9533

Public Works (1896) Department.

G.O., No. 3025 W

DATED 26th October 1896

[Despatch Abstract.]

Municipal Drainage Scheme for the Native town of Karachi: Memo from the Engineer & Secretary, Karachi Municipality forwarding a Copy of the Report on the Completion of the ~~—~~ with a report on the working of the Sewage farm for 1895-96, recorded.

F.C 26/10 32/13

[P.W. 25. 2,000—23-10-96.]

BACK PAPERS.

G.O.	No.	Department.	Date.	G.O.	No.	Department.	Date.

FURTHER PAPERS.

G.O.	No.	Department.	Date.	G.O.	No.	Department.	Date.

Public Works (1896) Department.

CURRENT No. 9533

W/B

Order No. 3025 W.D. 26th October 1896

Recorded

24/10/96

K.S.

From The Engineer & Secretary Karachi Municipality

No. G./7238

Dated 14. 10. 96

Received 22. 10. 96

Enclosures 2

Spare copies —

SUBJECT.

Municipal Drainage Scheme for the Native town of Karachi.

Forwarding a copy of the report on the completion of the —

BACK PAPERS.

G.O.	No.	Department.	Date.

FURTHER PAPERS.

G.O.	No.	Department.	Date.

No. 153 OF 1896.

Karachi, 13*th May* 1896.

Annual Report on the Municipal Sewage Farm, Karachi, for the year 1895-96.

To

J. STRACHAN, Esq., M.I.C.E.,
Engineer and Secretary,
Municipality, Karachi.

SIR,

I have the honor to submit the Annual Report on the working of the Sewage Farm for the 12 months ending 31st March 1896, for disposal as you think best :—

Season.

1. Very little rain fell during the year under report so that the farm crops depended almost entirely on the sewage supply for irrigation. It is also no doubt due to the dry season that in most cases very fair prices were got for green fodder sold to the Public.

It is perhaps also due to this dry weather and the absence of anything green in the neighbourhood of the Farm that the crops on it were so much damaged by the young of nocturnal moths during the whole of last hot season.

Plan followed in laying out the Farm.

2. The site of the Farm slopes from the foot of the Munga Pir Hills southwards to near the Lyari River bed and is exposed to the full force of the South-west sea breeze which has a most damaging effect on plants of all kinds in Karachi; in order to be able to, in some measure, shelter the crops from this wind the farm fields have all been laid out in blocks of 4 acres, these blocks being surrounded by roads along the sides of which trees either have been, or are being, planted, and where they are high enough to shelter the farm crops on the windward side, the result is a well marked increase in the height and luxuriant appearance of the crops over all the fields.

Soil.

3. The soil of the farm varies from light sandy loam to hard black caking earth several feet thick, the subsoil is gravel in some places, pure in others with a mixture of yellow clay in it. No water is to be found even in the lowest fields near the River bed at a less depth than 18 feet from the surface. The small well in the farm-yard close to the lower end of fields Nos. 1 and 2 shows no sign of being effected by the sewage run on to them, though they have been treated to a larger supply of it than any other part of the farm, as they were the first fields croped.

The system followed in distributing the sewage on the Farm fields.

4. Various plans of irrigation were tried and given up as unsuitable before we hit on that now followed, which has given perfect satisfaction in growing any crop yet tried, and I believe, gives equal satisfaction from a sanitary point of view in disposing of the sewage quickly and with little or no offensive smell even alongside of the fields on to which it is being run. Each field measures one acre, and for irrigation is divided into beds 20 feet wide, and the full length of the field (198 L. ft.) The sewage which is brought to the upper end of the ground in earthen channels is run on to a bed till it has reached about $\frac{3}{4}$ of the length of it, when it is shut off and turned into another, where the same process is repeated till the whole field has

been irrigated; when the flow is strong it may be running into several beds at the same time. The fields have a fall of about 4½ inches per 100 running feet and the water running in a bed when cut off when it has reached ¾ its length is sufficient to reach the lower end of the bed before it ceases flowing. The sewage when running on to a field is in no part of it over 2½ inches deep, and if by any chance more be run on than is required for its proper irrigation, the surplus is run on to the next lower one or used for roadside trees as happens to be most convenient. There is no effluent from any field, the whole of the liquid part of the sewage is either evaporated by the sun or absorbed by the soil within a few hours after it is run on to a field. A watering once in eight or nine days is sufficient for all the crops as yet tried on the farm. Chubber (Cynadon Dactylon) usually requires but two waterings a month, and for one watering it takes as much sewage as is required for three fields of crops which have not got the stems close together, the chubber grass acts like a filter and by the time the sewage reaches the lower end of the field it is almost as clear as ordinary well water.

Crops tried on the Farm.

5. Guinea Grass (*Panicum Jumentorum*), Lucerne (*Medicago Sativa*), Chubber (*Cynaton Dactylon*), Italian Rye-grass (*Loluim Italicum*), Sugar-cane (*Sacharum Officinarum*). These crops may be called perennials, as with the exception of sugar-cane they will under favourable circumstances continue growing for several years without renewing or resowing. All have grown well and some of them have given heavy yields, particulars as to this will be given later on.

Annuals or Season Crops.

Juar (*Sorghum Vulgare*), Bajri (*Panicum Spicatum*), Mukai (*Indian Corn Zea Mays*). Wheat spelt or Wheat Barley (*Hordeum Spec.*), Barley common (*Hordeum Vulgare*), Millet (*Panicum Miliaceum.*) With the exception of Barley which tillered too much with the result that the stems were too weak to support their own weight. All the other kinds did very well.

Vegetables—country and Europe.

Various sorts of country and Europe vegetables were tried in small plots in field Nos. 1 and 17 and on the borders of some of the roadsides, all grew well, Cabbage and Cauliflowers most luxuriantly. There were some excellent heads of Cauliflower though last cold weather was not a good season for this vegetable, being far too hot for good heads to form.

Guinea Grass: a good Sewage Farm Crop.

6. Panicum Jumentorum or Guinea Grass as it is usually called, is a hardy perennial plant, easily propagated by sets or divisions of the roots and less so by seed. It is a hot weather crop, though it does not entirely cease growing during the cold weather it yields very little during that period of the year. Cattle thrive well on it and seem to relish it after having had it a few times. The two one-acre plots on the farm were planted during April 1895, and have yielded up to the end of March 1896—196,507 lbs. of green fodder. No moth pest has yet damaged this crop to any appreciable extent.

Lucerne.—Medicago Sativa in the climate of Karachi yields all the year round, but its period of most luxuriant growth is the cold season. An acre plot sown on the 8th December 1895 gave 4 cuttings between that time and the last day of March 1896, the weight of the whole was 30,385 lbs.

The seed used was 30 lbs. to the acre sown broadcast, this, though a large quantity of seed, is less than native growers use here.

Lucerne is a favourite feeding material used by all who can afford to get it for horses or horned cattle.

Lucerne Pests.—It is very subject to the attacks of the Larva of nocturnal moths and a small black fly, both of which play great havoc with it at different times of the year. The most effective cure for them is to cut the crop as soon as possible after it is noticed to be attacked by either of these insects. For the Larva of moths when they are very plentiful a good plan is to sprinkle the ground as soon as convenient after the crop has been cut, with newly slaked lime which kills them without hurting the young Lucerne shoots as they begin to grow.

A Moth-trap.—As a preventive a great deal can be done by using an American plan of catching the perfect insect when it comes to lay its eggs on the crop during dark nights. It is thus. Fix a tray of any convenient length and breadth and about an inch or more deep in the field they are likely to come to; fill this tray with kerosine oil (we use phenyle and water which is cheaper) set a fairly bright lantern in the middle of it, the following morning the trays will show how busy these destructive insects must have been during the night.

They lay their eggs sometimes in one field only, when hatched the caterpillars are almost as bad as a swarm of young locusts, in such cases they eat every green blade on the plants and then leave the field in search of other pastures in such numbers that the boundaries of the field seem a moving mass. Through their being allowed to leave a field of Lucerne last season we lost the crops on 5 acres which were completely denuded of everything green in the space of a few days. On a second occasion when they attacked an acre of chubber grass of about a month's growth, every blade of it was gone in about 4 days after the field was noticed to be infested with them. A trench, a little more than a foot deep, was made round the field and kept fill of sewage water, by this means the crops near this field were saved and the caterpillars destroyed.

Black Fly,—difficult to destroy.—A solution of phenyle in water sprinkled over the plants attacked will kill them, but when you come to do this over acres of ground the plan is barely practical, and where the plants are used for feeding purposes I doubt whether it would be safe to use a very strong insecticide except when the plants are very young and even then great care would be necessary.

8. Chubber (*Cynadon dactylon.*)—This is a native perennial grass which yields excellent fodder either in its green state or cured as hay. It is easily grown and once planted it requires little care except to water and harvest it when it is in flower. It has no period of entire rest here, but during the cold weather its growth is very slow.

During the hot weather of the year under report it was badly damaged by the caterpillars of night moths, two cuttings and a deal of time were lost on this account. The two acres under it yielded in all 33,189 lbs. hay. Some of this quantity was sold as green fodder, but the greater quantity was turned into hay. I count ⅔ths of the weight sold in the green state as the weight of hay it would be equal to, and have given the whole weight as hay. We have been selling it at Rs. 15 per 1,000 lbs. delivered on the farm, Rs. 17 delivered in the City or Camp, and Rs. 5 per 1,000 lbs. in the green state delivered as above. It is troublesome and costly to harvest with the country reaping hook, a small reaping machine would soon pay for itself working on this crop.

To reap an acre of chubber with the implement, we now have, costs about Rs. 1-8 per 1,000 lbs. inclusive of making it into hay.

9. *Italian Rye-grass.*—I am unable as yet to offer any opinion on this crop. It was sown last cold weather and the first cutting yielded 13,475 lbs. green feeding material of fair quality. None of it was sent for sale in the open market, most of the crop went at a fixed rate of Rs. 4-9-9 per 1,000 lbs.

10. *Sugarcane,—Local varieties.*—One-third of an acre was under this crop which occupied the ground about 12 months, the yield was 4,383 canes, which were sold for eating, and brought in Rs. 73-7-1, or per acre Rs. 220-5-3. I am not satisfied with this result, the value per acre of this crop can certainly be doubled if not tripled, some of the canes were slightly worm eaten, and this lowers the value very much when the crop is sold for eating, as is done with all the cane grown near Karachi.

11. *Juar.*—This crop grew well till attacked by caterpillars from the effects of which it suffered so badly that but one field of it could be disposed of as a standing crop. The others were cut and stacked to feed the Farm cattle with during the cold weather. Though no doubt juar is generally a much better feeding material than mukai or maize, and also in a climate which suits it a much heavier yielder, it possesses neither of these virtues near Karachi; besides it occupies the ground about a month longer than does mukai, and does not yield a greater quantity of feeding stuff than it does. It is, however, far superior to Indian corn for dry feeding.

12. *Bajri.*—This is not a favourite fodder either green or dry in this part of the country. In its green state cattle seem to thrive well on it and eat it as freely as they do any other green stuff. It is not subject to the attacks of moth larva; it occupied the ground for 51 days from 9th July to 13th August, on which date we began to harvest it. We tried but one acre of this millet, the yield from it was between 13th August up to the 26th September 1895, 27,450 lbs. of green feeding stuff.

