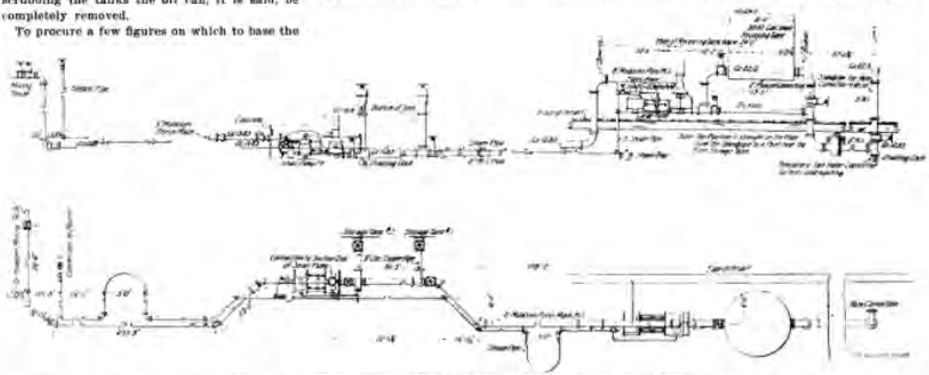
A Molasses Pumping Plant in Boston.

When the engineers of the Boston Molasses Co. undertook last winter to design a pumping equipment and pipe lines for discharging molasses from tank steamers into tanks in the company's storehouses at the head of its wharf, they could find no published data to furnish precedents and very little information of any sort, in spite of the fact that a few such installations were already in existence. If it could be pumped, it could be carried in tank steamers as oil is carried, thus saving the packages, the cost of which runs from 10 to 100 per cent. of the cost of the molasses itself, time in loading and discharging, space in vessels and on shore, and leakage, which latter is a big item with the wooden method of shipping. The cost of handling is much reduced and cooperage is eliminated by shipping in tank steamers. Nowadays there are tank steamers plying between Atlantic and the Gulf ports, which carry molasses from March to October, and oil the remainder of the year, the molasses being more economically pumped in the warm weather. By battening down the hatches after discharging a cargo of oil, it is possible to thoroughly steam out the hold, and then by scrubbing the tanks the oil can, it is said, be completely removed.

To procure a few figures on which to base the design of its plant, the Boston Molasses Co. at first set up a small pump in its warehouse and made a rough test. A 4x4-in. triplex pump attached to a gasoline engine was placed over a 200-gal. hogshead so as to have a suction lift averaging about 6 ft., through a 2½-in. wrought-iron pipe, and discharged against a head of 12 ft. through a 2-in. wrought-iron pipe into a tank, the object being to determine the coefficient of friction for the flow of molasses in the pipe. The results of these tests were as follows, average figures being given: The specific gravity of the molasses, 1.4; its temperature, about 40° Fahr.; rate of flow in feet per minute in the suction pipe, 8; and in the discharge, 11; average number of gallons pumped per minute, 2; average number of revolutions of pump per minute, 64; average discharge pressure, 25 lb. gauge and vacuum gauge on suction, 5.3 in. average. From these data the coefficient of friction was computed in accordance with a method which will be stated subsequently, the value obtained being 160. The trial was very unsatisfactory, as the temperatures were too low and the suction lift too great; hence the results were regarded as of almost no practical value.

Other plants were then visited for data. At Macahan's sugar refinery, Philadelphia, there are twelve steel tanks 43 ft. in diameter and 28 ft. high, each holding approximately 365,000 gal., with a 5,000-gal. receiving tank and a 14x10x16-in. duplex pump on the wharf. Vessels discharge to the receiving tank, which is on an elevated platform, and the molasses flows from this tank into the 8-in. suction end of the pump, from which it is forced through a 6-in. wrought-iron pipe line into one of the storage tanks, the distance pumped varying from 200 to 800 ft. Their average rates of pumping were reported to be 20,000 gal. per hour with a discharge pressure of 80 lb. gauge in summer, and 8,000 gal. per hour with a pressure of 120 lb. in winter. The accompanying detailed pumping records were obtained for 1903. The discharge pressures are pounds per square inch by gauge, and the temperatures of the molasses are in degrees Fahrenheit:

Month.	Time, hrs.	Quantity, gal.	Distance, ft.	Discharge pressure.	Temperature of molasses.
Feb.	9.5	150,000	725	120	--
Feb.	10.5	242,000	320	120	--
Mar.	12.5	240,000	465	120	--
Mar.	14.5	243,000	350	130	65
Apr.	11.0	240,000	350	--	--
Apr.	10.0	240,000	350	110	72
May	10.0	238,000	350	--	--
May	10.0	230,000	350	100	--
June	11.0	255,000	350	--	--
June	11.0	253,000	315	80	74



General Diagram of Pumps and Piping for Molasses Pumping Plant.

