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SOME NOTES UPON THE TRANSPORT OF MOLASSES IN BULK.

(BY W. H. GERMAN.)

When Mr. Reeks, in June last, read his paper on "Modern Methods of Steamship Construction," he alluded to the cantilever system of framing, which enables triangular-shaped tanks to be economically built between the main deck and the ship's side, and which are thus suitable for carrying water ballast or liquid cargo. In the discussion which followed, the author of the following notes mentioned that the Colonial Sugar Refining Company, Limited, had recently taken advantage of the facility thus offered by arranging in their new s.s. "Fiona" for the carriage of molasses in her top side tanks; at the same time he promised to describe to members later on the methods adopted for delivering to and from these tanks.

It may be mentioned that, until the last year or two, New South Wales was able to produce all the molasses required in Sydney for distillery and other purposes; some of this was carried in coastal steamers in casks and steel drums, but principally in flat-sided tanks specially fitted into these steamers' holds, and to which the molasses gravitated at the mill wharves on the Tweed, Richmond, and Clarence Rivers, the discharge from the steamers to the Pyrmont tanks being affected by direct-acting steam pumps delivering through 6in. indiarubber flexible hose. Owing to a number of steamers being thus equipped, and the run being short, tanks to carry 90 to 100 tons per vessel were sufficient to meet the case.

The increased demand for molasses for distilling, and the growing recognition of its food value for stock, coupled with the reduction in the New South Wales

cane crop, compelled the Company to look elsewhere for the supply, and, as most of the Queensland mills are distant from navigable waters, and other transport difficulties from thence presented themselves, it was decided that means should be adopted for bringing to Sydney the molasses made at some of their Fiji mills.

The problem to be solved then stood as follows:—

(a) As a steamer (the "Fiona") to carry 5000 to 6000 tons of sugar was to be ordered, to make suitable arrangements aboard for 1000 tons molasses, with gear for receiving it at Lautoka Wharf, Fiji, and for discharging at Pyrmont or Auckland Wharves, at any state of tide or trim—either operation not to materially exceed 24 hours.

(b) To arrange plant at Lautoka Wharf to collect molasses during the "Fiona's" absence, and to deliver it quickly to her.

(c) To arrange pumps, or other gear, at the Auckland and Pyrmont Refineries for transfer from wharf receiving tanks to large reservoir tanks some distance away.

In order to illustrate the three divisions above specified, a diagrammatic sketch has been photographed (Plate No. II., Fig. 1).

To make suitable provision for the first part (viz., tanks to carry 1000 tons) was comparatively simple after it had been decided to use the top side ballast tanks of the steamer, as above explained. These, having an average cross sectional area of 62.5 square feet extending on each side of the ship for a length of 210 feet, accommodate the necessary quantity, as 160 gallons of average molasses—viz., 26 cubic feet—go to the ton.

Each side molasses tank has a central bulkhead for

safety and trimming purposes, so there are in all four compartments, each compartment being drained by a 9in. steel pipe leading to the pumps; the forward extension of these side tanks (originally intended for water ballast) has, however, since been converted to carry molasses, so the total molasses bulk cargo that the steamer now carries in six compartments is thus increased to 1400 tons.

During the construction of the vessel in England, Lloyds authorities several times raised the question of expansion and contraction of molasses due to variations in temperature, and pointed out that certain steamers, fitted with deep tanks, trading from Cuba to Great Britain, had been injured through excessive shrinkage of the molasses before arrival, it being stated that the reduction in volume was something like 5 per cent. of the whole. To overcome the difficulty in question it is now usual to arrange large compensating hatches, evidently with the intention that, when a hold is being filled, it should be filled to the top of the hatch, so that, after shrinkage, only the hatch will be empty, instead of a void being left in the hold proper, which allows the molasses to range about.

It was pointed out that the Colonial Sugar Refining Co.'s experience concerning the shrinkage of molasses in bulk showed that this was due only slightly to reduction in temperature, but principally to the imprisonment of air bubbles introduced during the filling, for when a stream of molasses is poured on to the surface of the fluid, a vortex, or cone-shaped opening, is formed in the body, and bubbles of air are thus caught and carried down into the mass. In water, such bubbles rise quickly, but in molasses very slowly; movement at sea tends to liberate them, so naturally the surface is lowered. Eventually a compromise was effected by the filling trunks being made 3 feet square and carried up

through the 'tween decks. This plan, in addition to allowing space for shrinkage, provides for filling either through the poop deck or through the 'tween decks, doors being arranged at this level, also wing doors in the skin of the ship.

