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TAMIL NADU ARCHIVES

GOVERNMENT OF TAMIL NADU

Paluvay DEPARTMENT

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GOVERNMENT OF MADRAS.
PUBLIC WORKS DEPARTMENT.

2nd May 1879, No. 1,282 W.

Buildings and Roads.

Civil Works.

Read the following paper :—

No. 14. From Captain G. F. L. MARSHALL, R.E., Officiating Assistant Secretary to the Government of India, Public Works Department (Civil Works—Miscellaneous), to the Secretary to the Government of Madras, Public Works Department, dated Simla, 4th April 1879, No. 123 M.

I AM directed to forward for information twenty copies of a report by Mr. Buckley, Executive Engineer, Eastern Sons Division, on the working of Mr. Fouracres' Patent Automatic Dredger, with copies of the drawings therein referred to.

2. I am to add that the dredger promises to be a very useful adaptation.

TRIAL OF FOURACRES' PATENT AUTOMATIC DREDGER.

1. This dredger has now been subject to a carefully conducted trial for ten weeks in the Eastern Main Canal for the purpose of practically testing its powers both as regards the quantity of work it can perform and the cost at which it can do it. A Sub-overseer was especially deputed to work the dredger and to record all the facts necessary to lead to a correct judgment on the value of the invention.

2. The particular dredger used was one principally composed of such machinery as was available in the Dehree Workshop; the actual excavating bucket itself and its immediate fittings, in which the essence of the invention lies, being of course quite new. The dredger was worked by a six-horse power portable engine which drove a 1½-ton crab winch, the excavating bucket being swung to a portion of an old travelling crane. The accompanying drawings show the general arrangement of the dredger itself and the details of the excavating bucket, which had a capacity of 16 cubic feet. The dredger was accompanied by six mud punts which were fitted with removable sides, so that the silt could be easily scraped off from the decks. It was found during the trial that this number was just sufficient to keep the dredger in full work when the lead from the dredger to the spot where the silt was thrown into the river did not exceed about half a mile. The silt in each punt was levelled off and measured before it was discharged into the river.

3. The actual cost of the dredger (some allowance being made for the fact that the engine and winch were not new) is given by Mr. Fouracres at Rupees 6,111, but it is estimated that a dredger specially and, of course, better constructed of machinery intended for the purpose, and not merely adapted, as in this case, would cost almost Rupees 8,000. Each mud punt cost Rupees 4,000. The value then of one of Fouracres' patent dredgers, with the necessary number (six) of mud punts, is about Rupees 32,000.

4. Mr. Fouracres' specification describes the action of the dredger as follows :—

"The main lifting chain B is attached to an engine or crab winch with suitable crossed and direct straps and loose pulleys, &c., or any suitable arrangement such that the man who regulates the machinery can wind up or unwinch the chain, or hold it stationary at any moment he pleases. The dredger is first lowered into the water in the position shown in Figure 1 by unwinding the main lifting chain B from the engine while it is being lowered. This chain is of course tight; as it bears the whole weight of the bucket, the long wooden spear, and of the whole movable part of the machine the strain on the main lifting chain tends, of course, to draw the travelling collar W upwards on spear L. This tightens the closing chain P, the strain on which, acting on the semicircular angle irons O, tends to close the scoops of the bucket. These scoops are only prevented from closing by the catch T, which holds the two scoops together at the top and prevents their closing. In this manner the bucket descends, the wooden spear C sliding freely down in its guides D and E.

"When the bucket reaches the bottom, which it generally does with somewhat of a blow if the engine be run quickly, the two scoops M are pressed upwards as it were. As the strain is thus taken off the catch T it rises by means of the floatation of the ball attached to it, and

thus the scoops are released and free to close. At this period the stops S come into action: they prevent the scoops from opening more than is just sufficient to release the catch T. Immediately the catch T is open the engine-man (or the man who is working the winch) reverses the winch and the main lifting chain beings to ascend. At this moment, also the lever G is pulled over by the rope attached to it; this jams the spear C tightly in the guide E by means of the cam F. The main lifting chain as it ascends draws the travelling collar W up the spear L. As this collar W ascends it draws up the closing chains P; these draw the semicircular angle irons O towards the sheaves Q, and the scoops of the bucket are gradually closed upon the silt or mud; the spear all this time being held fast in the jib-head by the cam, and the jib being fixed so that it cannot rise, the bucket is compelled to bite into the soil. As soon as the bucket is closed (and this can be told easily by a mark on the spear to which the collar X will descend) the lever G is released and the whole apparatus rises to the surface. As the bucket rises above the water, the crane A is revolved until the bucket hangs over the mud punt, which is moored alongside the dredger. When the clutch collar X rises up to the hooks H, the projecting arms push back the hooks H, which immediately afterwards, by the action of the counterbalance weight K, fall back into their old position. As soon as the winchman sees that the hooks H have caught the arms of the clutch collar X, he immediately reverses the winding of the main lifting chain. The apparatus then descends; but as the clutch collar X is caught by the hooks H the rods Y are placed in tension; the spear and the heavier portion of the dredger continue to descend, the scoops M are pulled open partly by the weight of the material they themselves contain, partly by the weight of the descending parts which press with all their weight upon the cross-head of the spear L, and thus tend to press open the bucket. When the scoops are widely open the stops S bear on the spear L and the catch T falls of its own account into position, catching the other scoop.

"The dredger is now ready for another lift; the slack of the main lifting chain is taken up by the engine, and the weight of the apparatus is lifted sufficiently to allow the hooks H to be drawn back by the rope which is attached to them. The winch or engine is then reversed and the bucket descends again as before.

"The engine (or winch worked up by the engine) has to be reversed three times during each lift: first, after lifting the apparatus from the hooks H, it has to be reversed to lower the bucket; secondly, when the bucket reaches the bottom, it has to be reversed to lift it; and, thirdly, when the bucket is over the mud punt, it has to be reversed to empty the bucket."