At the Columbus Distillery Co.'s plant in Brooklyn there is a 6x6x6-ft. receiving tank and a 13½x10x18-in. single pump on the wharf which forces the molasses through a 6-in. wrought-iron pipe to two storage tanks about 500 ft. distant. These storage tanks are 60 ft. in diameter and 30 ft. high, holding 600,000 gal. each. The discharge pipe from the pump formerly entered the tanks at the top, that is, 30 ft. above the ground, giving that head at all times, a disadvantage which has recently been remedied. The usual pressure on the pump discharge is 90 lb. by gauge, and in March the pressure was 100 lb. In July the quantity discharged averaged 20,000 gal. per hour. At the Great White Spirit Co.'s works, in Boston, not now in operation on account of the failure of the company, there is a receiving tank 16 ft. in diameter, 5 ft. high, from which a 14x12x18-in. duplex pump forces the molasses through a pipe line 8 in. in diameter, 220 ft. long against a vertical lift of 36 ft., into the storage tank 60 ft. in diameter by 47 ft. high, holding approximately 1,000,000 gal., the usual discharge pressure being about 80 lb. by gauge. Some 600,000 gal. have been pumped by this plant in 28 hr. With the storage tank full 10,000 gal. have been discharged by gravity into a tank car in 12 min. through a 10-in. pipe approximately 34 ft. long, with an 8-in. nozzle, the head being approximately 35 ft. from the surface of the molasses in the tank to the top of the car. At the Macahan works the pipe is partly underground, partly under plank floors, and partly under the wharf. The Columbus Distilling Co.'s pipe lies on top of the ground exposed for most of its length, although part is in one of their buildings which is kept warm for the process of manufacturing. At the Great White Spirit Co.'s works the pipe lies mostly on the wharf, although a part of it is under a shed. The effect of cold on the pipe friction has already been referred to in noting the variations in pressure on the pump discharge in the different plants, but to this it may be added that the Louisiana Distilling Co. attempted to pump molasses about a mile through a 6-in. pipe; the discharge pressure was so great that the pipe line burst.

The data thus collected were used in determining the friction losses in pipes, the formula, given in "Mechanics of Engineering," by Prof. I. P. Church, based on Bernouilli's theorem, being employed. In this manner the coefficient of friction, f, was worked out for the seven complete sets of these data to be, respectively, 0.26, 0.27, 0.54, 0.18, 0.17, 0.12, 0.15, the average being 0.242. Data from the Columbus Distilling Co. gave as the value of f, 0.30. To compute the pipe sizes and the power required for the Boston plant, the maximum value of f, 0.54, given above, was selected. The first problem was to calculate the size of the pipe line from the receiving tank and pump on the wharf to the storage tanks to deliver 600,000 gal. in 36 hours, the length of the pipe line being 450 ft. A pressure of 100 lb. was assumed for the discharge, and an 18x9x18-in. pump with 60 lb. steam pressure, which would allow 240 lb. back pressure. Introducing these values into the formula and solving for the diameter gave 0.62, and so an 8-in. standard pipe would be required on these conditions. The size of the pipe line from the storage tanks to the mixing room was computed by the same method assuming a discharge pressure of 130 lb. and a 12x6x12-in. duplex pump with 60 lb. steam pressure, a length of line equal to 450 ft., f equal to 0.54, and a discharge of 7,500 gal. per hour. These assumptions gave for the diameter a value of 0.4, indicating a 5-in. standard pipe.

