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THE DREDGING FLEET OF MONTREAL HARBOUR.

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To be Read Before the Mechanical Section, 14th January, 1904.

To fully describe the working part or details of operation of the various machines comprising a dredging fleet is, of course, beyond the limits of this paper and therefore the writer will only touch upon such points as he deems of common interest among dredge men.

The Harbour Commissioners' Dredging Fleet proper at present consists of four dipper dredges, five floating derricks, one drill boat, five tugs and twenty-three scows. There are other machines, but as the work done by them cannot be said to pertain to dredging, no particular mention will be made of them. It may be stated, however, that the complete fleet comprises forty-one vessels.

The work performed is for the most part confined to dredging in localities where deeper water is desired, the material dredged being utilized in the construction of piers, wharves and other harbour improvements.

The dredges deposit their material on scows which are unloaded by the floating derricks at points where filling is needed.

With the exception of one dredge and one derrick, the fleet works day and night, offsetting to a certain extent, the disadvantages of a short season. The total number of men employed in operating the fleet is 220 during the warm weather, but a slight increase in the force takes place in the late autumn owing to the extra labour necessary when lines are frozen and decks coated with ice. In another portion of this paper, mention is made as to the number of hands required to work each vessel and also the duties assigned to individuals.

The dredges are all of the dipper or spoon type, their principal dimensions being as follows: Length of hull 90 ft., width of hull 36 ft., maximum depth of hold from 9′ 6″ to 10′ 9″ according to dredge; size of main engine 16″ x 18″ double cylinder.

Each dredge has three spuds, two at the bow and one at the stern. The bow spuds are each operated by two wire ropes, one for lifting and one for pinning up, the former passing around a sheave located in the spud near its lower end and the latter over a similar sheave held in a casting at the upper end. The lifting and pinning up wires lead to the same drum, one coming in while the other comes off. The forward spud drums are operated by the main engine, clutches and brakes being provided for throwing in and out of gear or holding the drums stationary. The stern spud is raised by a wire rope attached near the lower end, no spud sheaves or pinning up arrangement being used. The wire passes to a drum driven by an engine which also actuates the deck capstans. Thus spud passes through an aperture in the stern deck and is held in position by rollers carried in yokes, one at the deck line and the other at the top of the spud slides. The upper yoke is directly secured to the piston rod of a long stroke steam cylinder, thereby affording means of moving ahead when the bow spuds are lifted.

The dipper is lifted by means of a single wire rope passing to a spirally grooved drum. The diameter of the drum varies in such a manner that the wire comes in slowly while the bucket is in the cut with an increase of speed when the dipper is clear of the material being dredged. The drum is driven by two cast steel spur gears which engage or disengage with the drum by means of a pair of belt frictions operated by a toggle joint mechanism and a steam thrust cylinder.

The dipper handles used are of the split type and are built of Douglas fir encased on all sides by steel plates, the plating being secured by Lowmoor iron rivets which pass through the wood from plate to plate. A heavy steel casting with lugs to receive the bucket connections, is bolted to each side of the handle at its lower end.

The handle is gripped or allowed to slide, as the case may be by means of a steam piston and a combination of fibre-covered plates which bear upon the sides of the handles as well as upon four long plates secured to the inner surfaces of the split portion of the arm.

Rivets are snap-headed wherever possible, but unfortunately their use is very restricted on account of the necessity of having a smooth surface where the handle passes through the friction trunnion box.

Several designs of steel bucket arms have been tried, but as the rivetting gave continual trouble they have been discarded in favour of those of combined wood and steel construction. The latter are comparatively easy to repair and give good satisfaction generally.

The total weight of a handle as described above is about 26,600 lbs. There is no doubt whatever that a solid dipper arm would prove much more durable than one split for the greater portion of its length, but its use is hardly possible with a single hoisting wire.