5. The place selected for the trial of the dredger was the head of the Eastern Main Canal at Baron. The accompanying plan shows the first 2,600 feet of this canal; for this length the channel has a base of 180 feet narrowed suddenly at the 26th chain to 80 feet. This portion had silted up to an average depth of $2\frac{1}{2}$ feet, there being 1,100,000 cubic feet in the first 26 chains. In some places there was as much as four feet of silt, the water being so shallow that the float of the bucket was occasionally not sufficiently immersed to act; this and the fact that the mud punts often went aground while they were being loaded caused occasional delay, but the difficulty was eventually overcome by closing the head sluices entirely during the night, so that, without increasing the total discharge of the canal, it was possible to raise the level of the water at the head during the day. During the first few days the dredger was employed on clearing out the lock channel, which was but slightly silted up, and then the dredger was put steadily to work to clear out a channel, about 50 feet broad, as shown by the dotted lines. The silt excavated was discharged into the river near the island in such a position that it would be all cleared away through the under-sluices of the weir in the next flood.

6. The dredger was first started (in the narrow lock channel) with the regulating apparatus designed by Mr. Fourcares, who describes it as follows:—"The dredger boat is secured in position as shown in the plan by a T strut, the base of which rests on the bank, has two loops fixed on it through which iron pins are driven into the bank; the other end of the strut has an eye attached to it which works on a pivot fixed to the stern of the boat and thereby enables the boat to move in an arc of which the pivot is the centre. To the bow of the boat (the end where the excavator works) is attached a piece of quartering, working similarly to the strut, viz., on a pivot and of a length sufficient to enable the bow of the boat to be moved to a few feet beyond the half width of the canal. This piece of quartering is, for convenience sake, marked into divisions (four feet in the present case) equal to the size of the excavator when fully opened. After the excavator has taken its first bite the boat is shoved off the distance of one of these divisions and ready for the excavator to descend and take its second bite and so on until the canal is cleared to its half width; if in passing over the first time the dredger does not excavate the full depth required, it can be worked in a similar manner back again; but if the desired depth is obtained after the first arc is travelled over, the T strut and quartering pieces are moved either up or down stream, as may be desired, a distance equal to the breadth of the excavator (2 feet 6 inches in this case), and the dredger travels over an arc parallel to, and at a distance from, the former equal to the breadth of the excavator. The moving of the dredger, as above described, is effected by men placed on the bank with a light two-fold block and a 2-inch rope attached to it, one end to a leg on the bank, and the other to the quartering or pole. This system entirely dispenses with chains or anchors, and has been found to answer the purpose

admirably. The successful and economical working of the dredger greatly depends on having good sharp men to move the dredger backwards and forwards.

This arrangement, though perhaps suitable in some places, as for instance if it were required to clear out a channel 40 or 50 feet wide near the edge of a wide channel where the T strut could be conveniently attached to the bank, is not good for a wide canal like the Eastern Main Canal of 180 feet base, nor is it even applicable for clearing out a channel as was done at the trial. Indeed, it appears doubtful whether a well-arranged system of anchors is not in all cases preferable, except perhaps where there is very heavy traffic; for this system has the advantage of leaving one side of the canal entirely open for boats. The T strut is cumbersome, and three or four men or required to push in and out of the regulating bar. This plan of regulating the dredger was then abandoned as soon as the excavation of the 50-foot channel was commenced and the following arrangement was adopted:—A small gipsy winch (A in figure) was fitted on two uprights to the edge of the dredger; a small capstan would have been more suitable as the regulating chain B would not have jammed on a capstan in the same way as it did on the winch. A man stationed at this winch A was able easily to regulate the movements of the dredger, causing it to oscillate in the arc C. D. The two anchors attached by half-inch chains to a bollard on the stern of the dredger kept the point E very nearly stationary; the action of the current tended, of course, to keep the anchor chains tight. Occasionally, as the stream varied, the dredger would perhaps float slightly out of its proper course, in which case the bucket would come up very nearly empty; but this did not occur very frequently. When the dredger had worked up to the point C, the anchor chains were slackened by about 2 feet 6 inches (the width of the bucket); the winchman then reversed his winch and gradually brought the dredger back to the point D; some care is necessary in thus regulating the dredger; when it is found that the bucket comes up with the silt piled up above the top of the bucket, the winchman should allow the bucket to take another bite at the same spot, or the channel will not be entirely cleaned out. When the dredger had worked up to the point D, the anchor chains were again slackened by $2\frac{1}{2}$ feet, the gipsy winch was reversed, and the dredger ate her way back again to the point C and so on continually. Occasionally, when the anchor chains became long and the dredger was perhaps somewhat swept off her course by the action of the current, or when the anchor chains had been slackened by more than the width of the bucket, a ridge of silt would be left; but, as a general rule, the channel was very fairly cleaned.

7. Some difficulty was at first found in managing the mud punt in the stream; the silt came up generally so dry and hard that it was necessary to move the punt frequently, so that the silt might be deposited all over the punt; in order to regulate the movements of the punts iron hooks were fastened about 6 or 8 feet apart all along the side of the punt, and small wooden stanchions were fixed at about corresponding intervals on the side of the dredger; two ropes were hooked on to the mud punt, as occasion might require, and the coolies, by loosening or hauling on these, were easily able to regulate the position of the punt. Another rope stretched right across the stream was used, both to keep the stern of the mud punt in any required position, when she protruded a long way beyond the nose of the dredger and thus was not fully under the command of the coolies on the dredger, and it was also used as a means by which the empty punt was hauled across the stream to the dredger as soon as the former one was full. Two pair of bullocks towed the full punts up to the lock and brought back the empty one.