Mukai, Indian Corn, Zea Mays.

13. This was found to be the best paying cereal on the farm for green fodder; it is of great repute especially for milch cattle. It is said to increase the yield of milk and improve its flavour, at any rate it has a ready market in Karachi, we sold 11 acres of it as it stood on the ground at prices ranging from Rs. 45 during the early part of the hot weather, to Rs. 81 during the cold season, and could have disposed of much more if we had had it. It is a very suitable crop for the Sewage Farm, if only for its occupying the ground for so short a time (about 2½ months) one is able to have any sewage silt that may remain on the surface ploughed in before it has had time to accumulate to any objectionable extent. It yields green feeding stuff per acre at from 16,000 lbs. to 24,000 lbs. The weight of the crop depends very much on the state it is in when harvested. Like Juar it is very subject to the attacks of moth caterpillars in its young state, but less so after the stems have grown firm and hard. I used lime water to sprinkle on the tender seedlings of several fields of this crop with good effect. This must be done when the larva are quite young and tender, it has little effect after they get big and strong.

14. *Wheat-Spelt or Wheat-Barley.*—This crop very considerably mixed with the black Tartarian oat turned out well on the farm far much more so than ordinary barley. An acre sown on 17th November 1895 was fit to cut as green fodder on the 15th February 1896. The harvesting as required for sale or otherwise was continued on to the 1st day of March 1896. The total quantity so harvested was 25,240 lbs. Cash value received for this quantity mostly sold in the open market was 96-1-10. It is a cold weather crop of faster growth than ordinary barley, and for the purpose of green fodder I think in every way superior to it. Native growers near Karachi are of a similar opinion, if the fact of their sowing it in preference to barley be any criterion to go by on this point.

Barley common, Hordium Vulgare.

15. I do not like this crop for the Sewage Farm, one acre sown with it in the beginning of January 1895 on very sandy soil when the sewage first reached the farm turned out well, but of 4 acres sown with it during the season under report after the land had been well sewaged,

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none turned out at all even fair. The plants were luxuriant to start with, but tillered so much that it was soon evident the crop would be laid by the first heavy dew we had, this happend on the 27th January and 2nd February of this year, when on the latter date we had a smart shower of rain for about 10 minutes or so, this laid the barley as well as other crops, but the barley never recovered its upright form and mostly had to be cut and stacked as dry fodder for the farm cattle. As many as 80 stems were counted, all the produce of one seed, and where the plants were far apart they spread out like a big tuft of jungle grass, the greater part of the stems on the ground.

16. This is not a favourite feeding article about Karachi, in fact it seems to be little known. An acre sown on the farm on the 7th December 1895 was fit for cutting by the 11th February 1896, or a little over 2 months from the date of sowing. The harvesting continued as the grass was required up to the 3rd of March of the current year, the total quantity so harvested was 25,887 lbs. to the acre. It can be grown here all the year round, but is best suited for the cold season, as it runs to seed too quickly during the hot weather. Cattle eat it readily and thrive well on it so far as I have seen. It is certainly worth more attention than it gets about Karachi. It is not subject to the attacks of insects in its green state.

Millet, common—Panicum Miliaceum.

17. We had only small plots of any one kind or what I may call enough to establish the fact that if it be found desirable to grow vegetables on the farm it can be done with success.

Vegetables of sorts, Country and European.

18. On account of the farm land being so fully exposed to the force of the South-West monsoon it is absolutely necessary that the crops be protected from it as much as possible and it is with this object in view, the planting of trees has been carried out, Casuarina Muricata has been used as a screen on the south side on account of its quick growth and fitness to stand the sea breeze. The permanent trees as yet planted consist of Cocoanut and Date Palms arranged in lines along the roadside borders, these when they have made a few years growth will not only give the crops the necessary shelter but will look well and also add to the income of the farm. The castor oil plant has been found to make a most effective temporary screen for the farm crops and also to give a fair return in the shape of oil-seed, which sells here at from Rs. 2-12 to 3-12 per maund of clean seed. The Jait plant (Seobania Agyptiaca) also forms a good screen or shelter for more tender plants, but it gives no other return for occupying the ground.

Arrangement of Road-side trees.

If the cocoanut and date planting can be carried out as it has been commenced on the farm roadsides it will give the place a most pleasing oriental appearance, while the crops will have the required shelter without their growth being effected by unnecessary shade, which trees of a more spreading habit would cause. On the west boundary of the fields along the Mungapir road, babul has been sown to form a close hedge along this road; so far it is doing well and likely to grow fast.

19. A small quantity of Makai and Nankin Cotton seed was received from E. Nicholl, Esq., Amritsar, for trial on the Farm. The Makai which came in the cob was very fine, the cobs or "bhutas" fully 9 inches long and closely packed with seed. It was sown in the field No. 3 on the 24th February and is being preserved for seed, the stems when they commenced to flower were fully one foot higher than the ordinary kind grown on the farm. The Nankin cotton has not yet been sown, but it should be put down about the end of the current month. I hope it may be a success, but fear it will be otherwise, Karachi has a bad climate for cotton growing.

Seed received for trial on the Farm.

20. Besides the ordinary cultivation work of ploughing, sowing and harvesting, 33½ acres in addition to roads and roadside borders were levelled and put in a state fit for sewage irrigation before the 31st of March of the current year. The levelling of the fields was done almost wholely by cattle labour. I did not keep a sufficiently correct record of the levelling of the fields first brought under crop to be able to say with any certainty what the cost was, but the cost of levelling the seven acres last finished was for the whole Rs. 126-2-8, not including supervision, new ropes for and repairs to keens or ploughs which may safely be counted at Rs. 2-8 per acre more or about Rs. 20-8-8 per acre. As the heaviest levelling required has been finished the cost per acre of levelling the remainder of the farm land will not exceed the amount just stated. A distributing channel which commands the irrigation of 58½ acres besides the roadside borders which may be put down at 8 acres more or a total of 68½ acres has also been completed, and should eventually be made a pucka channel so as to economise the sewage as much as possible.

Work done on the Farm up to the end of March 1896.

21. Both men and cattle residing on the farm have been healthy throughout the year. In fact there has been less sickness among the farm hands than among those working in the Gardens during the past 12 months. The cattle were very hard worked, but there was no sickness among them during the year.

The Sewage Farm not unhealthy.

22. Appendix **A** is a report received from the Veterinary Officer in charge of the Richmond Crawford Veterinary Dispensary on some of the farm products he has tried. The mangels were given him one or two daily for about a month specially for experiment. There is no market at present for them in Karachi. The farm cattle fed on them freely and seemed to like them.

Report by the Veterinary Officer.

23. The total quantity of feeding stuff produced on the farm during the year, including 73,302 lbs. used for the farm cattle for which no charge was made, amounts to 996,621 lbs. as under:—

Income and Expenditure.

Fodder stacked partly in March and partly in April is not counted here.

Supplied to Lyari Stable	277,990 lbs.		These are Municipal institutions and the rate allowed per 1000 lbs. including delivery is Rs. 4-9-9.
„ Ranchore	232,430	„	
„ Fire Engine Horses	3,350	„	
„ Zoo	52,000	„	
„ Public	158,379	„	
11 fields crops sold, standing	176,000	„	Estimated.
Sold to Public as Chubber Hay	23,170	„	
Total quantity sold	923,319	„	
Not charged for in Farm accounts. Feed to farm cattle	48,617	„	Green fodder.
	24,685	„	Dry do.
Total yield of Farm	996,621	„	

The Income is considerably over the Estimate, even if the receipts for March be left out, which I have not done. I include them to show the actual results of the farm as near as I possibly can during the first year of its existence when a deal of costly work had to be got through, the cost of which would usually be charged over a number of years and not all to the first one. Levelling the fields cost a good deal laying out, the ground for levelling was not done for nothing nor the kutcha water channels made without expense, we had besides to pay higher wages than ordinary to get men to work on the farm at all. The income including the value of produce sent out up to the 31st March 1896—

Whether paid for or outstanding, was Rs. 4,585 5 10
And the expenditure for the year „ 4,330 15 2

Both the Income and Expenditure are here shown for 12 months only. As adjusted in the Municipal Office the Income will be for 11 months and the Expenditure for 12, no produce from the farm having been sold before the 1st of April 1895.

I have the honor to be,

Sir,

Your most obedient Servant,

W. STRACHAN,
Superintendent, Municipal Gardens.

P.S.—I forgot to mention that the Government Sanitary Engineer, Mr. Pottinger, when he visited the Farm last cold weather left in the visitors book a very favourable opinion about the laying out of the farm and disposal of the sewage. The visitors book contains the opinions of several gentlemen interested in sewage farming and might with advantage be circulated among the members of the Sewage Farm Committee.—W. S.

No. G. 7238 of 1896.

Municipal Office.

Karachi, 14th October 1896.

Memo,

Forwarded with compliments a copy of the Report on the completion of the Municipal Drainage Scheme for the Native Town of Karachi together with a report from the Superintendent of Gardens Karachi on the working of the Sewage farm for the year 1895–96.

H. Luckman
for S. & E.
Engineer & Secretary,
Karachi Municipality.

To,

The Secretary to Government
Public Works Department
Bombay

Genl. I
5833/96

The Secretary to Government
Public Works Department
Bombay

Final report on the completion of the Municipal Drainage Scheme for the Native Town of Karachi together with a report on its working from the date of opening by H. E. Lord Harris, Governor of Bombay, to the present date by

J. STRACHAN, M.I.C.E., MUNICIPAL ENGINEER.

To

THE PRESIDENT AND MEMBERS
OF THE KARACHI MUNICIPALITY.

GENTLEMEN,

I have the honor to submit for your information the following report on the Drainage Works lately carried out in the Native Town of the City of Karachi :—

The accompanying plan marked **A** shows the position of the various works connected with the scheme, including the site of compressor station, direction of air and sewage mains, position of the ejector stations, and the position of the Sewage Farm. On this plan the sewage main is shown by dotted lines, thus — — — and the air mains by dotted lines, thus — . — .

Plan marked **B** shows in detail the area which has been sewered which includes the following quarters, *viz.*, Old Town, Napier, Market, Bunder, Muchi Meani, and part of Jail, Serai and Garden quarters. Plan **B** also shows the manner in which the sewered area has been divided into blocks ; the positions of the various ejectors, manholes, lamp holes, etc., together with the position and sizes of those portions of the air and sewage mains which are within the limits of the above quarters, and the positions and sizes of the gravitating sewers. The five blocks contain a population of about 9,000 each, and arrangements have been made for the discharge from each block of 180,000 gallons of sewage per day.

The works first taken in hand were those connected with the erection of the engine and boiler house with the chimney attached, and the residence of the Engineer. Messrs. T Cosser & Co., of Karachi, were the contractors for these works which were commenced in June, 1893, and finished by them in a satisfactory manner by the end of May, 1894.

Drawing marked **C** shows the plan of engine and boiler house.

Drawing marked **D** is the plan of engine beds.

Drawing marked **E** shows the general arrangement of the compressing engines.

Drawing marked **F** shows the chimney attached to the boiler house, and Drawing marked **G** shows the Engineer's bungalow.