Pump sizes were arrived at by computations in the following way. Experience at other places indicated that the molasses should flow to the suction side of the pump, so that there

would be little if any suction lift, and that the pump should make long strokes. Data on the efficiencies of pumps handling molasses at the Macahan and Columbus works showed that it approximated 50 per cent. On this basis the pump on the wharf, in order to handle 600,000 gal. in 36 hours, or 227 gal. per minute, should have a capacity of 554 gal. per min., and for this an 18x9x18-in. duplex pump at 50 strokes per minute would be required. Similarly, the pump for delivering molasses from the storage tanks to the mixing room at the rate of 7,500 gal. per hour, or 125 gal. per minute, should be a 12x6x12-in. duplex pump at 80 strokes per minute.

The power necessary to operate the pumps had to be estimated in order to know what demands would be made upon the boiler plant of the establishment and what size the steam-transmission main should have. For the large pump, on the basis of the figures just given, it was computed that 29-horse-power would be required, and that, allowing 20 per cent. for friction loss, the pressure on the steam end should be 30 lb. by gauge. The small pump was estimated to require 18 h.p. with steam at 40 lb. gauge. The steam-transmission problem was a little out of the ordinary on account of the length of the pipe and the exposure of a portion of the line. The distance from the boilers to the pump on the wharf is 900 ft.

As the plant was built, some changes were made from the sizes indicated by the computations. Accompanying drawings suggest the general arrangement and show some details of the pumping equipment. On the wharf at a convenient point there is an 8-in. standpipe with an elbow at a suitable height for making connection with the vessel's pump force main by means of hose. From this standpipe the 8-in. line extends under the wharf to a 5,000-gal. steel receiving tank, which, with a 16x8½x18-in. Warren duplex pump, are located in a small wooden building near the head of the wharf. The receiving tank is on an elevated platform at such a height that the molasses flows into the pump suction under a head of not less than about 5 ft. The molasses cylinders of the pump are lined with composition on barrels and heads, and the stuffing boxes are of composition. The piston rods are of Tobin bronze, and metal ring packing is used in the molasses cylinders. The pump valves are composition disk valves of large area ground to composition seats. The pump has a long stroke and is fitted with outside adjustable valve gear to prevent short stroking. This pump is estimated to have a displacement efficiency of only 50 per cent. in cold weather, giving a capacity of 15,000 gal. per hour. It will be observed that the steam end is large compared to the pump end.

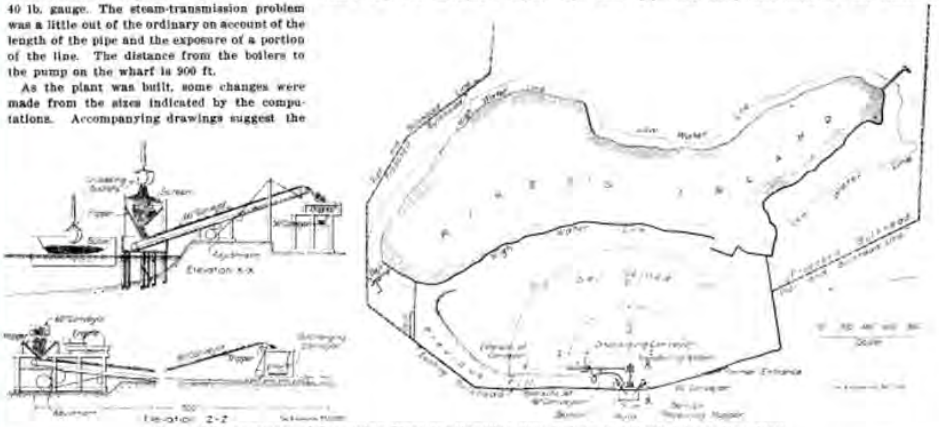
The pump on the wharf discharges through an 8-in. wrought-iron pipe line, partly suspended under the wharf and partly buried in the ground, into the storage tanks. Near the storage tanks, in a concrete pit near the floor of the storehouse, is a 12x6x12-in. Warren duplex pump used for supplying molasses from the storage tanks to the mixer room. The pipe line for this pump is 5 in. in diameter, with an extreme length of about 450 ft. The molasses pipe lines are of wrought iron with cast-iron fittings, the elbows being the extra long turn pattern. Gates valves are inserted at the convenient points. The pipe lines are laid at such inclinations that they can be drained at certain points, and a connection can be made for flushing them with salt water from beneath the wharf if this should ever be desired. The portions of the pipe lines underground are enclosed in a cypress box along with the steam pipe and the box is filled with dry sand. The 8-in. pipe is exposed for 250 ft. under the wharf, this portion being supported by iron U-hangers and painted with asphalt but not covered. In each connection at the storage tanks a short length of corrugated copper pipe was used in order to prevent damage to the pipe line if the tank should settle; the tanks rest on concrete bases 2 ft. thick supported by piles. No rubber was used in any part of the molasses pipe lines, because rubber is rapidly rotted by the action of the molasses; all gaskets are copper. Flange unions were placed in the line at the ends of alternate lengths of pipe; no expansion joints were used in the molasses line.