8. The silt excavated varied from pure sand to soft black mud; the heavier particles, i.e., the sand, were of course deposited near the head sluice; the silt gradually became less and less sandy and more and more muddy the further the dredger worked from the sluices. One of the greatest advantages of this dredger is that it brings up the silt quite dry and hard; the greater portion of the silt which has been excavated during the present trial could have been at once carried away on coolies' heads in baskets if necessary. It is also remarkable how little the dredger stirs up the mud in the canal; it works most cleanly, taking its bite without disturbing the silt near it; in this respect it is much superior to other dredgers. The leather valve in the bucket acted capitably; whenever the bucket came up at all empty most of the surplus water fell out into the canal before the crane had revolved over the mud punt. It was noticed that in the pure sand the bucket frequently came up only half full, but that in the mud it frequently brought up as much as 20 cubic feet; the bucket will not bite fully into hard sand as at present constructed; for the spear rises even though the lever be most tightly pressed against it. Mr. Fourcares proposes to attach a rack to the spear, so that it will be impossible for it to slide in the jib-head. The full capacity of the bucket is 16 cubic feet, but on the average it only brings up 12 cubic feet each lift; this is due partly to bad regulation of the dredger, partly to sand being hard to cut, and partly to the fact that if the bed is thoroughly cleaned out it is not always possible to give the bucket a full bite. An average of $45\frac{1}{2}$ buckets can be lifted per hour and the average quantity excavated per working day has been 3,691 cubic feet. The greatest quantity ever done in one working day of $9\frac{1}{2}$ hours was 4,647 cubic feet. In ten weeks 210,132 cubic feet have been excavated.

9. The following establishment was employed in working the dredger and regulating the mud punt:—

LACCA.				
Number.	Description.	Rate.	Amount.	
		RS. A. P.	RS. A. P.	
1	Driver	4 0 0	9 4 0	Driving the engine.
1	Winchman	4 0 0	0 4 0	Do. winch.
1	Fireman	3 0 0	0 3 0	Firing the engine.
1	Jibman	3 0 0	0 3 0	Working the hook and lever of the crane.
1	Gipsy winchman	2 6 0	0 2 0	Regulating the dredger.
6	Coolies	2 6 0	0 15 0	Moving mud punt.
2	Woodcutters	2 6 0	0 5 0	Cutting wood.
1	Boat, with manjee	3 0 0	0 5 0	Taking off men and firewood to the dredger and carrying tow rope to mud punt.
	Extra allowance		0 6 6	Allowance of 1½ annas per 1,000 feet made to men for each 1,000 cubic feet in excess of first 2,000 feet.
	Total		2 15 6	

The following were the principal materials consumed each day:—

MATERIALS.				
Kind.	Weight.	Rate.	Amount.	
		RS. A. P.	RS. A. P.	
Firewood mds.	11	0 2 0	1 6 0	
Castor-oil lbs.	2	0 3 2	0 6 4	
Grease "	1	0 3 4	0 3 4	
Jute "	1	1 6 0	0 1 6	
Total materials			2 1 2	

The following establishment was kept up for hauling the mud into the river:—

No.	Labor.	Rate.	Amount.
		RS. A. P.	RS. A. P.
2	Bullocks	5 0 0	0 10 0
2	Mullahs	2 6 0	0 5 0
10	Coolies	2 0 0	1 4 0
8	Do.	1 6 0	0 12 0
	Total		2 15 0

An accurate daily account was kept of all expenditure, all materials used were carefully weighed, the time taken in loading each barge was taken by the sub-overseer, one of the lascars was appointed to count the number of buckets lifted. The accompanying tabulated statement shows the results of the ten weeks' trial. A total quantity of 210,132 cubic feet have been excavated and discharged into the river, with an average lead of about 1,800 feet, at a cost of Rs. 2-4-3 per 1,000 cubic feet. The average cost per 1,000 cubic feet of the silt delivered into the punt has been Rs. 1-6-8, and average cost per 1,000 cubic feet, of hauling the punts to the river and discharging them has been Rs. 0-12-7. The cost here given is of course only the actual working charges, independent of repairs and interest of the original cost of machinery.

10. The original cost of one of Fouracres' patent dredgers of six horse-power, together with six mud punts, is about Rs. 32,000, allowing 15 per cent. for interest and depreciation, and 5 per cent. for repairs. The yearly charge for these items amounts to Rs. 6,400, or say Rs. 22 per working day, or about Rs. 6 per 1,000 cubic feet. The full cost then of dredging by this dredger is per 1,000 cubic feet—

	RS. A. P.
Repairs, interest and depreciation	6 0 0
Working charges	2 4 0
Total	8 4 0

The cost of excavating silt from this same canal by hand labor, after the canal was run dry, was in 1877 Rs. 5-8-0 per 1,000, and in 1878 Rs. 6-4-0 per 1,000. The silt was all carried to the top of the large spoil banks. The cost of clearing the canal in the way must, of course, yearly increase, as the spoil banks become larger and larger.

The actual cost of one of an ordinary ladder and bucket dredger of 15 horse-power is about Rs. 50,000; these dredgers are supposed to excavate 4,000 cubic feet of silt per hour; but it has been found by the Executive Engineer of the Midnapore Canal that, under the most favorable circumstances, the actual performance does not exceed 2,000 cubic feet per hour. The working expenses of these dredgers in the Midnapore Canal amounted, in 1875-76, to Rs. 10-12-0 per 1,000 cubic feet, the lead was longer by about one-fourth mile than was the case at the trial of Fouracres' patent dredger. If one of these dredgers worked under the most favorable circumstances, she could excavate about 12,000 cubic feet per day, and would require from 20 to 24 mud punts, costing about Rupees 80,000 to keep her in full work, making the full cost of dredger and punts Rupees 1,34,000. Taking 15 per cent. for interest and depreciation, and 5 per cent. for repairs, the yearly charge of these items amounts to Rupees 26,800, or say Rupees 90 per working day, or Rupees 7-8-0 per 1,000 cubic feet. The cost of dredging by the ordinary ladder and bucket dredger per 1,000 cubic feet is—

	RS. A. P.
Repairs, depreciation and interest	7 8 0
Working expenses	10 12 0
Total	18 4 0