The specifications for these various works will be found as appendices to this report I., II., etc.

It is unnecessary for me to enter here into a detailed description of these works, as the plans and specifications accompanying, explain themselves. It is only necessary here to remark that the chimney as actually built is altogether in excess of the requirements, present or prospective of the Drainage Works. The chimney as built is 150 feet high, and has an inside diameter at the top of 5 feet. These dimensions were adopted in order to provide sufficient draught for a 12 celled refuse destructor in addition to that required for the compressing engines. The difference between the actual cost (which was paid from loan money) and the amount in the estimate has been refunded by the Municipality. It may be useful here to note that the foundation of the chimney was taken down below the surface of the ground to a depth of 12 feet, and that water was reached at a depth of 7 feet (5·27 above M. S. L.)

The following is the cost of this portion of the works :—

Engine house, boiler house, coal shed, cooling well, water tank, drains, etc...	Rs.	9,460	10 6
Engineer's bungalow and out-houses, etc....	„	10,045	2 0
Chimney and flue, etc.	„	16,625	4 5
Total Cost...	Rs.	36,131	0 11
Deduct amount debited to destructor	„	12,750	0 0
Total charge debited to Drainage Works	Rs.	23,381	0 11

Ejectors and Main Manholes.

With the erection of the engine and boiler house, the works connected with the five ejector stations were taken in hand. These works consisted in excavating a well 16 feet square, within which the cast-iron tubbing which forms the outer walls of the ejector station had to be fixed. The excavation at the various ejector stations ranged in depth from 19 to 22 feet. Owing to the large quantity of water met with in the excavations and to the nature of the soil in which the excavations were made, the work was both difficult and costly. To Messrs. T. Cosser & Co., of Karachi, entrusted the excavation, while Messrs. Hughes & Lancaster fitted up the tubbing and placed the ejectors in position inside it. Drawing marked **H** shows the mode of timbering adopted in the excavation, the poling boards marked A A A were kept close to the bottom as the excavation proceeded A 6-inch centrifugal pump driven by an 8 horse-power portable engine was kept constantly at work day and night at each station while the tubbing was being erected. The subsoil water at the

various ejector stations on the commencement of the work stood as follows :—

Ejector Station No.	Reduced Level.
1	4·00 above M. S. L.
2	4·27 „
3	4·00 „
4	4·45 „
5	4·00 „

Drawing marked **I** shows the nature of the tubbing and the position of ejectors when in place. At each ejector station two of Shone's ejectors of 200 gallons capacity each are erected. The tubbing is composed of cast-iron flanged plates $1\frac{1}{4}$ inches thick built up in sections. The access from the road to the ejectors is by means of a manhole grating and a circular cast-iron shaft in which a wrought-iron ladder has been fixed. The joints of the tubbing plates were all carefully planed and fitted together before being finally erected, and to ensure their being perfectly water-tight, strips of sheet lead were placed between each of the plates then screwed up and the joints finally caulked.

Main Manholes.

A main manhole has been built in connection with each ejector station. Into this main manhole all the gravitating sewers in the block to which the ejector belongs, discharge, and from it the sewage flows into the ejectors to be eventually forced through the discharge main to the sewage farm at the outfall. The difficulties attendant on the excavation and building up of the ejector stations attended also the construction of the main manholes. Timber had to be freely used, and the pumps had to be kept constantly at work. Drawing marked **J** shows the plan and section of the manholes as built. They consist of walls of dressed stone 12 inches thick set in cement mortar. The wall is built in two concentric rings dressed to the proper radii. Between each course a fillet of cement $\frac{3}{4}$ inch thick is inserted. The courses break bond both horizontally and vertically. The cement mortar was made up of equal parts of Portland cement and clean sharp river sand. Each manhole is provided at the street level with a cast-iron cover as shown on the drawing. Iron foot rests inside the manhole are also provided.

Laying of Air and Sewage Mains.

This work formed part of the contract of Messrs. Hughes & Lancaster and presented no very formidable obstacles. The air mains convey the air under pressure from the receiver near the compressing engines to the ejectors. The following are the lengths and diameters of the mains used. They have, along with the necessary valves and fittings undergone a satisfactory test by sustaining a pressure of 60 lbs. per square inch and by maintaining a pressure of 55 lbs. per square inch, during a period of two hours.

Total lengths of air main laid are—

5	inch	cast-iron mains ...	...	... 1,206	Lineal yards.
4	,,	,, ...	...	... 716	,,
3	,,	,, ...	...	... 1,391	,,

From the ejectors to the outfall the contractors provided and laid cast-iron pipes with turned and bored joints as sealed sewage mains varying in diameter from 7 inches to 12 inches. The contractors rates included all trenching and restoring the surface of the road. The sealed sewage main is provided with seven 7-inch, one 8-inch, one 9-inch, one 10-inch, and four 12-inch sluice valves, together with all special pipes, bends, junctions, and other fittings necessary to complete the same in a workman-like manner. In addition to the above the sewage main is provided with five back pressure valves one on the line of piping from each ejector. A large air vessel has also been provided and fixed on the sewage main at the north-end of Napier Road behind the branch pipe from No. 5 ejector. This air vessel is intended to prevent "hammering" on the mains when the ejectors are working. Where sewage main crosses the two branches of the Lyari river it is secured by iron piles set in concrete so as to protect it from the force of the river when in flood. The following statement shows the sizes and lengths of the sewage mains laid throughout the work, *viz.*:—

12	inch	cast-iron	sewage	mains	...	... 3,463	Lineal yards.
10	,,	,,	,,	,,	...	... 483	,,
9	,,	,,	,,	,,	...	... 618	,,
8	,,	,,	,,	,,	...	... 540	,,
7	,,	,,	,,	,,	...	... 1,196	,,
				Total Lineal yards.		... 6,300	

Gravitating Sewers, Manholes, &c.

The gravitating sewers are partly of cast-iron piping and partly of glazed earthenware piping, the former being used wherever water was met with in the excavation. The iron pipes are of the usual description with lead joints and laid in the usual manner; a branch pipe to which the house drains will be connected has also been laid in front of each house along the whole length of the gravitating sewers. These pipes are continued up to within 6 feet of the surface of the road-way, and their mouths closed with caps till such time as the connections with the house drains are required. The earthenware pipes are of the best description, true in form, smooth on the surface, and straight, and of a close grained, impervious, and thoroughly vitrified material, well-burned throughout, entirely free from air blows, fire cracks, and other imperfections. They are glazed with a salt glaze both inside and out. The 4-inch pipes are not less than $\frac{3}{8}$ inch in thickness; the 6-inch, $\frac{7}{16}$ inch, and the 9-inch $\frac{1}{2}$ inch. Special care was taken to see that they had full sockets not less than $2\frac{1}{2}$ inches in depth, and a diameter of not less than one inch in excess of the diameter of the pipe. Unless proportions such as these are adhered to for the earthenware pipes a satisfactory result cannot be obtained. The earthenware pipes were jointed with cement mortar: 3 of sand to 1 of cement. The work of laying the gravitating sewers was commenced as soon as the ejector stations

were completed. They are laid cut with gradients varying from 1 in 80 to 1 in 150, and are thus thoroughly self-cleansing. They are provided with the usual manholes, lamp holes, and flushing arrangements. All manholes over 7 feet in depth are circular in plan, and with the exceptions of the five manholes adjoining the ejectors are built of cement concrete blocks. The smaller manholes are built of common rubble masonry lined with cement plaster $\frac{1}{2}$ inch thick.

Drawing marked **K** shows a manhole built of concrete blocks.

Drawing marked **L** shows the smaller manholes built of rubble masonry and disc flush tank, and Drawing marked **M**, shows a lamp hole.

Drawings marked **N, O, P, Q,** and **R** show the sections of the main gravitating sewers, the total length of gravitating sewer measures 58,048 lineal feet.

At the head of each main line of gravitating sewer a flush tank has been built, fitted with an automatic syphon and connected by a small service pipe with the water main. The flush tanks are of various capacities, from 200 gallons downwards, according to the length of the sewers on which they are placed. The longest length of gravitating sewer is 2,000 feet. On the smaller lines of sewers, disc flush tanks have been built. These will be supplied with water for flushing by means of a water cart.

Drawing marked **S** shows an automatic flush tank.

As the tender rates for laying the gravitating sewers were considered by the Committee too high, it was decided on my recommendation to carry-out this part of the work departmentally. This was done with very satisfactory results. The cast-iron and glazed earthenware pipes of various sizes were supplied by Messrs. McKenzie & Co., of Karachi, under contract.

By laying the gravitating sewers departmentally, a very considerable saving to the Municipality has been effected. The lowest tender rate for cast-iron pipes amounted to Rs. 4 per lineal foot, for excavating trenches, laying and jointing the pipes 5 inches to 7 inches diameter, pumping and timbering, and refilling trenches, including repairing roads. The departmental work cost Rs. 3 per lineal foot, resulting in a saving Rs. 25,528. The cost of excavating and building manholes on these pipe lines was proportionately reduced by the departmental work. The work of laying the gravitating sewers was commenced on the 29th January 1894, at ejector station No. 5, and was carried on till the 15th of April, 1895. In connection with this work two 8 horse-power portable engines and centrifugal pumps were purchased and were kept in constant use to enable us to cope with the great quantity of water met with in the excavation. Timber to the value of Rs. 6,000 was also purchased to be used in the trenches, the nature of the soil being such as to render careful timbering absolutely necessary. The five main manholes which were built of dressed stone set in cement mortar turned out costly and when in addition, a farther difficulty arose owing to a rise in the

wages of masons, I resolved to alter the plan and to adopt cement concrete for the remainder of the circular manholes instead of stone. As the work proceeded, the immense advantage of having adopted, this change became more and more apparent. During the year which has passed the rate of wages to masons increased by 30 per cent. while the cost of stones and lime also increased in proportion, and at one part of the year it was almost impossible to obtain masons even at 50 per cent. increase on their former wages. Had I then been dependent on them for building the large manholes of stone, the work would have been most seriously delayed, and could only have been carried on at a very greatly increased cost. The concrete blocks were cast in moulds in the Municipal Workshop and carted to the site of the manhole, and at once placed in position. There was thus completed in one day, what if built of stone and lime, would, under ordinary circumstances, have occupied a week. The cement concrete was composed of 15 parts of broken stone, (1 inch cubes) 10 parts of clean river sand and 3½ parts of portland cement.

The following table shows in a summary form the various works connected with the gravitating sewers in each block :—

Description of Works.	EJECTOR NUMBER.					TOTAL.
	1	2	3	4	5	
						L.ft.
Cast iron pipes, 9 inches diameter ...	...	...	1,516	1,325	...	2,841
„ 8 „ „	797	1,233	...	...	...	2,030
„ 7 „ „	874	...	...	1,638	1,025	3,537
„ 6 „ „	1,451	3,511	2,983	1,377	688	10,010
„ 5 „ „	3,288	830	2,449	543	...	7,110
„ 4 „ „ for branches to house connections...	500	450	550	600	250	2,350
Earthenware pipes, 7 inches diameter ...	240	436	...	1,404	321	2,401
„ 6 „ „ ...	543	500	1,151	2,315	1,666	6,175
„ 5 „ „ ...	5,270	4,658	5,618	5,273	3,125	23,944
						Nos.
Circular manholes built of cement blocks.	26	22	30	24	5	107
Square manholes built of rubble masonry with stone covers and lined with portland cement ½ inch thick	61	53	71	58	44	287
Lampholes built of rubble masonry, concrete, and earthenware pipes	20	20	17	14	17	88
Automatic flush tank built of rubble masonry, stone covers lined with Portland cement ½ inch thick, fitted with cast-iron patent automatic syphon 6 inches diameter	10	10	11	12	6	49
Disc flush tanks as above, fitted with cast iron disc and chain complete	34	30	41	29	28	162

Ventilators.