The standard bucket is of seven cubic yards capacity, and is built with a curved lip and front. There are also a few straight lipped dippers of five and a quarter yards capacity, but though specially designed for dredging very hard material they have proved not at all superior to the larger bucket and are, therefore, used only for work in a strong current where swinging is difficult with the dipper of large size, or when filling boxes which the seven yard bucket would overload. The body or shell of both sizes of dippers is of steel plate, with butt joints and single cover strap. The lip and lower band are of cast steel and are rivetted to the shell, rivetting being countersunk on the inside to insure a smooth surface. The door is composed of a single piece of inch and a quarter steel plate rivetted to a cast steel hinge piece. The latching device is on the toggle joint principle, and, considering the extremely severe usage it is subjected to, gives good satisfaction. Bails are a single steel casting, secured to the hoisting wire socket a cast steel shackle. The shackle takes up considerable room, but its use is necessary to prevent injury to the wire by sharp bending at the point where it enters the socket.

Each dipper carries four teeth which are of cast steel with chisel points. The teeth are made hook shaped, the hook fitting over the lip at places where projecting lugs are provided to prevent side play. The lower end of each tooth is secured to the shell by four bolts. With this arrangement of fastening, a change of teeth can be effected in about half an hour.

Several attempts have been made to design a dipper tooth that will last a reasonable length of time in hard digging. Detachable points of hardened steel were experimented with but proved a failure through lack of strength either in the point itself, or in the body of the tooth which had to be cut away to receive it.

Silver tips were V-welded into the teeth and given a trial in rock digging. It was found that when the points were tempered sufficiently to wear well, they were brittle and broke too frequently to warrant their use.

At present the only effort being made to improve the lasting qualities is confined to heating and dipping the tooth point after it is drawn out under the hammer.

The life of a set of teeth will of course depend upon the nature of the material being dredged. In unblasted grey rock seven hours continuous work is a fair average as shown by records kept by the writer. Upon becoming too blunt to hold well, the points are again hammered out, but there is a limit to the drawing out process and the tooth soon goes to the scrap pile.

During last season the four dredges of the fleet used up 181 teeth, each tooth having been in service at least four times.

The weights of the several parts of a seven yard dipper are as follows:—

Cast steel lip..	2,510	lbs.
Cast steel bottom band..	3,230	"
Cast steel bail..	1,335	"
Door, complete, with latch..	2,230	"
Shell..	1,500	"
Cast steel shackle..	125	"
Rivets, pins, etc..	605	"
Four cast steel teeth..	1,800	"
Total weight of bucket..	13,335	"

Considerable trouble has been experienced on account of the very rapid wear of the faces of the latching dogs, even though they have until very recently been made of Mangenese steel. Castings of common steel with faces hardened as much as possible are now being tried and though the duration of the test will not allow of a decision as to the wearing qualities, it is certain that they withstand shocks and blows far better than those of Mangenese steel.

Experiments are in progress to determine the advisability of an annealing all steel castings used in the construction of buckets and clams. There is no doubt that the initial strain in some of these castings is very high, as its presence is frequently denoted by shrinkage cracks. It is hoped that annealing will relieve more or less of this tension and materially increase the life of the piece.

With regard to rivetting, it has been proved that rivets driven by pneumatic tools are superior to those put in by hand. The drift pin seems unavoidable in work of this kind, but it is certain that were all holes drilled fair and good, slack rivets and broken castings would not be so common.

Taking the spud record of the last three seasons, it has been found that the average life of a thirty-six inch by thirty-six inch (36″ x 36″) dredge spud is 5.7 months, working day and night. It must be remembered that the dredges have been working for the greater proportion of the time in rock and hardpan at a depth of water ranging from 30 to 40 feet. Examination of the broken spuds has shown that in most cases the failure was due to the giving way of the outer fibres of the stick under tensile stress. A few spuds however, have failed by a longitudinal shear along the grain.

Two dredges are now being fitted with forward spuds 42″ x 42″ and it is hoped that they will prove more satisfactory as regards length of service.