The only filling gear supplied consists of large funnels, 12in. pipes and sluice valves, so that the tanks on either side can be isolated or fed. In actual practice filling is only done through the poop deck, the side doors not being used for 'tween deck filling. For discharging the contents of the tanks, there is arranged at each side of the ship and at the after end, a pair of Clarke Chapman's vertical direct-acting pumps; these are double-acting, the steam cylinders are 11in. diameter, the molasses cylinders 9in. diameter, the stroke 15in., and steam pressure carried 90 lbs. The suction to each set of pumps communicates with the tanks on both sides, in case of one pump being disabled; the delivery from both unites in the centre of the ship into a 14in. rising main, to which is coupled, when molasses is being discharged, a system of portable pipes, including several lengths of 14in. armoured flexible india-rubber pipe by Perdriau and Co., of Sydney, the delivery end of which connects to and delivers through a check valve at wharf level, as shown in Plate II., Fig. 2.

Plate III., Fig. 1, illustrates a similar pipe system delivering across the wharf at Chelsea Refinery, Auckland; this pipe, 15in. in diameter, delivers to an 1100-tons storage tank built there on a slight elevation, as illustrated in Plate III., Fig. 2.

The total estimated head against which the pumps would require to work when delivering to the Auckland tank was 68 feet, equal to 40 lbs. per square inch, including friction head, and it was thought reasonable to subject the india-rubber pipes and system generally to this pressure; but at Pyrmont, where the main

storage tanks are some 700 feet distant and 100 feet high, it was considered too great a risk to attempt this means of pumping direct from the ship, especially as her range of vertical movement is about 25 feet—i.e., from "loaded at low water" to "light at high water." Therefore the receiving tank at the wharf was arranged as an intermediate reservoir only, provision for elevating therefrom to the hill tank having been separately arranged for as described later on.

PLANT AT LAUTOKA WHARF.

Plate IV., Fig. 1, shows a general view of Lautoka Mill, with the wharf in the distance.

It was under this heading that the principal difficulties met with in the scheme presented themselves, and offered more room for difference of opinion as to the most suitable means to the end. Experience on the N.S.W. rivers had already shown the desirability of the tank from which the steamer drew being placed as near to the wharf as possible, and at a considerable elevation, also that the connecting pipes should have a large area to ensure a rapid flow when the molasses was cold or viscous from other causes; so designs were prepared for a steel receiving tank containing 1000 tons, to be erected on a ferro-concrete superstructure moulded on to ferro-concrete piles, the tank to be high enough to gravitate direct to the steamer's tanks, it being also the intention to lay a pipe direct from the mill, 2500 feet distant, for the slow conveyance of molasses to the tank during the period of three or four weeks' absence of the steamer. The structure carrying the tank was intended to be built on the inside of the "T" head of the wharf, but as the records of the original pile driving at the site showed that deep driving in any case would be necessary, fresh borings—or, rather, probings—were taken in order to find a suitable spot.

These showed so great a depth of mud, and were so disappointing, that the project had to be abandoned in favour of erecting a tank on the tongue of land from which the jetty starts, which, of course, meant that a second pumping or some other means of transferring to the steamer would have to be found. A third scheme was also considered—namely, that of pumping direct to the steamer through 16in. or 18in. piping—but the cost, including a pair of powerful pumps at the mill, worked out too high, although it appeared simple; there was not the same feeling of security about this scheme as that with the tank nearer to the steamer.

As there were but few data available respecting the carrying capacity of different sized pipes for conveying molasses of varying temperatures, a series of experiments were conducted at Pyrmont Refinery, as follows:—A head tank 8ft. diameter, 20ft. high, and a receiving tank of similar dimensions were installed on vacant ground, and three pipes (15in., 10in., and 6in. bore respectively) were laid horizontally, and side by side, for a length of 100 feet, and were provided at the delivery ends with valves for opening instantaneously; the tanks were calibrated and floats arranged therein for actuating pointers on indicator boards outside.