The sewers are ventilated according to Messrs. Shone and Ault's system, which was devised in order to overcome the difficulties which surrounded the ventilation of the sewers on the old method. The description of this method of ventilation has been already published, and its details are probably familiar to most of you ; but for the benefit of those who may not have read the pamphlet on the subject, I may state that at the upper end of each gravitating sewer is fixed an air inlet-shaft, having a cap, by which the entering air can be regulated in volume. The inlet-shaft, which may be from 7 to 12 feet high, communicates with the sewer by means of a pipe carried from the bottom of the shaft to the manhole at the head of the sewer. Between the ejector chamber and a chamber built at the foot of the outlet ventilating shaft, is a pipe called the exhaust pipe, fitted to a nozzle in the latter chamber. There is also a pipe connecting the adjoining manhole on the gravitating sewer with the nozzle chamber. The outlet ventilating shaft may be of any height above ground, but it is advisable to have it sufficiently high to be above the tops of the surrounding houses. When the ejector is being filled with sewage, the air within it is displaced and passes along the exhaust-pipe connecting the ejector chamber with the nozzle chamber. The air displaced from the ejector in passing through the nozzle causes a partial vacuum, and as this nozzle is fixed in a chamber, (whose communication with atmosphere is by means of the pipe connecting it with the sewer and the inlet air-shaft at the head of the sewer,) it follows that the partial vacuum will be filled by means of air entering the sewer through the inlet-shaft and travelling along it, and the communicating pipe passes out by the outlet air-shaft. When the ejector has filled with sewage and the compressed air has been admitted and has forced out the sewage, the exhaust-pipe is automatically opened and the whole volume of compressed air rushes along the exhaust-pipe and through the nozzle. The effect of this is to produce an intense current of air down the inlet-shaft and through the sewer every time the ejector has completed its discharge of sewage. The sewers are, therefore, swept by a gentle current of air drawn in at the inlet air-shaft and given out at the outlet air-shaft during the time the ejector is filling, and when it has become full and its contents discharged by compressed air, an air flush of large volume and high velocity is produced through the sewers. By this means, also, the objections to the exhaust-air being discharged at the level of the street are avoided. The chamber into which the exhaust pipe discharges, acts as a muffling chamber, so that the objections raised to the noise of the exhaust have been obviated.

Drawing marked **T** shows the outlet air-shaft and its connection with the ejector chamber.

Engines, Boilers, &c.

The machinery supplied by Messrs. Hughes & Lancaster comprise 2 engines each with two steam cylinders (one high and one low pressure) and two air cylinders. Each engine is about 25 nominal horse power and is capable of compressing sufficient air to deliver 375 gallons of sewage per minute

from five ejector stations to the outfall, the lift including friction does not exceed 130 feet. The actual working lift exclusive of friction is 51 feet. The engines were erected by Messrs. Hughes & Lancaster on foundations built by the Municipality. The two boilers supplied by the contractors are of the type known as "dryback" "tubular" type. Each boiler is capable of supplying sufficient steam at 120lbs. per square inch pressure, to work one of the air compressing engines. Proper mountings including safety valves, water gauges, stop valves, blow-off cocks, and other fittings have been provided and fitted with the boilers. In connection with the engines and boilers two feed-water heaters have been supplied and fixed by the contractor so as to utilize the exhaust steam from the engines in heating the water fed to the boiler, and for supplying the feed-water for the boilers two feed-pumps have been provided and fixed. The air cylinders are cooled by water being caused to circulate round their jackets. The water is pumped from a well outside the boiler house. The pump was supplied by the Municipality. Near the engine house an air receiver 12 feet long by 6 feet diameter has been provided and erected by the contractors, capable of withstanding a constant pressure of 60 lbs. per square inch. The air receiver rests on cast-iron cradles supplied and fixed by the contractors, these in their turn rest on a foundation prepared by the Municipality. Proper mountings for connecting the air main leading from the engines, and the air mains leading to the town, have been provided and fitted by the contractors, and a stop valve, blow-off cock, and pressure gauge have been supplied and fitted to the receiver. All the necessary steam, air, and other pipes, between the boilers and the engines; between the engines and the feed-water heaters; between the feed pumps, feed-water heaters, and boilers; and between the engines and air receiver, have been provided and fixed in proper position by the contractors, together with all necessary stop valves, back pressure valves, and other fittings necessary to complete the work. The waste water from the engines has been collected by the contractors where necessary, by means of steam traps, and led into a drain by means of pipes conveniently arranged. The drain was constructed by the Municipality.

Sewage Farm.

At the farm the sewage is discharged into a masonry tank, capable of containing 15,000 gallons, raised on arches about 10 feet above ground level. The discharge from this tank is by means of an automatic syphon. The tank is thoroughly self-cleansing. The syphon discharges into a masonry channel built on the top of an earthen embankment with sides properly pitched with stone. From this main channel subsidiary channels, or carriers convey the sewage to all parts of the land under cultivation. These carriers are provided with sluice-doors at various points, so that the sewage can be diverted to any part of the farm when required. At the present time, only some 150 house connections have been made, but in one of the blocks a large night-soil depot has been erected, into which night-soil and sullage-water, etc., are thrown, and in various streets of the town, sinks have been constructed into which, the sweepers empty the contents of the sullage-pails from all the houses in the neighbourhood. Connections

have been made with all water services, urinals, stand-pipes, etc., and at present about 1,50,000 gallons of sewage are being daily discharged on the farm, and some 50 acres of land are either under cultivation, or, being prepared for cultivation.

Drawing marked **U** shows the Discharge Tank at Farm Yard.

The following table shows the quantity of sewage discharged on the farm since the 29th January 1895 :—

1895.	Date from inclusive.	Date to inclusive.	Total days per month.	Total number of hours worked per month.	Average number of hours per day.	Capacity of each ejector.	Number of discharges of each ejector per hour.	Number of ejectors working.	Total output of sewage per hour.	Total daily output.	Total monthly output.	Grand Total of output up to date.
				H.		gls.			gals.	gals.	gals.	
January	29	31	3	12·15	4·01	200	18	4	14,400	58,752	176,256	...
February ...	1	28	28	109·5	3·89	200	18	4	14,400	56,016	1,568,448	...
March	1	31	31	157	5·6	200	18	4	14,400	80,640	2,499,840	...
April	1	30	30	186	6·2	200	18	5	18,000	111,600	3,348,000	...
May	1	31	31	207	6·68	200	18	5	18,000	120,240	3,727,440	...
June	1	30	30	222	7·4	200	18	5	18,000	131,200	3,996,000	...
July	1	31	31	250	8·06	200	18	5	18,000	145,080	4,497,480	...
August	1	23	23	196	8·52	200	18	5	18,000	153,360	3,527,280	23,340,744

Private Connections.

Many applications have been received to connect private houses with the Municipal drains, and as this matter is of the most urgent nature, I have taken steps to carry on the work as speedily as possible. To this end I have ordered from Bombay a large supply of the necessary piping to enable the work to be proceeded with, till such time as sanction has been accorded for the purchase of material from England. The work of connecting private houses with the drainage system was not included in the original estimate.

Drawing marked **V** shows the manner of making connections with private houses.

On the 7th December 1894, the works (as far as they were completed) were opened by H. E. Lord Harris, Governor of Bombay, Ejectors Nos. 1, 4, and 5 were brought into use, and they have been continuously at work from that day to the present time. About the middle of January, 1895, ejector No. 3 was brought into use, and No. 2 by the 1st of April. These have also been working constantly since the dates mentioned.

The machinery including the ejectors has been placed in charge of Mr. Markwick. He reports that since he took charge of the engines at the compressor stations, they have worked in a most satisfactory manner. Some additions and alterations have been made in order to render them more efficient, but these have all been carried out at the expense of the contractors. They include—(1) supplying gun metal slippers

with adjusting screws, and fitting them to the cross-heads of both high and low pressure side of both engines. These slippers have added much to the smooth working of the engines ; and (2) the spindles of the outlet air valves (in all 40) fixed in the ends of the air cylinders were found to be too weak, and others of a stronger description have been substituted. Steam is daily raised to a pressure of 110 lbs. per square inch, and an engine started about 6-45 A. M., and run without stopping till noon. This time is found sufficient to empty all the mains and manholes of the sewage which had accumulated during the night. Steam is again raised at 2 P. M., and an engine worked from that hour till 5-15 P. M. Pumping from 2 to 5-15 P. M. is sufficient to again empty the drains of the sewage collected. By thus raising steam twice a day a greater quantity of coal is consumed in proportion to the work done than is generally the case when the engines are in full work all day, but this is a more economical mode of working than that of running the engines all day at a low pressure ; and until a much greater number of house connections have been made, this plan must needs continue to be adopted. Working as at present 6 lbs. of water is evaporated for an expenditure of 1 lb. of coal. With the engines working up to their full power, better results would no doubt be obtained, but these figures may be taken as an indication of fair work under the circumstances. The boilers and steam receivers have been lagged since they were erected by the contractors which, no doubt, has effected a saving. The engines run at an average speed of 70 revolutions per minute, and keep up a constant and steady pressure of 35 lbs. per square inch in the air mains. The cut off on the high pressure cylinder is $\frac{3}{8}$ of the stroke, which allows the steam to work with good expansion. The five ejectors have been working very satisfactorily since some trifling alterations have been made, *viz.*—I.—Pressure gauges have been fixed on the inlet air pipes inside the ejector stations enabling the pressure on the mains to be at once observed. These will be found very useful at times when the ejectors may not work satisfactorily as they will show at once whether the defect is due to want of pressure or otherwise. In the absence of a pressure gauge, the defect might be wrongly attributed to some other cause. II.—A small brass cock has been fixed at the lowest point of the exhaust air pipe in each ejector station, which allows for the removal of any water that may lodge there, and flow back to the automatic valve and prevent its free working. From observations carefully made it has been found that at present the five ejectors discharge their contents on an average once in $3\frac{1}{2}$ minutes, which gives the following amount in gallons, as the quantity of sewage daily discharged on the farm. Calculating that it takes fifteen minutes from the starting of the engine to bring the pressure on the air mains up to 35lbs. per square inch, on two occasions daily, and if the two daily runs aggregate $9\frac{1}{2}$ hours, this would leave 9 hours actual working time. From five ejectors each of 200 gallons capacity working 9 hours, and each discharging once in $3\frac{1}{2}$ minutes, we have the following sum :—

$$\frac{5}{1}\times\frac{200}{1}\times\frac{9}{1}\times\frac{60}{1}\times\frac{2}{7}=$$ 1,54,285 gallons, the quantity of sewage at present daily discharged on the farm. The difference of air pressure between the

main at the receiver, and the main at the farthest ejector, is about 18 per cent. that is, when the engine is working up to a pressure of 35lbs. per square inch, the pressure on the main at No. 1 ejector is 29lbs. The Karachi Municipality now possesses an almost perfect sewage scheme, capable of extension at any point. It now remains for the inhabitants of the town to make the fullest possible use of it, by connecting their houses with the drains.