The boom is built entirely of steel and is supported at its outer end by two parts of a wire rope which passes around a revolving cap on a pivot at the apex of the A frame. The A frame is of wood, its lower extremity resting upon the top of the forward spud slides. It is guyed by wire cables extending aft to the lower members of the hog frames.

Three of the dredges have wooden hulls, but the latest machine is built of steel.

A dredge crew is composed of one engineer. one assistant engineer, one cranesman, one firemen, and four deckmen. The engineer has charge of the whole machine and is responsible for its operation generally. He handles the levers controlling the main engines, capstan engines, spud drums and stern spud moving ahead gear. The assistant looks after the machinery and sees that lubricators and oil cups are filled and in proper working order. He also relieves the engineer when the latter has for any reason to leave the operating dredge. The cranesman stands on a small platform secured to the side of the boom and manipulates the levers controlling the swinging engine, backing drum and dipper handle compression cylinder. The fireman tends the boiler and when opportunity permits, is supposed to help the assistant when oiling. The deckmen handle lines and do general work about the dredge.

A night shift is identical with the day crew but has in addition a watchman whose duties are to scour floors and decks, wipe down the machinery and keep the dredge throughout as clean as possible.

Dredges 2, 3 and 4 are equipped with Clyde boilers, while No. 1 dredge has a boiler of the locomotive type.

Four of the floating derricks are equipped with clam shells of approximately four cubic yards capacity. The clam shells unload soft material exceedingly well and also give good satisfaction when handling rock provided it is fairly well broken. In the latter class of work the clams are fitted with cast steel teeth which can be attached or detached in a few minutes time. The remaining derrick has tackle for handling four yard boxes which are used almost exclusively for rock work. The boxes are arranged closely together on scows and the dredges load directly into them, care being taken not to overload or cover up the iron work provided for attaching the derrick hoisting and tripping chains.

The principal dimensions of a derrick are as follows:—Length of hull, 76 ft.; width of hull, 27 ft.; maximum depth of hull, 7′ 6″ to 8′ 0″ according to derrick; size of main engine 12″ x 14″ double cylinder.

The boom is 80 feet long and is swung by a turn table working on a pivot casting fastened to the forward deck

The spud arrangement is similar to that of the dredges, namely, two at bow and one at stern. Spuds are operated by wire ropes as in the dredges, but the method of braking or holding spuds in one position varies. In derricks 5 to 6 the spuds are equipped with chains which run on rollers held in castings at the top of the spud. One end of the chain is secured to one side of the spud slides, while the other end passes through a clamping device bolted to the opposite side of the slide. When the derrick is pinned up, the clamps grip the chain and carry the load. Derrick No. 4 has a wire instead of the chain. In derricks 1 and 3 the arrangement is identical with that of the dredges. The weight is carried by the top wire, the drums being held stationary by brakes.

The original spuds used were 21″ square but as they have not proved durable, they are being replaced by spuds 21″ x 27″.

The main engine has two grooved drums, one for the hoisting wire and the other for the tripping wire. Both drums are fitted with ordinary cone driving frictions which are thrown in or out of gear by steam thrust cylinders secured to the drum shaft and revolving with them. Drums are checked by brake straps operated by foot levers.

Two derricks have steel hog frames and back legs, but the others are of wood throughout.

A derrick day crew is composed of one engineer, one assistant, one fireman and four deckhands. The night crew is the same but with an additional hand as watchman. The engineer is in charge of the shift. The assistant works with the engineer in the operating cabin, the fireman doing the necessary oiling besides firing. The deckhands tend the lines.

As before stated, five tugs are in operation. Two of them are of steel construction while the others are of wood.

The Robert Mackay, the larger of the two steel boats, was built by Messrs. Carrière & Lainé, of Quebec, and delivered to the Harbour Commissioners in the fall of 1901. Her principal dimensions are as folows:—

HULL.

Length over all	81′ 9″
Length between perpendiculars	71′ 0″
Moulded beam	16′ 10″
Draught with full coal bunkers, about	11′ 0″

ENGINE. (Fore and Aft Compound.)

