30.71	35.10	39.48	43.87	48.26	52.65	57.04	61.42	65.81	70.2
1.	1.93	3.68	5.44	7.19	8.94	12.45	15.96	17.72	22.03	26.5	30.80	35.28	39.75	44.06	48.53	52.83	57.30	61.6	66.07	70.37
2.	2.10	3.86	5.61	7.37	9.12	12.63	16.14	17.90	22.12	26.67	30.88	35.46	40.02	44.23	48.78	53.	57.56	61.77	66.33	70.56
3.	2.28	4.03	5.79	7.54	9.29	12.80	16.31	18.07	22.20	26.85	30.93	35.63	40.27	44.41	49 05	53.17	57.82	61.95	66.60	70.73
4.	2.45	4.21	5.96	7.72	9.47	12.98	16.49	18.25	22.30	27.03	31 06	35.81	40.55	44.59	49.31	53.35	58.18	62.12	66.86	70.89
5.	2.63	4.38	6.14	7.89	9.64	13.15	16.66	18.42	22.39	27.2	31.15	35.98	40.81	44.77	49.58	53.52	58.35	62.3	67.13	71.08
6.	2.80	4.56	6.31	8.07	9.82	13.33	16.84	18.60	22.47	27.38	31.24	36.16	41.07	44.94	49.83	53.7	58.61	62.47	67.39	71.25
7.	2.98	4.73	6 49	8.24	9.99	13.50	17.02	18.77	22.56	27.56	31.33	36.33	41.33	45.11	50.10	53.87	58.87	62.65	67.65	71.42
8.	3.15	4.91	6.67	8.42	10.17	13.68	17.19	18.95	22.65	27.73	31.41	36 51	41.60	45.29	50.36	54.06	59.04	62.83	67.91	71.6
9.	3.33	5.08	6.84	8.59	10.34	13.85	17.37	19.12	22.73	27.91	31.50	36.68	41.86	45.47	50.63	54.23	59.30	63.	68.18	71.77

TABLE SHOWING POUNDS OF COAL PER HORSE POWER PER HOUR AND EQUIVALENT DUTY.

Coal per Horse Power per hour.	Equivalent Duty.	Coal per Horse Power per hour.	Equivalent Duty.	Coal per Horse Power per hour.	Equivalent Duty.	Coal per Horse Power per hour.	Equivalent Duty.	Coal per Horse Power per hour.	Equivalent Duty.	Coal per Horse Power per hour.	Equivalent Duty.	Coal per Horse Power per hour.	Equivalent Duty.	Coal per Horse Power per hour.	Equivalent Duty.
4.950	40m.	3.960	50m.	3.300	60m.	2.828	70m.	2.475	80m.	2.2	90m.	1.980	100m.	1 8	110m.
4.829	41m.	3 882	51m.	3.245	61m.	2.788	71m.	2.444	81m.	2.175	91m.	1.96	101m.	1.783	111m.
4.714	42m.	3.807	52m.	3.193	62m.	2.75	72m.	2.419	82m.	2.152	92m.	1.941	102m.	1.767	112m.
4.604	43m.	3.735	53m.	3.142	63m.	2.712	73m.	2.385	83m.	2.129	93m.	1.922	103m.	1.752	113m.
4.500	44m.	3.666	54m.	3.093	64m.	2.675	74m.	2.357	84m.	2.106	94m.	1.903	104m.	1.736	114m.
4.40[illegible]	45m.	3.6	55m.	3.046	65m.	2.64	75m.	2.329	85m.	2.084	95m.	1.885	105m.	1.721	115m.
4.304	46m.	3.535	56m.	3.000	66m.	2.605	76m.	2.302	86m.	2.062	96m.	1.867	106m.	1.706	116m.
4.212	47m.	3.473	57m.	2.955	67m.	2.571	77m.	2.275	87m.	2.041	97m.	1.850	107m.	1.692	117m.
4.125	48m.	3.413	58m.	2.911	68m.	2.538	78m.	2.250	88m.	2.02	98m.	1.833	108m.	1.677	118m.
4 040	49m.	3.355	59m.	2.869	69m.	2.506	79m.	2.224	89m.	2.000	99m.	1.816	109m.	1.663	119m.