Working of the Sewage Farm.

There is little to report in connection with the working of the sewage farm since my last report, except to record the fact that it is at present paying its working expenses, and will do much more in the future.

The Superintendent of Gardens has favored me with the following report on the farm :—

The commencement of cropping on the sewage farm may be said to date from the 1st of January of the current year. The season for sowing cold weather crops had then long passed, and it was too early to begin with hot weather ones. Barley and lucerne were first tried. The former did remarkably well all through, the lucerne was troublesome to keep alive during the early period of its growth. We, however, eventually succeeded in getting about two acres of it fit for cutting before the end of March ; and ever since, it has given a cutting every 15 or 20 days. *Panicum millaceum* (a kind of millet) proved a most useful crop for the early part of the season. Makai or Indian corn and juar, red and white, have succeeded very well indeed, considering the very exposed situation of the farm and the strong sea breeze which usually prevails there. Guinea grass (*panicum jumentorum*) planted between the 18th and 21st of March was ready for cutting by the 23rd May. The yield of green fodder from the first cutting of this acre was 8,635 lbs., and the side of the field first cut, is about ready for harvesting again. Two acres of chubber, (*huriali* or *cynodon doctylon*), were planted between the beginning of March and the middle of April. The first half acre has given two cuttings, and the rest one only, up to date. So far it is of slow growth, and at present does not impress a person with the idea that it would be a very paying crop. About a third of an acre has been planted with sugarcane, which is growing very well. Potatoes tried in about a quarter of an acre of light, sandy soil, did not eventually turn out so well as expected, partly on account of late planting, but chiefly, from the salt rising to the surface and killing the stems. Some fair-sized tubers were produced, a few of which have been kept to try, whether they will remain good throughout the hot weather. At the present time they are quite firm and fresh, and apparently free from disease. Whether they will keep good for another two months, remains to be seen. From about the beginning of April all the green fodder required for the conservancy bullocks of the Health Department, has been supplied daily from the farm. Since the 10th of June the quantity of green forage disposed of from the farm is daily about 1,746 lbs. We could without any difficulty supply 3,000 lbs. daily from the present time. Now that the men have got into a suitable

system of distributing the sewage, we have no trouble with any of the crops we have tried. All have grown and are growing well. Twenty-four acres have been levelled, twenty of which are at present under crops of different kinds, and an additional thirty-two acres are being got ready as fast as possible, so that, we may in case of rain, have plenty of uncropped ground on which to dispose of the sewage, till such time as it is again required for the growing crops. The heavy levelling required in some of the fields takes up a great deal of time, but unless the fields be so levelled (that the sewage will have no chance of meeting with any obstruction from the time it is let on at the high end of the field till it reaches the opposite side, or is allowed to run off into a lower field) there is little chance of rearing a crop on it, satisfactorily. The ordinary plan followed by cultivators in distributing irrigation water in Sind, does not answer for sewage. About the end of April, lucerne, makai, and chubber were attacked by the caterpillar or larvæ of a grey kind of moth or moths, and in the course of a few days the whole of the lucerne, about two acres of makai, and half an acre of the best chubber, were left without a single leaf on their stems. So numerous were these catepillars that the ground was literally moving with them. They still give trouble among the young, tender cereal seedlings, but we are now able to keep them fairly in check, by sprinkling the young plants with lime-water, in the evening. So far, the farm has been laid out in four acre plots, with spaces between in which to plant trees, to give the crops some shelter from the strong sea breeze, to which the site is so fully exposed. A commencement has been made in planting cocoanuts, dates and casuarinas. Tamarind, bher, and date seeds are brought out among the sewage and germinate all over the place, melon and jamalo plants grown from seed brought out among the sewage, form the most troublesome sort of weeds we have on the farm at the present time.

In conclusion I may mention that the first acre of juar harvested as it began to show flower yielded 16,290 lbs. of green fodder and the crop of makai taken after barley yielded 10,888 lbs. This latter field was rather thin on account of much of the seed having failed to germinate, it being old.

Drainage Establishment, &c.

As to the present cost of working, the following figures will be of interest. They do not include the cost of working the sewage farm, as it already pays its own way :—

1	Establishment	... Rs.	4,296	0	0
2	Fuel	} „	3,804	0	0
3	Sundries, including repairs, stores, oil, etc.				
		Total Rs....	8,100	0	0

The cost of maintenance I estimate at Rs. 600 per annum, and the amount which should annually be placed in a Sinking Fund to provide for depreciation of the boilers and machinery, I set down at 6 per cent. on £6,000 equal to about Rs. 7,500 per annum.

The total work which was originally estimated at Rs. 6,00,000 has been completed within the sanctioned amount as may be seen from the accompanying statement, *viz.* ;—

(1)	Purchase of pipes ... ...Rs.	50,375	15	3
(2)	Excavating trenches, laying and joining pipes, excavating and building manholes, etc. ... „	1,01,375	10	5
3)	Excavating and building five main manholes ... „	2,214	10	2
(4)	Excavating and building, flushing syphons and erecting ventilating pipes ... ... „	30,172	3	10
(5)	Excavating and erecting night-soil depots ... „	945	4	2
(6)	Building engine and boiler house and engineer's bungalow and works at farm yard ... ... „	34,103	5	3
(7)	Supplying engines, compressors, and boilers, excavating and laying sewage mains and air mains „	3,55,758	1	6
(8)	Establishing and contingencies ... ... „	22,054	13	5
	Grand Total Rs...	5,97,000	0	0

leaving an unexpended balance of Rs. 3,000-0-0.

In addition to this balance in cash the following materials of the value noted against each item are in hand :—

Debited to Head No. 1 of Account.

	cwts.	qrs.	lbs.					
Cast-iron pipes	636	3	0	at R. 4/1/6 per cwt.	...Rs.	2,606	11	1
Special castings	725	0	7	at Rs. 6/8/0 „	... „	4,712	14	6
					Total Rs...	7,319	9	7

Debited to Head No. 2 of Account.

2 Nos.	8 horse-power portable engines, complete, Rs. 3,800 each... ... ...Rs.	7,600	0	0
1 No.	8-inch centrifugal pump at Rs. 630 ... „	630	0	0
1 „	6-inch „ „ „ 558 ... „	558	0	0
1 „	4 ton chain block at Rs. 50 ... ... „	50	0	0
1 „	2 ton „ „ 25 ... ... „	25	0	0
2 Nos.	Rolled iron girders, 25' × 10" × 3" × ½" = 50 R. ft. at 28 lbs. per foot = 12½ cwts. at Rs. 6... ... „	75	0	0
1 Set	Manhole block clamps ... ... „	50	0	0
1 „	Bottom clamps ... ... „	50	0	0
2 Nos.	Wooden gantry with winch at Rs. 125 each ... „	250	0	0
2 Sets	Pulley blocks at Rs. 30 each ... ... „	60	0	0
1 No.	Manilla rope ... ... „	15	0	0
	Total Rs.	9,363	0	0

Debited to Head No. 4 of Account.

16 Nos.	Inlet ventilating shafts at £7 each=£112 at 1*s.* $1\frac{27}{32}$*d.* per rupee= ... ...Rs.	2,092	13	6
9 „	6" automatic flushing syphons at £ 9-5-0 each £=$83\frac{1}{4}$ at 1-$1\frac{13}{32}$ per rupee= ... ... „	1483	2	10
7 „	6" disc flushing valves at 18*s.* 6*d.* each=£6-9-6 at 1*s.* $1\frac{1}{4}$*d.* per rupee= ... ... „	117	4	4
6 „	5" disc flushing valves at 17*s.* 6*d.* each=£5-5-0 at 1*s.* $1\frac{1}{4}$*d.* per rupee= ... ... „	95	1	5
	Total Rs.	3,788	6	1

It should be noted that in the original estimate exchange was calculated at 1*s.* 4*d.* per rupee, while the actual rate at which home payments for machinery and stores was made, varied from 1*s.* $0\frac{1}{2}$*d.* to 1*s.* $3\frac{3}{4}$*d.*, causing a total loss of Rs. 32,367-11-0. The saving on the estimate amounts therefore as follows :—

Cash balance ... ...Rs.	3,000	0	0
Materials on hand, including engines, pumps, etc... „	20,370	0	0
Loss on exchange ... ... „	32,367	11	0
Total Rs.	55,737	11	0

In conclusion, I would beg to bring to the notice of the President and the Corporation the valuable assistance I received from Mr. Markwick in reference to the machinery employed on the Works, and from Dewjee. Maistry, in reference to the laying of the pipes. Mr. Abraham Reuben, who took charge of the survey work, performed his duties most efficiently.

I have the honor to be,
Gentlemen,
Your most obedient servant,

J. STRACHAN, M. I. C. E.,
Engineer and Secretary,
Karachi Municipality.

Municipal Office,
Karachi, 3rd September 1895.

APPENDIX I.

SEWERAGE WORKS.

Specification of the various works connected with the erection of Engine and Boiler Houses, &c., in connection with the Sewerage Works on the Shone Hydro-Pneumatic System.

Setting out. The site of the buildings will be marked out for the contractor by the Municipal Surveyor or such other person as may be deputed by the Engineer for the work. The necessary levels will also be given.

Excavation. Trenches for foundations are to be dug to the depth and of the width shown on the drawings, or further down and wider if found necessary in order to obtain a hard and firm bottom. No building is to be commenced until the foundation has been approved of by the Engineer in charge of the works.

The earth from the excavation is to be used in filling in, but will only be paid for as excavation.

Filling in. The remain filling in will have to be brought from a distance, or wherever the contractor may be able to find it, and will be paid for according to the Schedule rate. The Municipality do not undertake to find a place for excavating the earth nor to grant a pass free.

Foundation. The foundation is to be laid of such ordinary thickness as may be required and is to consist of large flat bedded stones laid in good lime mortar. The stones to be of the largest workable size set with their broadest and truest bed downwards. All inequalities on the larger stones to be levelled up with smaller stones on the top bed only and the whole must be thoroughly grouted with thin lime mortar.

Concrete. Where concrete is ordered to be used it shall consist of broken stone, sand, and lime in the following proportions, *viz.*, three parts broken stone, two parts gravel, and one part lime in shell. These materials are to be accurately gauged and mixed in the dry state, they are then to be moistened and mixed till the whole mass is brought to a tough consistency. It shall then be filled into baskets and thrown into the trenches or spread where required, and to be laid in layers of not more than twelve inches thick, well punned and watered.

Wall from foundation to ground level. Walls from foundation to ground level to be of common rubble of the thickness marked on the plans and to consist of parallel bedded stones not less than six inches thick set in good lime mortar, the courses to be levelled every twelve inches in height. Headers are to be laid in each course not less than 4 feet apart and must go through the walls.

Damp course. The first course at ground level is to be covered with half an inch of asphalte to prevent damp rising through the walls.

Walls to plinth.