Diameter of high pressure cylinder	16″
Diameter of low pressure cylinder	32″
Stroke of pistons	24″

The high pressure cylinder is fitted with piston valve, while the low pressure has a double ported balance slide valve.

When running at 125 revolutions per minute the engine indicates about 440 horsepower.

The engine is equipped with a steam reversing gear actuated by a steam cylinder fastened to the bed plate. It is quick in its action and is so constructed that the links can be held in any position which feature is of value when a variation of cut off is desired.

BOILER.

(Water leg firebox, return tubular. Two D flues leading to a single combustion chamber.)

Length over all	12′ 0″
Diameter of shell	8′ 9″
Area of fire grate	43 sq. ft.
Total heating surface	1402 sq. ft.
Ratio of H. S. to area of fire grate	32.6
Ratio of fire grate area to area through tubes	6

It may be stated that this boiler is an excellent steamer, and, considering the exceptionally heavy towing the boat does, the coal consumption is not high. A table showing the coal consumed by the various vessels of the fleet is given below, though it must be borne in mind that the fuel burned by a tug depends greatly upon the conditions under which the boat is working, and that as these conditions vary from day to day, it is difficult to more than average the quantity of coal used per stated interval. The quality of the coal is also a varying factor.

Steering is done by means of a steam steering gear operated by a direct steam cylinder fitted with a single piston secured to the centre of a rod which passes through both cylinder heads, the rods being attached to the tiller rope. A controlling lever in the pilot house moves a specially constructed valve gear admitting steam to either side of the piston as may be desired. The apparatus is so designed that the piston follows the motion of the steering lever, ceasing to move when the lever becomes stationary. The whole arrangement has proved very efficient and convenient, especially for quick work when handling scows in confined spaces. Owing to the rapid action of this steering gear upon the rudder, it is an easy matter to cause the boat to roll and advantage is taken of this feature when the tug is breaking heavy ice. Without the rolling movement, five inches of green ice will stall the boat, but nine inches can be broken with engines at full speed and the rudder moving from side to side as fast as the tug will roll it.

On the 28th of November last, the writer received orders to proceed to Cascade Point and render all possible assistance to the light ship "Lurcher" which was on her way to the Atlantic. The "Robert Mackay", having already quite a reputation for freeing ice-bound vessels, was chosen as being most suitable. While passing through the Lachine Canal several miles of six inch ice were steamed through, and with the exception of a diminished speed, no difficulty was experienced. On reaching the Lake St. Louis end of the canal, it was found that lolly had accumulated and frozen to a thickness of about nine inches. The progress at this point was slow, but at no time did the tug become stalled. It will doubtless be remembered that several tugs and their tows were frozen in the canal at the time. To them the arrival of the "Mackay" meant a great deal for they were able to proceed to their destinations with very little further trouble.

The presence of floating timber and other obstacles renders the use of the sectional propeller a necessity, and all the tugs of the fleet are equipped with wheels of this style. Broken blades are a frequent occurence, but the replacing of a blade or even a whole set, is a small matter when compared with fitting a solid wheel. The propellor blades of the "Robert Mackay" are of cast steel, while the other tugs have cast iron blades. Except when breaking ice, the use of steel for this purpose is of doubtful merit, on account of the great danger of injury to the tail shaft and shoe if the blades do not give way on striking a heavy object. Another objection to their use is the difficulty of securing castings with smooth surfaces.

While dealing with the subject of tug boats, it may be stated that ease and accuracy of handling is an essential feature in a tug which is to render efficient service in a crowded waterway. The steersman should not be forced to exercise his full muscular strength when moving his wheel, nor should the movement of the rudder be so slow as to allow an undue length of time to elapse before the boat alters her course. The engineer should not have to wrestle with a ponderous reverse lever or unbalanced throttle, and above all he should not be cursed with an engine liable to stick on the centre. A steam steerer will enable the tug captain to perform quicker and better work and the engineer can respond to his bells with certainty and despatch when his engine is fitted with steam reversing gear, properly designed throttle and a two cylinder fore and aft engine with cranks at ninety degrees.