This table may be extended by aid of the following rule.

RULE.—Divide by 2. the quantity of coal standing opposite one-half of the required duty.

EXAMPLE.—Required coal per horse power per hour and equivalent of 150m. duty. 150m. divided by 2. equals 75m. Quantity of coal opposite 75m. in the table is 2.64 which divided by 2. gives 1.32 pounds of coal per hour per horse power as the Equivalent of 150m. duty.

TABLE SHOWING NUMBER OF GALLONS OF WATER DISCHARGED THROUGH DIFFERENT SIZED APERTURES, UNDER DIFFERENT HEADS OF WATER, IN A MINUTE, AND IN TWENTY-FOUR HOURS.

Diameter of Aperture in Inches.		1-32		1-16		1-8		3-16		1-4		3-8		1-2		5-8		3-4		7-8	
		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.	
Head of Water, in feet.	Lbs. Pressure per square inch.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.
20	8.8	.085	122.4	.34	489.6	1.36	1958.4	3.07	4,420	5.47	7,876	12.31	17,726	21.88	31,507	34.1	49,104	49.2	70,848	67.	96,480
40	17.6	.12	172.8	.48	691.2	1.93	2779.2	4.35	6,264	7.73	11,131	17.40	25,056	30.94	44,553	48.3	69,552	69.6	100,22[illegible]	94.7	136,368
60	26.4	.148	213.1	.59	849.6	2.36	3398.4	5.32	7,660	9.47	13,636	21.31	30,686	37.89	54,561	59.2	85,248	87.25	125,640	116.	167,040
80	35.2	.17	244.8	.68	979.2	2.73	3931 2	6.15	8,856	10.94	15,753	24.62	35.452	43.76	63,014	68.3	98,352	98.4	141,696	134.	192,960
100	44.	.191	275.	.76	1094.4	3.05	4392.	6.88	9,907	12.24	17,425	27.54	39,657	48.95	70,488	76.4	110,016	110.1	158,544	149.9	215,856
120	52.8	.21	302.4	.83	1195.2	3.35	4824.	7.53	10,843	13.4	19,296	30.15	43,416	53.6	77,184	83.7	120,528	120.6	173,664	164.1	236,304
140	61.6	.227	326.8	.905	1303.2	3.61	5198.4	8.14	11,721	14.48	20,851	32.58	46,915	57.91	83,390	90.49	130,305	130.3	187,632	177.3	255,312
160	70.4	.242	348.4	.967	1392.4	3.86	5558.4	8.8	12,672	15.47	22,276	34.81	50,126	61.88	89,107	96.69	139,233	139.2	200,448	189.5	272,880
180	79.2	.257	370.	1.02	1468.8	4.1	5904.	9.23	13,291	16.38	23,587	36.93	53,179	65.65	94,536	102.58	147,715	147.7	212,688	201.	289,440
200	88.	.271	390.2	1.08	1555.2	4.32	6220.8	9.73	14,011	17.30	24,912	38 94	56,073	69.23	99,591	108.17	155.764	155.7	224,208	212.	305,280