It is more than probable that the working expenses of these dredgers might be reduced below Rupees 10-12-0 per 1,000 under favorable circumstances; but the dredgers, working in the Midnapore Canal, have never worked for less than that, and latterly have cost Rupees 13-11-0 per 1,000 cubic feet. The great wear upon the links and pins of the ladder and bucket dredger soon causes the chain of buckets to sag down, the buckets then foul the edge of the well unless the beam is raised, which, of course, reduces the depth to which the dredger can cut; there is often difficulty also in getting the buckets of the ladder dredger to empty themselves if the silt is at all stiff. Concerning this difficulty the Executive Engineer of Midnapore Canal (Mr. Apjohn) writes: "The sandy silt could not be made to come out of her buckets until they had so far passed the vertical that it would not fall into the shoot, consequently we had to allow it to fall on the deck, and shovel it into the mud barge alongside. Of course, this reduced the dredging power to a minimum, and I think that 3,000 cubic feet per day, the best that was ever yet got out of her, also the resistance of the hard silt, was so great that her level gearing was always breaking its teeth in the effects to force the buckets through. Altogether, for canal work, I condemn the bucket dredger."

11. Fouracres' patent dredger appears admirably adapted to excavate silt from canals. One of its greatest advantages for India is that it can be readily constructed from machines—a portable engine, a crab winch, and a crane of any kind—that are generally available on any large works in this country. It is very simple, easily managed by natives, and the working parts are so simple and light that they can easily be repaired by any intelligent fitter. The cost of working is much less than that of other dredgers, and even including the charges for depreciation, interest and repairs, the cost of the work done does not largely exceed that of hand labor when the canal is dry. Three of these dredgers in the Patna Canal (83½ miles in length) would probably, if kept constantly at work, keep the canal clear of silt, and obviate the necessity of closing the canal yearly for the purpose of clearing it out. It is difficult to exaggerate the immense advantage this would be.

6th February 1879.

(Signed) R. B. BUCKLEY,
Executive Engineer, Eastern Sone Division.

Abstract showing the Weekly Cost of working Fouraces' Patent Dredger.

Week ending	AVERAGE OF EACH WEEK.										TOTAL OF EACH WEEK.		
	Time taken in filling mud	Number of buckets put in	Cubic feet in put when loaded	Cubic feet lifted by bucket	Number of buckets per hour	Time dredger was actually working	Yards per day	Yards per day	Yards per day	Yards per day	Quantity extended	Cost of delivery into mud per 1,000 cubic feet	Land of points
												Cost of discharge into mud per 1,000 cubic feet	Cost of discharge into mud per 1,000 cubic feet
Saturday, November 2nd..	0.51	39.5	437	12.0	42.5	8.5	8.5	8.5	8.5	8.5	25,474	28.12	28.12
Sun..	0.55	36.1	426	12.4	45.1	8.5	8.5	8.5	8.5	8.5	15,977	28.12	28.12
10th..	0.55	37.1	454	12.2	42.1	8.5	8.5	8.5	8.5	8.5	16,092	28.12	28.12
23rd..	0.49	39.4	465	12.0	47.3	8.5	8.5	8.5	8.5	8.5	22,572	28.12	28.12
30th..	0.50	39.6	468	11.8	47.7	8.5	8.5	8.5	8.5	8.5	22,572	28.12	28.12
Saturday, December 7th..	0.50	41.3	466	11.2	45.0	8.5	8.5	8.5	8.5	8.5	22,572	28.12	28.12
14th..	0.50	38.6	475	11.6	41.1	8.5	8.5	8.5	8.5	8.5	22,572	28.12	28.12
21st..	0.53	40.5	483	11.9	44.4	8.5	8.5	8.5	8.5	8.5	22,572	28.12	28.12
28th..	0.49	41.1	483	11.8	50.5	8.5	8.5	8.5	8.5	8.5	22,572	28.12	28.12
January, 4th..	0.51	40.6	483	11.4	48.6	8.5	8.5	8.5	8.5	8.5	22,572	28.12	28.12
Total ..	6.48	394.5	4,573	118.3	353.9	82.34	82.34	82.34	82.34	82.34	207,438	28.12	28.12
Average ..	0.51	39.4	457	11.8	45.6	8.5	8.5	8.5	8.5	8.5	207,438	28.12	28.12

P.S.—Since the above was written Mr. Fouraces has attached to one of his dredgers the rack referred to in paragraph 8 of the report. The rack is attached to the spear of the dredger, and is so constructed that the cam of the lever retains the spear fixed in the jib-head while the scoops are cutting; the spear therefore cannot rise, and the scoops are compelled to take their full bite. This arrangement acts well. It has been working this morning in pure sand. The bucket came up nearly full each time, whereas without the rack only about half a bucketful was raised. The dredger now acts capitally in pure sand. The rack is so arranged that if any very great resistance, such as a large stone or log of timber, be met with, the cam jumps out of the rack without damage being done to any of the working parts.

DEHREE,
27th February 1879.

R. B. BUCKLEY,
Executive Engineer, Eastern Sone Division

No. 15.

ORDER THEREON, 2nd May 1879, No. 1,282 W.

COMMUNICATED to all Superintending Engineers for information.

(True Extract.)

Major, R.E.,
Ag. Under Secy. to Govt., P.W.D.

To Superintending Engineers.
To the Chief Engineer for Irrigation.
Superintendent, Madras Harbour Works.

Ed. E. O. Shunker.
Spare Copies

BUILDINGS AND ROADS.
CIVIL WORKS.

Estbl. of (1873) ~~Madras~~

PUBLIC WORKS.

SUPERINTENDING ENGINEERS.

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Date May 2nd.

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Each.

G. O., 2nd May 1879, No. 1283 W.

MAY.

No. 14-15.

Mr. Pouraere's Patent Automatic Dredger
— Letter from the Government of India
forwarding twenty copies of a report by Mr.
Buckley, Executive Engineer, Eastern Sone
Division, on the working of —, communi-
cated to Superintending Engineers for
information.

All communications
should be addressed
to the Secretary.

No. 123-M.

GOVERNMENT OF INDIA
PUBLIC WORKS DEPARTMENT.