The single cylinder engine of large size is exceedingly difficult to handle if even a moderate amount of exhaust lap is given to the valve, and, in the opinion of the writer, should never be installed unless first cost or lack of space forbids the adoption of a fore and aft double engine with ninety degree cranks. The double engine with cranks at one hundred and eighty degrees is, of course, as bad as regards sticking on the centre, and unless handled with great care by a skilful engineer, is bound to give trouble sooner or later.

Except when working in the St. Mary's current, the water available for boiler feed is generally of a muddy character and much trouble is experienced by the rapid accumulation of a muddy deposit in the boilers. Frequent blowing off and examination is imperative, the frequency of doing so depending upon the style of boiler and the locality in which the vessel is working.

Ordinary vertical boilers, unless the tubes are set in well separated rows, without staggering, have given much trouble from this course and cracked crown sheets are not uncommon. With pure water they give fair satisfaction, but when using feed heavily charged with impurities, their use is not advisable. With this type of boiler, and in all boilers for that matter, numerous washout plugs should be provided, not scattered promiscuously about the shell but so located that every portion of the boiler liable to become foul can be reached by scraper and water jet.

In the locomotive firebox type, the crown sheet offers a good lodging place for mud and especially is this the case when girder stays are used. Radial stay bolts and a curved crown will do much to prevent the accumulation of mud.

The Clyde and Fitzgibbon boilers have proved the easiest to maintain in this respect, though the combustion chamber crown sheets of both these types require careful attention.

In certain parts of the harbour, the water is so impure that it causes foaming, and water tanks filled outside the "Mackay Pier" have to be kept alongside the vessel, hose connections leading to the injector or feed pump.

Boiler compounds have been experimented with, but to no great extent, as the first attempts in this direction developed leaks owing to the loosening of scale which probably had been acting as a seam filler for a greater or lesser length of time.

Although the rate of coal consumption varies considerably from month to month, a statement showing the average fuel burned may be of interest.

Type of Vessel.	Size of Main Engine.	Coal per month per vessel.	Remarks.
Dredge..........	16″ x 18″ two cyls. simple non-cond.	106 tons Double Shift.	Av. of 3 dreds. for 6 months.
Floating Derrick	12″ x 14″ two cyls. simple non-cond.	53 tons Double Shift.	Av. of 4 dks. for 6 months.
Tug............	16″ & 32″ x 24″ Compound cond.	160 tons Double Shift.	Av. of 2 tugs for 6 months.
Tug............	20″ x 22″ simple non-cond.	90 tons Double Shift.	Av. of 1 tug for 3 months.
Tug............	16″ x 18″ simple non-cond.	37 tons Single Shift.	Av. of 1 tug for 6 months.
Tug............	9″ x 10″ simple non-cond.	12 tons Single Shift.	Av. of 1 tug for 6 months.

The above quantities of coal include that consumed in keeping fires banked on Sundays and holidays. It may also be stated that the compound tugs were doing heavy work in St. Mary's current. The other tugs were chiefly occupied in general towing about the harbour.

An important item of expense in the maintenance of the fleet is that of lubrication. During last season the oil consumption was as follows:—Cylinder oil, 1,610 galls.; engine oil 517 gals.; castor oil, 4,070 lbs.; tallow 1,196 lbs.; cup grease 537 lbs.; crude petroleum 177 galls.

Average Quantity of Lubricants Used per Month, per Vessel.

Vessel.	Gal. Cyl Oil.	Gal. Eng Oil.	Lbs. Castor Oil.	Lbs. Tallow.	Lbs. Cup Gr'se.	Gal. Crude Petrol'm.
Dredge..	16.7	7.4	9.4	18.5	12.4	3.7
Derrick..	8.0	6.3				1.5
Tug 16″ & 32″ x 24″ comp. cond.	23.4		184.0	49.2		
Tug 20″ x 22″, simple non-cond.	6.0		93.0	12.0		
Tug 16″ x 18″ simple non-cond...	7.0		41.6	5.6	3.7	

Castor oil is deservedly a favorite among tug runners, though its cost is high compared to that of a medium grade engine oil. There is a great difference of opinion regarding the respective merits of castor and mineral oil for tug engines, but trials have shown the former to be more satisfactory and its use is now general on the tug boats of the fleet.