For the steam line 3½-in. wrought-iron pipe was used so as to provide sufficient capacity to permit the future installation of a second 16x8½x18-in. pump, if it should ever be required. Two long U expansion bends were placed in this line at points indicated on the drawings. The portion of the pipe line under the wharf is not covered. A No. 1 Walworth steam trap was placed in the line at each pump.

When the pumps and pipe lines were installed and the tanks completed, they were filled with salt water and tested for tightness as well as to see that everything was in good working order. The first practical test of the plant under working conditions was made July 18 to 20, when the steamship Toledo, of the Son Line, arrived with a cargo of 500,000 gal. of "blackjack" in tanks. The steamer began discharging about 11 A. M. Monday, and after running as nearly continuously as possible for 28½ hours, finished about 3 A. M. on Wednesday. The cargo could have been discharged in 22 hours had the vessel's pumping plant been suitable; the pump on the wharf did not receive the molasses fast enough to keep it employed at more than from one-quarter to one-half its capacity, and, possibly, for short periods of time, up to three-quarters of its capacity. The vessel's equipment was designed for oil, which is her usual cargo, and includes two 12x12x12-in. duplex plunger pumps. These pumps are placed in the hold elevated on pedestals about 6 ft. above the bottom, thus having a suction lift of approximately 6 ft. while discharging the latter part of the cargo. An improvement could be made by lowering the pumps nearly 3 ft. With the pumps placed as they were, it was almost impossible to draw the molasses into the suction after it got low in the tanks, and it took longer to pump out the last 2 or 3 ft. of the cargo than it did to pump all the rest.

The vessel carries seven tanks with a 10-in. pipe from each to a header at the pump. The pipes have many short turns, and this condition also tended to reduce the discharging capacity. The vessel's pumps have no adjustable valve gear to control the stroke, and, as a result, neither piston of either pump worked up to full stroke. A large part of the time one side of the pump made about a 4-in. stroke and the other side about a 10-in. stroke.

In order to get as much information as possible from the unloading of this first vessel, the operation was conducted as a test. Height gauges were placed in the receiving and storage tanks, pressure gauges were put on the discharge mains and steam pipes, and thermometers were used for taking the temperatures of the molasses, the air and the water beneath the wharf, complete sets of data being recorded every 15 min. The maximum displacement efficiency of the pump was 98 per cent. and was attained when the pump was making about 47 strokes per minute. The steam pressure on the pump averaged 25 lb. by gauge, and the pressure on the molasses discharge main about 40 lb. The average pressure in the steam main was 70 lb. by gauge. The maximum number of gallons pumped per minute was 469. The molasses was almost constantly at a temperature of 78° Fahr., and the crew of the vessel stated that the temperature when she left Porto Rico



General Arrangement of Conveying Plant for Handling City Refuse at Riker's Island, New York.

was 79°. The coefficient of friction of the molasses in the pipe line varied considerably as computed from the data of this test. It should be kept in mind that the flow of molasses varied constantly, and was in fact a liquid of a consistency of foam at one time and molasses at another, owing to the inefficient pump service on the vessel. When the pipe line was full the coefficient of friction figured out very well, and was practically constant at about 0.1.

The plant of the Boston Molasses Co., including the large storage tanks and sheds and the pumping equipment, was built by Mr. Frank B. Gilbreth, of Boston, as contractor, many of the details of the pumping equipment being worked out during construction by the mechanical department of Mr. Gilbreth's establishment, with Mr. William H. Larkin, Jr., M. Am. Soc. M. E., in charge.