Civil Works.
Miscellaneous.

To,
The Secretary to the Govt. of Madras,
Public Works Department.

Simla, 4th April 1879.

Sir,
I am directed to forward, for
information, 20 copies of a report by
Mr. Buckley, Executive Engineer, Eastern
Sone Division, on the working of Mr.
Pouraere's patent Automatic Dredger,
with copies of the drawings therein referred
to.

2. — I am to add that the Dredger
promises to be a very useful adaptation.

I have the honor to be,

Sir,
Your most obedt. servant,

G. F. Marshall Captain R.E.

CCG
Offg. Asst. Secy to the Govt. of India

Port 2-5-79-1282

TRIAL OF FOURACRES' PATENT AUTOMATIC DREDGER.

1. This dredger has now been subject to a carefully conducted trial for ten weeks in the Eastern Main Canal for the purpose of practically testing its powers, both as regards the quantity of work it can perform, and the cost at which it can do it. A sub-overseer was especially deputed to work the dredger, and to record all the facts necessary to lead to a correct judgment on the value of the invention.

2. The particular dredger used was one principally composed of such machinery as was available in the Dehree workshop: the actual excavating bucket itself, and its immediate fittings, in which the essence of the invention lies, being, of course, quite new. The dredger was worked by a 6-horse power portable engine, which drove a $1\frac{1}{2}$ ton crab winch, the excavating bucket being swung to a portion of an old travelling crane. The accompanying drawings show the general arrangement of the dredger itself, and the details of the excavating bucket which had a capacity of 16 cubic feet. The dredger was accompanied by six mud punts, which were fitted with removable sides, so that the silt could be easily scraped off from the decks. It was found during the trial that this number was just sufficient to keep the dredger in full work when the lead, from the dredger to the spot where the silt was thrown into the river, did not exceed about half a mile. The silt in each punt was levelled off and measured before it was discharged into the river.

3. The actual cost of the dredger (some allowance being made for the fact that the engine and winch were not new) is given by Mr. Fouracres as Rs. 6,111, but it is estimated that a dredger specially and, of course, better constructed machinery intended for the purpose, and not merely adapted, as in this case, would cost almost Rs. 8,000. Each mud punt cost Rs. 4,000. The value then of one of Fouracres' patent dredgers, with the necessary number (six) of mud punts, is about Rs. 32,000.

4. Mr. Fouracres' specification describes the action of the dredger as follows:—

"The main lifting chain, B, is attached to an engine or crab winch with suitable crossed and direct straps and loose pulleys, &c., or any suitable arrangement such that the man, who regulates the machinery, can wind up or unwind the chain, or hold it stationary at any moment he pleases. The dredger is first lowered into the water, in the position shown in Fig. 1, by unwinding the main lifting chain, B, from the engine while it is being lowered. This chain is, of course, tight, as it bears the whole weight of the bucket, the long wooden spear, and of the whole movable part of the machine, the strain on the main lifting chain tends, of course, to draw the travelling collar, W, upwards on spear L. This tightens the closing chain, P, the strain on which, acting on the semi-circular angle irons, O, tends to close the scoops of the bucket. These scoops are only prevented from closing by the catch T, which holds the two scoops together at the top and prevents their closing. In this manner the bucket

remains open when the bucket reaches the bottom, which it generally does with somewhat of a blow if the engine be run quickly, the two scoops M are pressed upwards as it were. As the strain is thus taken off the catch T, it rises by means of the floatation of the ball attached to it, and thus the scoops are released and free to close. At this period the stops S come into action; they prevent the scoops from opening more than is just sufficient to release the catch T. Immediately the catch T is open, the engine-man (or the man who is working the winch) reverses the winch and the main lifting chain begins to ascend. At this moment, also, the lever G is pulled over by the rope attached to it; this jams the spear C tightly in the guide E by means of the cam F. The main lifting chain, as it ascends, draws the travelling collar W up the spear L. As this collar W ascends, it draws up the closing chains P; these draw the semi-circular angle irons O towards the sheaves Q, and the scoops of the bucket are gradually closed upon the silt or mud; the spear all this time being held fast in the jib-head by the cam, and the jib being fixed so that it cannot rise, the bucket is compelled to bite into the soil. As soon as the bucket is closed (and this can be told easily by a mark on the spear to which the collar X will descend) the lever G is released, and the whole apparatus rises to the surface. As the bucket rises above the water, the crane A is revolved until the bucket hangs over the mud punt, which is moored alongside the dredger. When the clutch collar X rises up to the hooks H, the projecting arms push back the hooks H, which immediately afterwards, by the action of the counterbalance weight K, fall back into their old position. As soon as the winchman sees that the hooks H have caught the arms of the clutch, collar X, he immediately reverses the winding of the main lifting chain. The apparatus then descends; but as the clutch collar X is caught by the hooks H, the rods Y are placed in tension, the spear and the heavier portion of the dredger continue to descend, the scoops M are pulled open partly by the weight of the material they themselves contain, partly by the weight of the descending parts which press with all their weight upon the cross-head of the spear L, and thus tend to press open the bucket. When the scoops are widely open, the stops S bear on the spear L, and the catch T falls of its own account into position, catching the other scoop."

"The dredger is now ready for another lift; the slack of the main lifting chain is taken up by the engine, and the weight of the apparatus is lifted sufficiently to allow the hooks H to be drawn back by the rope which is attached to them. The winch or engine is then reversed and the bucket descends again as before."

"The engine (or winch worked up by the engine) has to be reversed three times during each lift. First, after lifting the apparatus from the hooks H, it has to be reversed to lower the bucket; secondly, when the bucket reaches the bottom, it has to be reversed to lift it; and thirdly, when the bucket is over the mud punt, it has to be reversed to empty the bucket."

Cir 24-4-79.