Referring to the table of lubricants used during last season, it will be remarked that the consumption of tallow was large. In explanation of this, however, the writer wishes to state that unfor-fortunately a quantity of very low grade cylinder oil had been purchased and to render it fit for use a large proportion of tallow had to be added. The injurious effect of tallow upon a steam engine is too well known to require comment, but unless carefully watched the average tug engineer will use it, the amount used generally depending upon how much is given him. The judicious use of properly prepared graphite with cylinder oil is to be recommended.

There is no doubt whatever that a dredge equipped only with sight feed lubricators wastes much cylinder oil. The actual work of the machinery is more or less intermittant and unless the engineer shuts off the supply, oil will continue to flow into the cylinders after the engine has stopped. As there are usually several engines on a dredge, this source of waste becomes a serious matter if economy of working is to be considered. Mechanically operated oil pumps were experimented with last season and they proved so satisfactory that they are to be fitted to all the engines of the entire fleet. Being actuated by the engine itself, they feed only when the engine is running. They are positive in their action, and if of correct design, require little or no attention beyond filling. It is claimed by some engineers that this type of lubricator will clog if graphite is used with the oil, but the writer has experienced no trouble in this direction even when using a mixture composed of one part of Dixon's Flake Graphite to eight of oil.

The subject of the durability of wire ropes is full of interest to any one concerned in the efficient and steady operation of a dredging fleet.

In nearly every case, the design of a dredge or floating derrick will not allow of the correct diameter of sheave being used for any particular wire. Take spud wires as an example. The spuds of a dredge are 36″ square, and as it is necessary that the cable lie close to the sides of the spuds, the diameter of the sheaves cannot be much greater than 36″ on the tread. If, for this purpose, we use a two inch wire composed of wires 0.1 inches diameter, we find that the stress induced by the bending alone amounts to 83,000 lbs. per square inch, which is far too high for durability. Again in the case of a dredge hoisting wire, a two and a quarter inch cable composed of wires 0.134 inches diameter running over a six foot sheave, gives us a stress of 55,000 lbs. per square inch in the metal.

However, we are for practical reasons obliged to use sheaves of comparatively small diameter and so must make the best of it. Too much care, however, cannot be taken to so design running rigging that the same portion of a wire rope will pass over as few sheaves as possible, because the bending not only induces the undesirable stress above referred to but produces fatigue of the metal by repetition.

The correct size of wire to use for a certain purpose is often determined by trial. An instance of this may be given as follows: The floating derricks were originally equipped with 1¼″ swinging wires running over 15½″ sheaves to a turntable of 9′ 6″ diameter. These ropes have been replaced by others of 1″ diameter and results show a marked increase in the life of the rope.

Referring to the matter of spud wires, the writer suggests that the rope be not confined to two parts of large diameter over one sheave, but that the load be carried by four or more parts running over several sheaves. By using such an arrangement, the size of the rope could be greatly decreased and be more suitable to the sheaves, which would, of course, be of the maximum diameter permitted by the dimensions of the spud. There are mechanical difficulties to be reckoned with, but they are not insurmountable. Apart from the wire rope point of view a desirable feature of this arrangement would be the lowering of the pull on the hauling part of the cable when pinning up. Spud drums could be less massive than at present, though perhaps not much smaller on account of the increased length of wire to be accomodated. All running rigging should be properly lubricated with black oil or some substances suitable for the purpose. Wire rope manufacturers recommend a mixture composed of linseed oil and lamp black or Spanish brown.