The outside walls from ground level to top of plinth are to be of block-in-course outside and common rubble inside. The block-in-course shall consist of stones in courses at least eight inches thick laid as uniformly as possible with headers at intervals of not more than five feet. All headers to go through the wall. No stone to have a less breadth of bed than twelve inches. The beds and joints to be dressed to accurate plains, and no pinning of any kind will be allowed throughout the work. The face of the stones to be left rough with a chisel draft one inch in breadth cut all round. The rubble work of which the inside of wall is to be built must be of the best description, well and carefully bonded into the block-in-course face work. All to be properly grouted with best lime mortar.

Inner walls from ground to plinth common rubble.

The inner partition walls up to plinth are to be built of common rubble of the thickness marked on the plan and to consist of parallel bedded stones not less than six inches thick set in good lime mortar the courses to be levelled every 12 inches in height.

External and internal walls above plinth.

All walls above plinth are to be of good Random rubble work carefully set, the stones well bedded in good lime mortar and fully grouted. The wall is to be levelled every 12 inches in height as specified for the common rubble work.

Block course quoins.

Block-in-course quoins are to set round all door and windows openings and on all external angles of the building as shown on the plan. The Block in course to be as specified for the plinth course.

Coping of gables, &c.

The coping of gables and projecting cornice at eaves to be as shown on the drawing and of dressed animar 8 inches thick well and carefully laid.

Pointing.

The whole of the masonry outside and inside to be carefully pointed. The Random rubble walls to be round pointed as may be directed. The pointing to be paid for in the price of the masonry.

Headers.

All walls to have headers not more than 5 feet apart to go through the walls.

Foundations of compressors.

The foundation for the compressors and boilers to be as shown on the plan or as may be directed. The concrete well laid and rammed as described for the other portion of this work. The animar required for the foundation of compressors must be composed of large stones squared in all directions and all faces and beds to be chisel dressed—no stone to be of less cubic contents that 1½ feet. The top course which forms the bed for the compressors to be of ashlar and must be laid as shown in the drawing. This course must be 12 inches in thickness, each stone is indicated on the plan by brown lines and must be carefully dressed to the sizes and set in the position shown. The bolt holes to be circular as shown and to be made as required.

Paving.

The Boiler House and Coal Shed are to be paved with stone not less than 6 inches in thickness. The paving to be laid on a bed of prepared concrete 6 inches thick. The stones for the paving to be laid with lime mortar in regular lines at right angles to the length of the building all joints to break more than 6 inches. No stone to be used in the paving of a less superficial area than 2 feet, all stones to be clean dressed on the top ; side joints not to exceed ¼ inch and to have the bed paralleled to the face all to be properly levelled and joints grouted with good mortar.

Cement plaster.

Cement plaster must consist of one part of Portland cement to three part of clean sharp sand thoroughly mixed in a dry state, and subsequently moistened with water until it is of a proper consistency fit for use, on applying it to walls or floors the work on which it is to be laid must be well watered for two days previously, and the cement must be kept moist by water for some days after being laid.

Lime mortar.

The mortar to be used on the work shall be composed of fresh burnt lime of the best quality to be approved by the Engineer, and clean sharp sand in the proportion of two measures of sand to one of lime.

Lime in shell

The lime must be brought on the ground in shell free from salt. No lime that is injured by weather will be allowed to be used. The sand must be free from salt and no salt water will be allowed on any part of the work.

Lime to be ground.

The lime must be slacked on the ground after being measured, then mixed with sand and well tempered with the proper quantity of water in a pug mill, and only made as required for use, any mortar that is partially set or become bad shall not be permitted to be used on the work.

Sand must be screened.

All sand used in the masonry work must be screened, and must be perfectly clean river or pit sand free from salt or earth.

Arches.

All arches are to be carefully turned on centers of the proper radii and all stones to radiate to the proper arch centers.

Mason work to be flooded.

The mason work is to be kept well flooded with water during the progress of the works, each course as it is levelled should be edged of with mortar and the top filled with water.

Chunam plaster.

The internal walls of the Engineer's Bungalow to be plastered half an inch thick, and to receive two good coats of lime or color wash as may be required. The plaster should be composed of lime paste one part, sand two parts, hair or choped hemp one-sixth part (by volume) to make the paste.

The lime should be slacked with a moderate quantity of water, afterwards diluted to the consistency of cream by a mixture of thin jaggery and water of the proper proportions, the mass then allowed to harden by evaporation to the required consistency for working.

Lime washing.

Lime washing to be prepared from fresh burnt white stone lime, the lime to be dissolved in a tub with a sufficient quantity of water, and the whole well mixed, when thoroughly mixed to be strained through a clean cloth ; clean gum dissolved in hot water to be then added in the proportion of 2 oz. of gum Arabic to one cubic foot of lime or rice size may be used in place of gum. Each coat to be laid on with a brush one coat with a stroke of the brush from top downward another from the bottom upwards over the first stroke, and similarly one stroke from the right and another from the left over the first brush before it dries ; three coats to be applied.

Roofing.

The roof of Engine and Boiler House is to be of trusses consisting partly of wrought-iron and partly of mild steel and put together as per drawing.

All plates, bars, bolts rivets, and shoes are to be of mild steel and T and L irons to be of good quality wrought-iron.

The trusses together with all other iron work are to receive 3 coats of best oil paint one of which is to be applied and thoroughly dried before erection of the work and the remaining two after erection, the price for painting to be included in the price of the iron work.

The trusses are to be set square on squared bedstones the full width of the wall and these stones are to be not less than 2 feet in length by 8 inches thick, sufficient play is to be left at the ends of trusses to admit of expansion and contraction of metal.

The covering of the roof to be of Mangalore tiles made by Albuquerque & Sons or others of an equal quality as may be approved by the Engineer. The tiles to be laid on laths or ribs of Kutcha teak 1½ inches by 1 inch fixed the proper distance apart to suit the tiles, the rafters are also of Kutcha teak 3 inches by 5 inches and fixed on the purlins 1 foot apart. The Kutcha teak purlins are to be 5 inches by 7 inches and fastened by cleats to the wrought-iron principle.

Common roof.

The roof of the coal shed to be a good strong common roof of swallies, rafters split bambcos, matting and mud plaster only. The matting must be close and strong, the swallie purlins should not be less than 6 feet apart 6 inches in diameter, and the rafters 3 inches diameter and 1 foot apart. The mud plaster to put on in two coats of 1½ inches each.

Doors and Windows.

The prices of the doors and windows of every description must include all necessary posts, frames, locks, bolts, hinges, fastenings, and furniture required to make them in every way complete and effective. These articles must be of the best quality and pattern of their respective kinds, and they must be submitted for approval before being used. The doors and windows to be of pucca teak but the posts may be of kutcha teak. All the outside doors to be framed and panelled 1½ inch thick as shown.

The door posts to be 5 inches × 4 inches. The doors to be hinged each with three 4½-inch brass hinges, and fitted with iron rimmed locks, 8-inch brass bolts, &c., as may be required.

The windows are to be of pucca teak framed and glazed 1¼-inch thick, each hung with 3-inch brass butts and fitted with brass butts as may be ordered.

The glass to be of best crown quality. All doors and windows to receive two good coats of best copal varnish, the cost of which is to be included in the rate for the doors and windows respectively.

Timber.

All the wood work must be of first quality of their respective kinds, sound hearted, free from sapwood, shakes or sun cracks and must stand the full dimensions specified without any patching or plugging whatever. All joints and framing must be made and fitted in a workmanlike manner, and in accordance with any drawing which may be furnished to the contractor and to the satisfaction of the Engineer, and if after the wood work shall have been erected any undue skrinkage or bad workmanship show themselves the contractor shall forthwith amend the same. The prices for wood work of every description must include all labour and material connected therewith any necessary for fitting the same into place.

The floor of Engine House to be raised above the ground as shown on the plan, to be of 1½" Kutcha teak boards, grooved and tongued laid on Kutcha teak wall

All plates, bars, bolts rivets, and shoes are to be of mild steel and T and L irons to be of good quality wrought-iron.

The trusses together with all other iron work are to receive 3 coats of best oil paint one of which is to be applied and thoroughly dried before erection of the work and the remaining two after erection, the price for painting to be included in the price of the iron work.

The trusses are to be set square on squared bedstones the full width of the wall and these stones are to be not less than 2 feet in length by 8 inches thick, sufficient play is to be left at the ends of trusses to admit of expansion and contraction of metal.

The covering of the roof to be of Mangalore tiles made by Albuquerque & Sons or others of an equal quality as may be approved by the Engineer. The tiles to be laid on laths or ribs of Kutcha teak 1½ inches by 1 inch fixed the proper distance apart to suit the tiles, the rafters are also of Kutcha teak 3 inches by 5 inches and fixed on the purlins 1 foot apart. The Kutcha teak purlins are to be 5 inches by 7 inches and fastened by cleats to the wrought-iron principle.

Common roof.

The roof of the coal shed to be a good strong common roof of swallies, rafters split bambcos, matting and mud plaster only. The matting must be close and strong, the swallie purlins should not be less than 6 feet apart 6 inches in diameter, and the rafters 3 inches diameter and 1 foot apart. The mud plaster to put on in two coats of 1½ inches each.

Doors and Windows.

The prices of the doors and windows of every description must include all necessary posts, frames, locks, bolts, hinges, fastenings, and furniture required to make them in every way complete and effective. These articles must be of the best quality and pattern of their respective kinds, and they must be submitted for approval before being used. The doors and windows to be of pucca teak but the posts may be of kutcha teak. All the outside doors to be framed and panelled 1½ inch thick as shown.

The door posts to be 5 inches × 4 inches. The doors to be hinged each with three 4½-inch brass hinges, and fitted with iron rimmed locks, 8-inch brass bolts, &c., as may be required.

The windows are to be of pucca teak framed and glazed 1¼-inch thick, each hung with 3-inch brass butts and fitted with brass butts as may be ordered.

The glass to be of best crown quality. All doors and windows to receive two good coats of best copal varnish, the cost of which is to be included in the rate for the doors and windows respectively.

Timber.

All the wood work must be of first quality of their respective kinds, sound hearted, free from sapwood, shakes or sun cracks and must stand the full dimensions specified without any patching or plugging whatever. All joints and framing must be made and fitted in a workmanlike manner, and in accordance with any drawing which may be furnished to the contractor and to the satisfaction of the Engineer, and if after the wood work shall have been erected any undue skrinkage or bad workmanship show themselves the contractor shall forthwith amend the same. The prices for wood work of every description must include all labour and material connected therewith any necessary for fitting the same into place.

The floor of Engine House to be raised above the ground as shown on the plan, to be of 1½" Kutcha teak boards, grooved and tongued laid on Kutcha teak wall

plates and joists and fastened with screws. No board to be of a greater width than 6 inches.

Access to the space underneath the flooring to be furnished by a strap door fitted at a convenient place.

Iron gratings for ventilation will have to be fixed on the outer walls as may be directed in order to ventilate the space underneath the floor. The Engineer's office in Engine room is to be constructed of Kutcha teak posts 4" × 3" and horizontals at the bottom and middle of same dimensions and lined outside with deal wood ½-inch thick well fixed at either end. In the corner facing the Engine a window glazed with best crown glass is to be fixed. The door is to be plain ledged inside, lined with dealwood the same as the wall of office outside and fitted with brass hinges and locks. The walls to be 8 feet high. The whole to receive two good coats of best copal varnish.