A large number of trials were made, and the flow measured for the different heads, varying from 20ft. to 1ft., and, although some small discrepancies occurred, the several tests were averaged, and the results are tabulated in diagram form (Plate IV., Fig. 2). These are fairly approximate to what might be expected from the theory of the flow of liquids, but, for several reasons, should not be considered as absolutely correct, though, for the purpose intended, they were sufficiently accurate to determine the sizes of pipes necessary for the scheme under review. The average density and temperature of

the molasses used were 80 Brix. and 76 degrees F. respectively.

Referring again to the tank on the tongue of land, and which is now called the beach tank, a peculiarity of its behaviour is worthy of mention. It should first be explained that it is of the type described and illustrated in the author's paper upon a "Molasses Burning Furnace"—viz., that it consists of sheet steel belt and top, but with a concrete bottom covered with Val-de-Travers. When deciding upon the spot on which to build it, tests were made to ascertain what weight the ground would support without undue sinkage, so over a circle of 40 ft., five test weights were arranged. They consisted of old rails piled on cross timbers having a foot 2 feet square or 4 square feet. Six tons of rails were piled up, giving 30 cwt. per square foot, and it was found that the maximum sinkage was 1¼in. in 72 hours, which was considered not unreasonable, seeing that, if the tank sank at all when fully loaded, the settlement should be even. Strangely enough, the tank has sunk considerably, although the foundation area was proportioned to give a load of only 1 ton per square foot. When half full it had sunk 2½in., while, some time after filling, it had gone down 12in. on one side and 10in. on the opposite side; but, although the concrete base cracked badly in several places, no leakage has occurred, the Val-de-Travers evidently filling up the cracks without fracture to itself. Except that the connections between the tank and the montejus have had to be altered, this unusual sinkage has not caused any trouble.

What has caused the excessive settlement the author cannot say, but thinks that, probably, there is mud, or similar soft material, underlying a few feet thickness of comparatively stiff soil, this latter forming a crust

which, in the isolated tests, satisfactorily supported the load.

The method adopted for putting together the plates of these tanks is as follows:—The top belt and roof is riveted together on the tank foundation, then hoisted to receive the next belt underneath it, and so on until the last and bottom belt has been added. The total weight to be lifted is some 23 tons, which entails but little expense in comparison to the advantage that all riveting and caulking is done by the men on the ground, instead of being effected at the slower rate of work that would result from the use of staging inside and outside the tank, the cost of which itself would be appreciable. Plate V., Fig. 1, illustrates the beach tank with its pair of montejus.

For the conveyance of the molasses from Lautoka Mill to the beach tank, 6in. C.I. piping was chosen; this was laid underground, and, to explain the fact that this pipe is none too large, it may be mentioned that, with the mill tank full, equal to a head of 34ft., the molasses took two days and a half to reach the beach tank, a distance of 1259ft.; a Blake single direct-acting steam pump, 8in. x 6in. x 12in., specially installed for the purpose, was then started, with a steam pressure of 78 lbs. and exhausting into the open—it could only make about six strokes per minute, the pressure on the delivery pipe varying from 95 to 110 lbs. per square inch. The molasses was cold and viscous, having about 20 to 21 per cent. of water. This poor result was not entirely surprising, because an instance was on record at Pyrmont, where, with cold, gummy molasses, a 6in. pipe 500ft. long delivered only 14 gallons per minute with a pressure head of 120 lbs. per square inch. A more powerful pump was then installed (a duplex 10in. x 5in. x 12in.), which, in addition to having a much larger steam piston proportion, had the

advantage of a continuous delivery, and this, with somewhat lighter molasses and a pressure of 150 lbs. on the 6in. delivery main, gave a flow of 130 gallons per minute—sufficient for the purpose. Plate V., Fig. 2, shows the pump in position.

Compressed air was decided upon as the most suitable medium for forcing the molasses from the beach tank to the "Fiona's" tanks, and from the Pyrmont wharf tank to the distillery; so, in order to serve the double purpose, a compressor by Alley McLellan and Co., of Glasgow, was installed aboard. Its dimensions are as follows:—

H.P. steam 12in. diar. L.P. steam 20in. diar. 1st stage air 16in.; 2nd stage air 10in. (Compressing to 120 lbs. per square inch.)