When sockets are to be babbitted to the end of a wire cable, the material of the rope should be sufficiently soft to allow of bending the wires to a small radius without cracking. A socket splice is never too strong for the work it is called upon to do, and the swell on the rope end should be large enough to prevent any possibility of pulling through even if the babbitt was not present. If many wires break in bending over, we lose to a more or less extent this highly desirable feature. Of course, the babbitt cements the whole bulb together and adds materially to the strength of the splice. Possibly exception may be taken to the statement that the cable should have a swelled end, and perhaps not without reason for some wire rope manufacturers advise against the practice. The observations of the writer, however, are to the effect that a heavily loaded wire rope will gradually pull through the socket if a substantial swell is not made on the rope end. Unless the socket is of great length a thin ring or tube of babbitt generally comes with the wire, showing that the shearing strength of the alloy is not sufficient to withstand the load.

Break downs to the machinery and other gear are frequent, due probably as much to the prevalence of the double shift system as to the over straining or mishandling of the machines. However, on account of our short season and the large amount of work to be done, day and night crews are obligatory, even though they certainly are not satisfactory from a maintenance point of view.

In the case of a dredging fleet, where to a great extent one machine works in conjunction with another, and a breakdown to the one will in all probability delay the other, it is absolutely necessary to have means whereby quick and efficient repairs can be made. To effect quick repairs, material and spares must be in readiness, and when possible parts of machines should be made to templates so that no time will be lost in fitting them to their places. By efficient repairs are meant repairs that will stay repaired or done in as perfect a manner as circumstances will permit. Good workmen, and good workmen only, should be employed, for a cheap man is generally a dear man when time, mistakes and poor workmanship are reckoned up. A few cents an hour more in an employee's pay are insignificant when a dredge and its derrick are waiting on a tug which is out of business with, say, a broken piston ring. Hire good men, give them good tools and material best suited to the job in hand and the time lost will be a minimum.

The Harbour Commissioners, until a couple of years ago, maintained a floating shop, the hull of which had long done service as an elevator dredge. Now, however, a fairly equipped machine shop on the Mackay Pier attends to all repairs.

Frequently the person in charge of a dredging fleet has to decide as to whether or not a certain repair is absoluately necessary, and before giving his decision he must consider the probable effect if repairs are not made. Will there be danger to life or limb if complete breakdown should occur? Will the trouble extend or cause other apparatus to carry undue stresses? Are the conditions at the time favourable for stopping a machine or would a short delay prove more advantageous? It is often a nice point to render a decision upon, but it is best to err on the safe side. First, consider the safety of the men; second, the machine; and, last of all, the work.

The cause of a breakdown should always be investigated, and, if possible, means taken to prevent a repetition of the failure. At this point it may be mentioned that due regard should be paid to the fact that it is very desirable that a comparatively unimportant part should break when the load it carries reaches a certain figure, which should be well before parts of greater importance become overloaded.

Owing to the excessive and complicated straining action of a dredge, it is difficult to design its component parts so that the whole is of uniform strength, and especially is this the case in dredges with wooden hulls. A certain amount of flexibility is no doubt a good point, but this flexibility should never be so great as to cause certain members to bear stresses which properly belong to others. In a wooden dredge it is next to impossible to keep shafting or clutches in alignment and to remedy this evil all bearings should be provided with adjusting wedges or blocks. Steam piping should be put up with frequent offsets or expansion joints.

Taking the season of 1901 as an example, the cost of operation per working day or night for the different types of vessels is as follows:—

	Repairs and Maintenance.	Fuel.	Wages of Crews.	Estimated Depreciation of Plant.	Total Cost.
7 Yd. Dipper Dredge..	$27.53	$11.05	$20.30	$ 5.85	$64.73
Floating Derrick..	10.08	5.66	16.46	2.53	34.73
Tug (16″ x 32″ x 24″ Compound)	3.00	7.35	9.24	2.27	21.86
Tug (20″ x 22″ Simple)..	2.42	4.48	8.47	* .23	15.60
Tug (16″ x 18″ Simple)	4.05	5.20	7.43	* .16	16.84

*These two tugs, having been in service for many years, their value is rated at a very low figure.