Despatched 18-4-79. P-2-5-

5. The place selected for the trial of the dredger was the head of the Eastern Main Canal at Baroon. The accompanying plan shows the first 2,600 feet of this canal; for this length the channel has a base of 180 feet narrowed suddenly at the 26th chain to 80 feet. This portion had silted up to an average depth of 2½ feet, there being 1,100,000 cubic feet in the first 26 chains. In some places there was as much as four feet of silt, the water being so shallow that the float of the bucket was occasionally not sufficiently immersed to act; this, and the fact that the mud punts often went aground while they were being loaded, caused occasional delay, but the difficulty was eventually overcome by closing the head sluices entirely during the night, so that, without increasing the total discharge of the canal, it was possible to raise the level of the water at the head during the day. During the first few days the dredger was employed on clearing out the lock channel, which was but slightly silted up, and then the dredger was put steadily to work to clear out a channel, about 50 feet broad, as shown by the dotted lines. The silt excavated was discharged into the river near the island, in such a position that it would be all cleared away through the under-sluices of the weir in the next flood.

6. The dredger was first started (in the narrow lock channel) with the regulating apparatus designed by Mr. Fouracres, who describes it as follows:—"The dredger boat is secured in position as shown in the plan by a T. strut, the base of which rests on the bank, has two loops fixed on it through which iron pins are driven into the bank; the other end of the strut has an eye attached to it which works on a pivot fixed to the stern of the boat, and thereby enables the boat to move in an arc, of which the pivot is the centre. To the bow of the boat (the end where the excavator works) is attached a piece of quartering, working similarly to the strut, viz., on a pivot, and of a length sufficient to enable the bow of the boat to be moved to a few feet beyond the half width of the canal. This piece of quartering is, for convenience sake, marked into divisions (four feet in the present case) equal to the size of the excavator when fully opened. After the excavator has taken its first bite the boat is shoved off the distance of one of these divisions, and ready for the excavator to descend and take its second bite, and so on until the canal is cleared to its half width; if in passing over the first time the dredger does not excavate the full depth required, it can be worked in a similar manner back again; but if the desired depth is obtained after the first arc is travelled over, the T. strut and quartering pieces are moved either up or down stream, as may be desired, a distance equal to the breadth of the excavator (2 feet 6 inches in this case), and the dredger travels over an arc parallel to, and at a distance from, the former equal to the breadth of the excavator. The moving of the dredger, as above described, is effected by men placed on the bank with a light two-fold block and a 2-inch rope attached to it, one end to a leg on the bank, and the other to the quartering or pole. This system of regulating the dredger with chains or anchors is, however, subject to the objection that the success of the full and economical working of the dredger greatly depends on having good sharp men to move the dredger backwards and forwards."

This arrangement, though perhaps suitable in some places, as for instance if it were required to clear out a channel 40 or 50 feet wide near the edge of a wide channel where the T. strut could be conveniently attached to the bank, is not good for clearing out a channel as was done at the trial. Indeed, it appears doubtful whether a well-arranged system of anchors is not in all cases preferable, except perhaps where there is very heavy traffic, for this system has the advantage of leaving one side of the canal entirely open for boats. The T. strut is cumbersome, and three or four men are required to push in and out of the regulating bar. This plan of regulating the dredger was then abandoned, as soon as the excavation of the 50-foot channel was commenced and the following arrangement was adopted:—"A small gipsy winch (A in figure) was fitted on two uprights to the edge of the dredger; a small capstan would have been more suitable, as the regulating chain B would not have jammed on a capstan in the same way as it did on the winch. A man stationed at this winch A was able easily to regulate the movements of the dredger, causing it to oscillate in the arc C. D. The two anchors attached by half-inch chains to a bollard on the stern of the dredger kept the point E very nearly stationary; the action of the current tended, of course, to keep the anchor chains tight. Occasionally, as the stream varied, the dredger would perhaps float slightly out of its proper course, in which case the bucket would come up very nearly empty; but this did not occur very frequently. When the dredger had worked up to the point C, the anchor chains were slackened by about 2 feet 6 inches (the width of the bucket); the winch-man then reversed his winch, and gradually brought the dredger back to the point D; some care is necessary in thus regulating the dredger; when it is found that the bucket comes up with the silt piled up above the top of the bucket, the winch-man should allow the bucket to take another bite at the same spot, or the channel will not be entirely cleaned out. When the dredger had worked up to the point D, the anchor chains were again slackened by 2½ feet, the gipsy winch was reversed, and the dredger ate her way back again to the point C, and so on continually. Occasionally, when the anchor chains became long, and the dredger was perhaps somewhat swept off her course by the action of the current, or when the anchor chains had been slackened by more than the width of the bucket, a ridge of silt would be left; but, as a general rule, the channel was very fairly cleaned."

7. Some difficulty was at first found in managing the mud punt in the stream; the silt came up generally so dry and hard that it was necessary to move the punt frequently, so that the silt might be deposited all over the punt; in order to regulate the movements of

the punts iron hooks were fastened about 6 or 8 feet apart all along the side of the punt, and small wooden stanchions were fixed at about corresponding intervals on the side of the dredger; two ropes were hooked on to the mud punt, as occasion might require, and the coolies, by loosening or hauling on these, were easily able to regulate the position of the punt. Another rope stretched right across the stream was used, both to keep the stern of the mud punt in any required position, when she protruded a long way beyond the nose of the dredger, and thus was not fully under the command of the coolies on the dredger, and it was also used as a means by which the empty punt was hauled across the stream to the dredger, as soon as the former one was full. Two pair of bullocks towed the full punts up to the lock and brought back the empty one.