From the beach tank the molasses gravitates alternately to two montejus, or ejectors, one filling while the other is emptying; a 3in. pipe with flexible connections to the steamer carries the compressed air to the ejectors (which consist of a pair of old shell boilers); a pressure of 70 lbs. per square inch on these is found sufficient to force the molasses to the steamer through a 10in. steel main, 1254ft. long, at the rate of 43 tons per hour (this rate has been considerably exceeded on recent occasions with warmer and less viscous molasses), the liquid cargo thus being taken in in 24 hours, other cargo, of course, being loaded meanwhile.

Plate VI., Figs. 1 and 2, and Plate VII., Fig. 1, show the 6in. and 10in. pipe line on shore and along the jetty respectively, and the "Fiona" at the wharf.

Amongst the plans laid on the table for members' inspection is that of the double pipe line, showing the expansion joints, etc.; the 10in. flanged steel main is by Stewarts and Lloyds, and cost 4s. 1d. per foot f.o.b. England.

Molasses from another Fiji mill, called Rarawai,

some 29 miles distant, is brought to the beach tank at Lautoka by means of small tank trucks (Plate VII., Fig. 2) hauled by a Fowler locomotive, which stands by to provide the steam for a Blake pump. These trucks, 2ft. gauge, and carrying a 2-tons nett load, were made in Sydney, and cost £27 each. Plate VIII., Fig. 1, illustrates a train of these trucks, while incidentally are shown (on Plate VIII., Fig. 2, and Plate IX., Fig. 1) trains of sugar and of sugar cane respectively. Plate IX., Fig. 2, a train of the former with coloured labour aboard out for a holiday. Plate X., Figs. 1 and 2, show the trucks being filled at Rarawai.

Two other of the Company's Fiji mills have yet to assist in providing this liquid bulk cargo for the "Fiona," viz., Labasa and Nausori; the latter is situated on the Rewa, a river so shallow in parts that punts drawing not more than 4 feet are being fitted up with large cylindrical steel vessels measuring 6ft. 3in. diameter x 37ft. 6in. long, and carrying about 45 tons each, and have been made by the Mort's Dock and Engineering Co., Ltd. These punts will be towed down the river to the "Fiona" lying in Laucala Bay, where the air compressor will again be used for ejecting the contents through flexible pipes into her capacious tanks.

Much thought was bestowed upon the question of how best to elevate a semi-liquid, like molasses, from a steamer loaded or light, on even keel, or listing, to the Hill tank 700 feet distant, and the top of which is 100 feet above high water, at the rate of one (1) ton per minute. Pumps were naturally decided upon, and, as the steam boilers were distant from the site, electrical power was thought to be the best; so a motor was ordered, also steel gearing wheels, and the pattern of the pump bed-plate was actually in hand before it was realised that a compressed air system would serve the purpose in addition to those already described, so

the orders placed were cancelled, and a pair of montejus, or ejectors (Plate XI.), were made by Mr. W. Grant. These are filled, and the contents forced out by air from the "Fiona's" compressor with a pressure of 100 lbs.; delivery to the Hill tank is made through a 15in. steel flanged pipe 3/16in. thick, costing 7s. per foot f.o.b. England.

Plate XII., Figs, 1 and 2, show the steamer, the pipe line, and the main receiving tank, which latter holds 220,000 gallons, and is of similar construction to those already described—viz., steel sides and top, with concrete bottom having Val-de-Travers covering.

Plate XIII. shows a branch delivering to subsidiary tanks.

Light molasses has been delivered by the ejectors to the Hill tank at the rate of 150 tons per hour.

The author has to acknowledge the able assistance rendered in this matter by Mr. J. Pickering, of Glasgow, the Company's Consulting Engineer in Great Britain, who supervised the building of the "Fiona" and arranged her installation of molasses tanks, pumps, air compressor, etc.; while he has also to thank Mr. Jas. Kidd and Mr. W. Hillhouse, Chief Engineers of Pyrmont Refinery and Lautoka Mill respectively, for valuable help rendered and photos and data supplied, all of which have simplified the preparation of these notes, and materially tended to the economical and successful transport of the by-product in question.