Specification of work required for the erection of a Masonry Chimney 150 feet high for the Karachi Sewerage Works.

Setting out.

The site of the chimney will be marked out for the contractor by the Municipal Surveyor or such other person as may be deputed by the Engineer and Secretary for the work.

Excavation.

Excavation for foundation is to be dug to the depth and of the width shown on the drawing or further down and wider if found necessary in order to obtain a hard and firm bottom.

No building is to be commenced until the foundation has been approved of by the Engineer in charge of the work. The earth from the excavation is to be used in filling in around foundation but will only be paid for as excavation.

Concrete.

Lime concrete where ordered to be used shall consist of broken stone, sand, and lime in the following proportions, *viz.*, three parts broken stone, two parts gravel, and one part lime in shell. These materials are to be accurately gauged and mixed in the dry state, they are then to be moistened and mixed till the whole mass is brought to a tough consistency. It shall then be filled into baskets and thrown into the trenches or spread where required and to be laid in layers of not more than 12" thick, well punned and watered.

Cement concrete.

Any cement concrete used in foundations shall consist of broken stone, sand and cement in the following proportions, *viz.*, five parts broken stone not larger than 1½" cubes, three parts of gravel or coarse sharp clean sand, and one part of best Portland cement of a brand approved of by the Engineer and Secretary. It is to be mixed in the same manner as pointed out under the head of lime concrete.

Mortar.

Mortar in masonry with the exception of where otherwise specified is to consist of a mixture of 2 parts of screened sharp sand free from salt or earth to one part of lime. Lime must be brought on the ground in shell free from salt. No lime that is injured by weather will be allowed to be used. The sand and water must be both free from salt or they will not be allowed on any part of the work. The lime must be slacked on the ground after being measured, then mixed with sand and well tempered with the proper quantity of water in a pug mill and only made as required for use, any mortar that is partially set or become bad shall not be permitted to be used on the work.

Foundation.

The foundation is to be laid of such ordinary thickness as may be required and is to consist of large flat bedded stones laid in good cement or lime mortar. The stones to be of the largest workable

size set with their broadest and truest bed downwards all inequalities of the larger stones to be filled up with smaller stones on the top bed only and the whole must be thoroughly grouted with mortar. Headers of suitable length are to be laid in each course not less than 4 feet apart. No course is to be less than 8 inches in thickness.

Chimney.

The base of chimney with the exception of cornices, etc., shown on the plan shall be of first class animar on both inside and outside faces and shall consist of stones laid in courses of not less than 8 inches in thickness. No stone is to be higher in the course than it is broad on the bed and must be at least 12 inches in depth. Headers to be not more than 3 feet apart and to be at least 2 feet in length. The space between the inside and outside animar courses is to be filled in with well fitting stones well bonded together of equal thickness to the course. All beds and joints of stones in animar are to be dressed 3 inches in from the face and together with the faces all dressed to accurate planes and no pinning of any kind to be allowed in the work. The masonry from above the cornice on top of the base to the under side of the chimney cap is to be octagonal in shape and to have the same batter as shown on the drawing. The shaft is to be of first class animar on both inside and outside faces. Each course is to be not less than 8 inches in thickness and is to be composed of stone segments, the joints of one course to cross the joints of the other as shown on the plan. Each segment to be perfectly true in fit and level when placed in the work and no joint is to exceed $\frac{1}{4}$ inch in thickness. The whole of this octagonal masonry must be fitted in suitable number of courses on the ground before being raised for setting, then after being immersed in water for a few moments they can be raised and bedded in their respective positions as required. No chipping of the courses excepting any finishing, dressing, found necessary outside will be allowed after these segmental stones or once bedded in the work. All the joints of the outside and inside faces of the chimney shaft (with the exception of where lined with firebrick) are to be carefully scraped and pointed with fine lime mortar. The cap of the chimney and for a distance of 20 feet beneath it the masonry is to be set in a mortar consisting of fine sharp clean sand and Portland cement in equal proportions.

Chimney cap and cornices of chimney are to be of first class ashlar masonry of the best stone from Hand's Hill Quarry free from stains and blemishes, finely and truly dressed with the chisel on the face and dressed on all beds, and joints to the dimensions shown on the plan. All the points of the outside faces of ashlar work to be carefully scraped and pointed with fine Portland cement.

Firebrick lining.

The inside lining of the chimney for 30 feet above the ground level is to be lined with best English firebricks 9 inches in length radiating to a clear and true circle of 36 inches diameter on the inside. All firebricks to be soaked in water before being set, and to be true fitting and having joints not exceeding $\frac{1}{4}$ inch in thickness.

Fire clay to be of first class English quality, free from foreign matter and is to be soaked in water for at least three days before use to reduce all lumps and admit of it being worked to a proper smooth consistency for thin joints. Around the outside of all firebrick lining a space of $\frac{1}{2}$ inch is to be left clear for expansion, the inside to be smoothy pointed with fireclay. In no case is any part of the masonry to rest on the firebrick lining.

Arches.

The small arches for flue and doorway at the bottom of the chimney are to be of animar at entrance of chimney and lined with firebrick inside.

Door.

An iron plate $\frac{3}{8}$ inch in thickness is to be supplied for the door on ground line and to have suitable fastenings inside to retain it.

Lightning conductor.

On the completion of the chimney a lightning conductor shall be fixed consisting of a flat ribbon or strip of pure copper 4 inches in width weighing 6 oz. per foot run, from top to bottom of the chimney, securely fastened with copper nails driven into the masonry joints carefully at suitable intervals. Around the top course of masonry a copper band shall be fixed with stout sharp copper points about one foot long at intervals of 2 feet. These points to be nickleplated as a protection from oxidation. Where joints are necessary the ends of the copper ribbons must be well cleaned 4 inches up, scarfed or lapped and rivetted, and must be thoroughly soldered. The rod will finish in the cooling Reservoir.

An alternative tender will be called for, for a chimney stack 100 feet high according to the plan which may be seen in the Municipal Office.

The terms and conditions of specification are the same for both works.

General Conditions.

The whole of the work herein mentioned must be executed to the satisfaction of the Municipal Engineer who shall have power to cause to be removed any materials or cause to be pulled down any work that may not be in his opinion satisfactory.

Alter plan.

The Municipal Engineer has the power to alter the plan and specification for this work, at any time and in such manner as he may think necessary, whether such alteration increases or reduces the quantity of work to be performed, and the contractor will have no claim on the Municipality for the work so altered.

Date of completion.

The contractor shall be bound to complete the entire work within eight months from the date of acceptance of his tender for the same or pay a fine of Rs. 20 per day for every extra day until all the work be finished. On the completion of the work, he shall inform the Engineer of the same who will examine the whole work, and if found satisfactory his term of maintenance (being six months) shall commence during which time the building shall be kept in thorough repair by him.

Deposit.

The contractor to deposit a sum of money with the Municipality equal to 5 per cent. on the contract amount, this amount to be returned without interest at the expiry of the term of maintenance above mentioned after such fines as may have been inflicted under this specification have been deducted.

Power to end contract.

If the work should not progress to the satisfaction of the Engineer either as regards progress, workmanship, or material, the Engineer is hereby authorized to take the work out of the contractor's hands and carry on the same departmentally or re-let the contract to another person, the loss to be sustained by the first contractor whose work was considered unsatisfactory.

Contractor to enter into agreement.

The party whose tender is accepted must enter into a stamped agreement with the Municipality for the due fulfilment of the several terms of this specification. The cost of such stamped agreement to be borne by the aforesaid contractor.

Payment.

The work to be measured up monthly, and payments thereon to be made to the extent of 90 per cent. for work done, and the remaining 10 per cent. to be retained by the Municipality until the due completion of work.

It should however be distinctly understood that the periodical certificate of the Engineer for payments shall not be held to signify an unconditional, approval of the work or material included in such certificates, and that the contractor will not be relieved from any risks of liabilities to which he may be subject under the terms of this contract until a final acquitance shall have been given him.

The contractor shall not on any pretence whatever, sublet or assign the contract or any portion of it to another party without the special permission of the Engineer.

On the completion of the work the contractor shall clear away all rubbish and trim up the ground as may be directed.

J. STRACHAN, M. I. C. E.,
Engineer and Secretary,
Karachi Municipality.

Karachi, 16th May 1893.

APPENDIX II.

Specification of Works to be done for the Municipality of Karachi in Sindh in the Supplying and Erection of Compound Steam Engine Air Compressors Boilers Feed Water Heaters Feed Pumps Air Receiver and other fittings and connections, the Supplying and Erecting of Ejector Stations in Cast Iron Tubbing with Ejectors Valves and Connections the Providing and Laying of Air and Sewage Mains with Valves and other fittings together with all Works necessary to complete same in working condition.

1. In this Specification the term Municipality shall mean the Municipality of Karachi in Sindh. The term Engineer shall mean J. Strachan the Engineer to the Municipality. The term Specification shall mean this Specification together with any further descriptions and particulars which may be furnished by the Contractors and approved by the Engineer. The term Drawings shall mean and comprise the drawing already furnished to the Engineer and such further plans sections and other delineations which may be furnished from time to time by the Contractors. The term Contractors shall mean John Hughes and Charles Lancaster of 16 Great George Street Westminster and Acrefair Ruabon in partnership together as manufacturing Engineers both or either of them or their duly authorised representative. The term work or works shall mean and comprise all works materials labour acts matters and things required to be done or to be provided by the Contractors.

2. The whole of the works shall be executed with the best materials and workmanship of their respective kinds and be performed and completed in the most approved workmanlike manner to the entire satisfaction of the Engineer and if during the progress of the works or during the maintenance period provided for by paragraph 28 hereof it be discovered that bad or defective material has been used or that any of the workmanship is bad defective or faulty the same shall be made good by the Contractors to the satisfaction of the Engineer.

3. The Contractors shall at their own cost and charges find and provide all material labour plant and power necessary for the proper execution protection and completion of the works as well as for the safety of the public and the protection of property.

If any implements plant or material shall be brought on the ground for use which the Engineer may deem to be of inferior quality or in any way defective or improper to be used on the work the same shall forthwith upon receiving notice from the Engineer be removed by the Contractors and if such notice be not complied with the Engineer shall be at liberty to remove the same at the expense of the Contractors and the Municipality shall be at liberty to deduct such expenses out of any sums which may be due or thereafter become due to the Contractors for any work done.

4. The Engineer may at any time inspect the materials and manufacture of the various parts of the works and if the Contractors refuse to allow or prevent such inspection the work will be deemed insufficient and not in accordance with the terms of the Contract.

5. The Contractors shall commence the construction of the machinery and pipes immediately upon receiving a written order from the Engineer and shall complete the whole of the works with all reasonable despatch thereafter.

6. All the works to be executed will be paid for in sterling and in accordance with the Schedule of Prices appended hereto which Schedule is based upon the estimate contained in a letter addressed to J. Strachan and signed by Edwin Ault dated 25th March 1891 as provided for in Clause 17. The work may be diminished increased or altered at the will of the Engineer without vitiating the Contract provided that such alteration is not made in opposition to the just interpretation of the meaning and spirit of the Contract.