8. The silt excavated varied from pure sand to soft black mud; the heavier particles, i.e., the sand, were of course deposited near the head sluice; the silt gradually became less and less sandy and more and more muddy the further the dredger worked from the sluices. One of the greatest advantages of this dredger is that it brings up the silt quite dry and hard; the greater portion of the silt which has been excavated during the present trial could have been at once carried away on coolies' heads in baskets if necessary. It is also remarkable how little the dredger stirs up the mud in the canal; it works most cleanly, taking its bite without disturbing the silt near it; in this respect it is much superior to other dredgers. The leather valve in the bucket acted capably; whenever the bucket came up at all empty most of the surplus water fell out into the canal before the crane had revolved over the mud punt. It was noticed that in the pure sand the bucket frequently came up only half full, but that in the mud it frequently brought up as much as 20 cubic feet; the bucket will not bite fully into hard sand, as at present constructed, for the spear rises even though the lever be most tightly pressed against it. Mr. Fouracres proposes to attach a rack to the spear, so that it will be impossible for it to slide in the jib-head. The full capacity of the bucket is 16 cubic feet; but on the average it only brings up 12 cubic feet each lift; this is due partly to bad regulation of the dredger, partly to sand being hard to cut, and partly to the fact that if the bed is thoroughly cleaned out it is not always possible to give the bucket a full bite. An average of 45½ buckets can be lifted per hour and the average quantity excavated per working day has been 3,691 cubic feet. The greatest quantity ever done in one working day of 9½ hours was 4,647 cubic feet. In ten weeks 210,132 cubic feet have been excavated.

9. The following establishment was employed in working the dredger and regulating the mud punt:—

Number.	Description.	Rate.		Amount.
		Rs. A.	Rs. A. P.	
1	Driver	4 0	0 4 0	Driving the engine.
1	Winchman	4 0	0 4 0	Driving the winch.
1	Fireman	3 0	0 3 0	Firing the engine.
1	Jimman	3 0	0 3 0	Working the hook and lever of the crane.
1	Gipsy winchman	2 6	0 2 6	Regulating the dredger.
6	Coolies	3 6	0 15 0	Moving mud punt.
2	Wood-cutters	2 6	0 5 0	Cutting wood.
1	Boat, with manjoe	5 0	0 5 0	Taking off men and firewood to the dredger, and carrying tow rope to mud punt.
	Extra allowance		0 6 0	Allowance of 1½ annas per 1,000 feet made to men for each 1,000 cubic feet in excess of first 2,000 feet.
				2 15 6

The following were the principal materials consumed each day:—

MATERIALS.											Weight.	Rate.	Amount.	
Kind.														
Fire-wood Castor-oil Grease Jute	...	...	...	...	...	...	...	...	...	...	mds. lbs.	11	0 2 0	1 6 0
	...	...	...	...	...	...	...	...	...	...	...	2	0 3 2	0 6 4
	...	...	...	...	...	...	...	...	...	...	...	1	0 3 4	0 3 4
	...	...	...	...	...	...	...	...	...	...	...	1	1 6 0	0 1 6
	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total Materials											...	...	...	2 1 2

The following establishment was kept up for hauling the mud into the river:—

No.	Labour.	Rate.		Amount.	Amount.
		Rs. A. P.	Rs. A. P.		Rs. A. P.
6	Bullocks	5 0 0	0 10 0		
5	Mollahs	2 6 0	0 5 0		
10	Coolies	2 0 0	1 5 0		
8	Ditto	1 6 0	0 15 0		
	Total		3 15 0		

An accurate daily account was kept of all expenditure, all materials used were carefully weighed, the time taken in loading each barge was taken by the sub-overseer, one of the lascars was appointed to count the number of buckets lifted. The accompanying tabulated statement shows the results of the ten weeks' trial. A total quantity of 210,133 cubic feet have been excavated and discharged into the river, with an average lead of about 1,800 feet, at a cost of Rs. 2-4-3 per 1,000 cubic feet. The average cost per 1,000 cubic feet of the silt delivered into the punt has been Re. 1-6-8, and average cost per 1,000 cubic feet, of hauling the punts to the river and discharging them has been Re. 0-13-7. The cost here given is of course only the actual working charges, independent of repairs and interest of the original cost of machinery.

10. The original cost of one of Fournaces' patent dredgers of six horse power, together with 6 mud punts, is about Rs. 32,000, allowing 15 per cent. for interest and depreciation, and 5 per cent. for repairs. The yearly charge for these items amounts to Rs. 6,400, or say Rs. 22 per working day, or about Rs. 6 per 1,000 cubic feet. The full cost then of dredging by this dredger is per 1000 cubic feet.—

	Rs. A. P.
Repairs, interest and depreciation	6 0 0
Working charges	2 4 0
Total	8 4 0

The cost of excavating silt from this same canal by hand labour, after the canal was run dry, was in 1877 Rs. 5-8 per 1,000, and in 1878 Rs. 6-4 per 1,000. The silt was all carried to the top of the large spoil banks. The cost of clearing the canal in the way must, of course, yearly increase, as the spoil banks become larger and larger.

The actual cost of one of an ordinary ladder and bucket dredger of 15 horse power is about Rs. 53,000; these dredgers are supposed to excavate 4,000 cubic feet of silt per hour; but it has been found by the Executive Engineer of the Midnapore Canal that, under the most favourable circumstances, the actual performance does not exceed 2,000 cubic feet per hour. The working expenses of these dredgers in the Midnapore Canal amounted, in 1875-76, to Rs. 10-12 per 1,000 cubic feet, the lead was longer by about one-fourth mile than was the case at the trial of Fournaces' patent dredger. If one of these dredgers worked under the most favourable circumstances, she could excavate about 12,000 cubic feet per day, and would require from 20 to 24 mud punts, costing about Rs. 80,000 to keep her in full work, making the full cost of dredger and punts Rs. 1,34,000. Taking 15 per cent. for interest and depreciation, and 5 per cent. for repairs, the yearly charge of these items amounts to Rs. 26,800, or say Rs. 90 per working day, or Rs. 7-8 per 1,000 cubic feet. The cost of dredging by the ordinary ladder and bucket dredger per 1,000 cubic feet is:—

	Rs. A. P.
Repairs, depreciation and interest	7 8 0
Working expenses	10 12 0
Total	18 4 0

It is more than probable that the working expenses of these dredgers might be reduced below Rs. 10-12 per 1,000 under favourable circumstances; but the dredgers, working in the Midnapore Canal, have never worked for less than that, and latterly have cost Rs. 13-11 per 1,000 cubic feet. The great wear upon the links and pins of the ladder and bucket dredger soon causes the chain of buckets to sag down, the buckets then foul the edge of the well unless the beam is raised, which, of course, reduces the depth to which the dredger can cut; there is often difficulty also in getting the buckets of the ladder dredger to empty themselves if the silt is at all stiff. Concerning this difficulty the Executive Engineer of Midnapore Canal (Mr. Apjohn) writes: "The sandy silt could not be made to come out of her buckets until they had so far passed the vertical that it would not fall into the shoot, consequently we had to allow it to fall on the deck, and shoved it into the mud barge alongside. Of course, this reduced the dredging power to a minimum, and I think that 3,000 cubic feet per day, the best that was ever yet got out of her, also the resistance of the hard silt, was so great that her level gearing was always breaking its teeth in the effects to force the buckets through. Altogether, for canal work, I condemn the bucket dredger."