Diameter of Aperture in Inches.		1		1 1-8		1 1-4		1 3-8		1 1-2		1 3-4		2		2 1-4		2 1-2	
		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.	
Head of Water, in feet.	Lbs. Pressure per square inch.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.
20	8.8	87.5	126,000	110.7	159,408	136.7	196,848	165.4	238,176	196.9	283,536	268.	385,920	350.1	504,144	443.1	638,064	547.1	787,824
40	17.6	123.7	178,128	156.6	225,504	193.3	276,352	233.9	336,816	278.4	400,896	379.	545,760	495.	712,800	626.5	902,160	773.5	1,113,840
60	26.4	151.5	218,160	191.8	266,192	236.8	340,992	286.5	412,560	341.5	491,760	464.	668,160	606.2	872,928	767.3	1,104,912	947.3	1,364,112
80	35.2	175.	252,000	221.5	318,960	273.5	393,840	330.9	476,496	393.9	567,216	536.1	771,984	700.2	1,008,288	886.2	1,276,128	1094.1	1,575,504
100	44.8	195.8	281,952	247.8	356,832	305.8	440,352	370.2	533,088	440.6	634,464	599.7	863,568	783.3	1,127,952	991.4	1,427,616	1223.9	1,762,416
120	52.8	214.4	308,736	271.3	390,672	335.	482,400	405.3	583,632	482.4	694,656	656.6	945,504	857.7	1,235,088	1085.5	1,563,120	1340.2	1,929,888
140	61.6	231.6	333,504	293.2	422,208	361.9	521,136	437.9	630,576	521.2	750,528	709.4	1,021,536	926.7	1,334,448	1172.8	1,688,832	1447.9	2,084,976
160	70.4	247.5	356,400	313.2	451,008	386.7	556,848	467.9	673,776	556.9	801,936	758.	1,091,520	990.1	1,425,744	1253.1	1,804,464	1547.	2,227,680
180	79.2	262.6	378,144	332.3	478,512	410.3	590,832	496.4	714,816	590.8	850,752	804.2	1,158,078	1050.4	1,512,576	1329.4	1,914,336	1641.3	2,363,472
200	88.	276.9	398,736	350.4	504,576	432.6	622,944	523.5	753,840	623.	897,120	848.	1,221,120	1107.6	1,594,944	1401.9	2,018,736	1730.7	2,492,208

Diameter of Aperture in Inches.		2 3-4		3		3 1-2		4		4 1-2		5		5 1-2		6	
		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.		Gallons Discharged.	
Head of Water, in feet.	Lbs. Pressure per square inch.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.	Per Minute.	Per 24 Hours.
20	8.8	665	957,600	787	1,134,144	1072	1,543,680	1400	2,016,576	1772	2,551,680	2188	3,151,296	2660	3,830,400	3148	4,533,120
40	17.6	944	1,359,360	1113	1,603,584	1516	2,183,040	1980	2,851,200	2506	3,608,640	3094	4,455,360	3776	5,437,440	4452	6,410,880
60	26.4	1151	1,657,440	1366	1,967,040	1856	2,672,640	2424	3,491,712	3068	4,419.648	3789	5,456,448	4604	6,629,760	5464	7,868,160
80	35.2	1329	1,913,760	1575	2,268,864	2144	3,087,736	2801	4,032,152	3544	5,105,512	4376	6,302,016	5316	7,655,040	6300	9,112,000
100	44.8	1478	2,128,320	1762	2,537,856	2398	3,454,272	3133	4,511,808	3964	5,710,464	4895	7,049,664	5912	8,513,280	7048	10,149,120
120	52.8	1628	2,344,320	1929	2,778,624	2626	3,782,016	3430	4,940,352	4342	6,252,480	5361	7,719,552	6512	9,377,280	7716	11,111,040
140	61.6	1760	2,534,400	2084	3,002,112	2837	4,086,144	3706	5,337,792	4691	6,755,328	5791	8,339,904	7040	10,137,600	8336	12,003,840
160	70.4	1880	2,707,200	2227	3,207,744	3032	4,366,080	3960	5,702,976	5012	7,217,856	6188	8,910,720	7520	10,828,800	8908	12,827,520
180	79.2	1994	2,871,360	2363	3,403,008	3216	4,632,312	4200	6,050,304	5316	7,657,344	6565	9,453,888	7976	11,485,440	9452	13,610,880
200	88.	2102	3,026,880	2492	3,588,480	3392	4,884,480	4430	6,379,776	5607	8,074,944	6922	9,968,832	8408	12,107,520	9968	14,353,920