11. Fournaces' patent dredger appears admirably adapted to excavate silt from canals. One of its greatest advantages for India is that it can be readily constructed from machines—a portable engine, a crab winch, and a crane of any kind—that are generally available on any large works in this country. It is very simple, easily managed by natives, and the working parts are so simple and light that they can easily be repaired by any intelligent fitter. The cost of working is much less than that of other dredgers, and even including the charges for depreciation, interest and repairs, the cost of the work done does not largely exceed that of hand labour when the canal is dry. Three of these dredgers in the Patna Canal (83½ miles in length) would probably, if kept constantly at work, keep the canal clear of silt, and obviate the necessity of closing the canal yearly for the purpose of clearing it out. It is difficult to exaggerate the immense advantage this would be.

R. B. BUCKLEY,

Executive Engineer, Eastern Sone Division.

The 6th February 1879.

Abstract showing the weekly cost of working Fournaces' Patent Dredger.

WEEK ENDING.	AVERAGE OF EACH WEEK.										TOTAL OF EACH WEEK.			
	Time taken in filling mud punt.	Number of buckets put in punt.	Cubic feet in punt when loaded.	Cubic feet lifted by bucket.	Number of buckets per hour.	Time dredger was actually working.	Time men were employed.	Each day.	Quantity excavated.	Cost of delivery into mud punt per 1,000 cubic feet.	Lead of punts.	Cost of discharge into river per 1,000 cubic feet.	Cost per 1,000 discharged into river.	Rs. A. P.
Saturday, November 2nd	0-31	393	467	13-0	426	6 31	.....	.....	3,210	1 0 2	1,300	1 0 2	2 4 8	51 7 1
9th	0-33	361	423	12-4	467	6 35	9 17	8 52	3,133	1 2 0	1,300	1 2 0	2 11 3	42 0 9
16th	0-33	371	454	12-3	421	6 27	.....	.....	3,004	1 0 1	1,400	0 13 11	2 8 0	45 0 3
23rd	0-40	394	435	12-0	470	6 33	7 25	7 25	3,702	1 8 5	1,500	0 13 9	2 6 2	53 13 6
30th	0-40	396	425	11-8	477	6 30	8 33	8 33	3,023	1 6 2	1,600	0 14 10	2 5 0	50 4 6
Saturday, December 7th	0-40	413	426	11-5	480	7 37	9 6	9 6	4,172	1 3 8	1,800	0 12 0	1 15 8	40 5 5
14th	.....	393	425	11-0	.....	.....	.....	.....	3,809	1 7 6	1,300	0 14 1	2 5 7	45 1 6
21st	0-33	405	433	11-9	444	6 41	8 24	8 24	3,622	1 7 6	2,000	0 13 1	2 3 1	47 8 0
28th	0-40	417	459	11-3	503	6 53	8 25	8 25	3,591	1 6 7	2,100	0 12 2	2 2 10	43 6 6
January, 4th	.....	403	433	11-4	.....	.....	.....	.....	3,433	1 5 0	2,200	0 11 3	2 0 3	47 13 6
Total	6-18	3946	4073	118-3	2459	53 34	69 45	69 45	30,013	14 4 2	.....	8 10 3	22 14 0	478 2 11
Average	0-31	394	427	11-3	456	6 34	8 40	8 40	3,631	1 5 8	.....	0 13 7	2 4 3	.....

Proceedings of the Madras Government
Under date the 2nd May/79
Read the following

1282

P.S.—Since the above was written Mr. Fourcares has attached to one of his dredgers the rack referred to in paragraph 8 of the report. The rack is attached to the spear of the dredger, and is so constructed that the cam of the lever retains the spear fixed in the jib-head while the scoops are cutting; the spear therefore cannot rise, and the scoops are compelled to take their full bite. This arrangement acts well. It has been working this morning in pure sand. The bucket came up nearly full each time, whereas without the rack only about half a bucketful was raised. The dredger now acts capitally in pure sand. The rack is so arranged that if any very great resistance, such as a large stone or log of timber, be met with, the cam jumps out of the rack without damage being done to any of the working parts.

DEHREE,
The 27th February 1879.

R. B. BUCKLEY,
Executive Engineer, Eastern Sone Division.

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 Diagrams
 S. or at 17. 40
 W. R. 5 sets - or 2
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B. R.
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Proceedings of the Madras Government
Under date the 2nd May/79
Read the following

From
The Govt. of India (N.C. No 123. W. 4th April/79)

1282
10

Communicated
to all Supg. Engineers
for information

J. 18. 79

Engineers with to school limit
Chief Engg for S. is 17. 10/17/79
Supt. Mr. H. W. K. 5 Sels - 10/17/79

Desp. 15-5-79

No of 6 Sels Plans Despd - 10-7-79

Cir 24.4.79. N 30/4/79
J. C. 18-11-79 L. 2-5.

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To
Date
Issued
Recd. Encl.

G. O. 2 May 1879, No. 1722

Nos. 14 - 15

Mr. Inraer's patent
automatic bridge
Letter from the Supt. furnishing
20 copies of a report by
Mr. Buckley, & Engr. Easton
some Division on the matter
of course to supply
information