7. If the Contractors are required to do any work not provided for by the Schedule the price must be agreed upon in writing by the Engineer and the Contractors before such work is commenced and failing such agreement the Engineer may do or employ any other person or persons to do such work which shall in that case be deemed not to be included in the Contract.

8. From the commencement until the completion of the works the Contractors shall at their own expense provide to the satisfaction of the Engineer temporary bridges or other proper and sufficient accommodation for the traffic of the streets footpaths and roads interfered with and shall also at their own expense make arrangements for securing proper and sufficient access to all property passed through or the ordinary approach to which may be interfered with by the execution of the works. Should the Contractor fail or neglect to carry out within a reasonable time such of these works as may be necessary the Municipality may carry them out and duduct the cost from any sum due or thereafter to become due to the Contractors.

9. The Contractors shall at their own expense efficiently strut shore and protect all houses buildings walls fences and other property which may be interfered with or be likely to be effected by the execution of the works and shall make good restore and repair all houses buildings walls premises or other properties which may by or through any default of the Contractors be disturbed injured or destroyed by the execution of the works.

10. The Contractors shall at their own expense shore sling protect restore alter and make good to the satisfaction of the Engineer all water and other mains pipes and services which may by or through any default of the Contractors be damaged or interfered with by the execution of the works.

11. Any existing sewers drains or water-courses which may be unavoidably cut through damaged or interfered with shall be made good to the satisfaction of the Engineer by and at the expense of the Contractors who shall also at their expense and to the like satisfaction restore and make good all streets roads footpaths and land which may be broken up in the progress of the said works.

12. In case the Engineer shall direct any timbering to be left in any trench or excavation or in case it shall be found necessary for the protection of any houses buildings walls fences or other properties to leave any timber in or upon the works or in any trench or excavation such timber shall be of good and suitable quality and the sum of rupees two per cubic foot will be paid for such timber but if the necessity for so leaving it shall in the opinion of the Engineer have arisen from carelessness or neglect on the part of the Contractors such timber so left shall not be paid for.

13. The Contractors shall at their own expense provide and fix proper and sufficient pumps or other apparatus and shall pump out or otherwise remove all

water and other liquid matter which may exist or be found at any time in the trenches of the air and sewage mains and shall not floodroads and property with such pumpings but shall provide suitable means for conveying them away.

14. The works shall not be deemed completed until completed to the satisfaction of the Engineer in all respects and certificate to be so in writing under his hand but such certificate shall not be withheld unreasonably.

15. If the Contractors shall not duly commence any work pursuant to the provisions hereof or to the instructions in writing in that behalf given to them by the Engineer or if after having commenced any work they shall fail to carry it on at such a rate of progress as the Engineer shall deem proper or if at any time it shall appear to the Engineer that the works or any part thereof are not being executed in a sound workmanlike or satisfactory manner or if the Contractors shall at any time suspend or delay the execution of the works unreasonably then and in any of the said cases the Engineer may if he thinks fit so to do take possession of the whole of the works or part of the works to which such default relates and all materials implements and plant thereat or provided in connection therewith and may make what arrangements he may think fit for completing such works and using such implements and plant (free of charge for wear and tear) or for providing other implements and material as he may think proper for that purpose and no sum of money shall be payable to the Contractors until such work shall be completed and the accounts in respect thereof adjusted and then only such balance if any as the Engineer shall find to be payable to the Contractors after retention for maintenance and after all expenses and loss arising out of such taking of possession as aforesaid and all claims in respect of or incident to the completion of the works including the cost of all materials implements and plant if any purchased or otherwise provided for the purpose shall have been paid in full and after due allowance has been made for the use of the Contractors' plant and material.

16. The work as it proceeds shall be measured up monthly by the Engineer. The Contractors or their authorised agent must be present in order that they may agree on the measurements but the Contractors or their agent neglect or fail to attend or refuse to agree to the measurements the measurements made by the Engineer shall be final and conclusive. Only the net measurements of work will be allowed notwithstanding any local or other custom to the contrary.

17. The Engineer shall present to the Municipality a monthly statement of the work executed to his satisfaction and of the materials delivered at the site of the works and approved by him and payments shall be made monthly by the Municipality in sterling on certificates of the Engineer for the amount of the materials delivered less 20 per cent deducted until the works have been and as they are completed. When the works have been and as they are completed to the satisfaction of the Engineer he shall certify for and the Municipality shall pay to the Contractors in sterling one moiety of the 20 per cent retained subject to such deductions as herein provided. After the expiration of three months from the date of completion of the whole of the works the remaining moiety of the 20 per cent retained shall be paid on the certificate of the Engineer by the Municipality in sterling to the Contractors.

18. The Contractors shall at their own expense maintain and keep in good repair the whole of the works for a period of three calendar months next after the date of the Engineer's certificate that the whole of the works have been completed to his satisfaction. If during such period of three calendar months any defects shall be discovered or and if the Engineer shall by writing under his hand require the

Contractors to repair or make good any part of the work and the Contractors shall neglect or omit to commence so to do or if having commenced they shall not uninterruptedly and at such a rate of progress as the Engineer shall consider satisfactory continue and duly complete the same the Engineer may employ any other person or persons to do the work and may purchase and provide all materials implements plant and labour for that purpose and the costs thereof and all expenses incident thereto may be deducted from and defrayed out of the moneys which during the said period of three months are as hereinbefore provided to be retained by the Municipality and the Contractors shall only be entitled to receive the balance if any which shall remain after such deduction as last aforesaid and if the moneys retained shall be insufficient to cover such cost and expenses the deficiency shall be paid by the Contractors.

19. If any doubt, dispute or difference arises or happens touching or concerning the said works or any of them or relating to the quantities, qualities description or manner of work done and executed by the Contractors or to the quantity or quality of the materials to be employed therein or in respect of any additions, deductions alterations or deviations made in to or from the said works or any part of them or touching or concerning the meaning or intention of the specifications and of this agreement or of any part thereof or of the Contract entered into by and between the Municipality and the Contractors or of any plans drawings instructions or directions referred to in the said specifications or the Contract or which may be furnished or given during the progress of the works or touching or concerning any certificate order or award which may have been made or in anywise whatsoever relating to the interests of the Municipality or of the Contractors in the premises every such doubt dispute and difference shall from time to time be referred to and be settled and decided by J. Strachan the Municipal Engineer who should be competent to enter upon the subject matter of such doubt dispute or difference with or without formal reference or notice to the parties to this agreement or either of them and who shall judge decide order and determine thereon and to the said Engineer shall also be referred the settlement of this Contract and the determination of the sum or sums or balance of money to be paid to or received from the Contractors by the Municipality.

20. The directions decisions admeasurements valuations certificates order and awards given and made on such reference as aforesaid of J. Strachan the Municipal Engineer (which said directions decisions admeasurements valuations certificates orders and awards respectively may be made from time to time) shall be final and binding upon the Municipality and Contractors respectively and shall not be set aside or be atempted to be set aside on account of any technical or legal defects therein or in the Specifications or in the Contract founded thereon or on account of any informality omission delay or error of proceeding in or about the same or any of them or in relation thereto or on any other ground or for any other reason or for any pretence suggestion charge or insinuation of fraud collusion or confederacy or otherwise however and it shall not be competent for the Contractors or the Municipality to except to any hearing or determination before or of the said Engineer or of any certificate order or award had proposed made or executed by the said Engineer on the ground of any want of jurisdiction or excess of authority or irregularity of proceeding or otherwise howsoever but any and all matters made the subject of any such hearing or determination or included in any certificate order or award and whether of retrospective or prospective operation or effect shall be deemed to have been properly submitted to the said Engineer and be taken to have been properly adjudicated upon.

21. The said J. Strachan the Municipal Engineer shall not be made a party to or be required to defend or answer any action suit or proceeding at the instance of

the Municipality or of the Contractors nor shall he be required or be compellable by any proceeding whatever to answer or explain any matter touching or relating to any certificate or award made by him or to state or show how or why or in what manner or on what grounds he settled ascertained or determined or omitted to settle ascertain or determine any matter whatsoever nor shall he be required or be compellable in any way to state or give his reasons for any proceeding whatever which he may take or direct to be taken in or about the premises or to produce or show to any person or persons or for any purpose whatsoever any plans drawings or documents whatsoever or any calculations or memoranda whatsoever in his possession or power.

22. The Contractors shall be responsible for all risks to the works and shall make good at their own cost all loss or damage whether to life or property or to the works or to any matter or thing belonging to the Municipality or otherwise arising from by or through the default of the Contractors during the progress or maintenance of the works and in case the Municipality shall be called upon to make good any such costs loss or damage the amount which the Municipality may pay in respect thereof and the amount of any costs or charges which they may incur in reference thereto shall be payable by the Contractors and may be deducted from moneys due or to become due to the Contractors.

23. The Municipality shall provide all proper and sufficient authority for the Contractors to enter in and upon all streets roads premises and other properties to execute the works under this Contract and shall save the Contractors entirely harmless from any claim cost or expense arising from or incident to the entering and executing works in and upon any streets roads premises and other properties after having received instructions from the Engineer so to do.

24. The Contractors shall have an agent or agents on the works either or all of whom shall represent the Contractors in their absence and all instructions given in writing to such agent or agents by the Engineer shall be deemed to have been given to the Contractors.

25. The Contractors shall set out and keep correct the works in every particular according to Drawings duly signed by the Engineer or to written instructions issued from time to time or approved by the Engineer and shall be held responsible for the correctness of the same throughout the whole term of the Contract.

MACHINERY.

26. Each of the two air compressors to be supplied by the Contractors shall comprise two steam cylinders (one high pressure and one low pressure) and two air cylinders and shall be built from the disigns of Messrs Shone & Ault of 16 Great George Street Westminster. Each engine shall be capable of compressing sufficient air to deliver 375 gallons of sewage per minute from five Ejector Stations to the outfall the lift including friction varying between a minimum of 90 feet and a maximum of 130 feet. The engines shall be erected upon foundations to be built by the Municipality and shall be firmly secured by means of holding-down bolts thereto. The Contractors will fully erect the engines providing the material and labour therefor but any cutting to the foundations or alteration therein necessary in order that the engines may be properly erected shall be done at the expense of the Municipality.

27. The two boilers to be supplied by the Contractors shall be of the type known as the "dry-back" or the "tubular" type and shall be fully erected by the Contractors in their proper position. Each boiler shall be capable of supplying sufficient steam at 120 lbs per square inch pressure to work one of the air com-

pressing engines. Proper mountings including safety valves water gauges stop valves blow-off taps and other fittings shall be furnished and fixed with the boilers.

28. The flues leading from the boilers to the chimney shall be constructed at the expense of the Municipality.

29. In connection with the engine and boilers two feed water heaters shall be supplied and fixed by the Contractors so as to utilise the exhaust steam from the engines in heating the water fed to the boilers and for supplying the feed water for the boilers two feed pumps shall be provided and fixed. The water-supply to the engines and feed pumps shall be provided at the expense of the Municipality.

30. Near to the engine-house an air receiver 12 feet long by 6 feet diameter shall be provided and erected by the Contractors capable of withstanding a working pressure of 60 lbs per square inch. The air receiver shall rest on iron cradles supplied and fixed by the Contractors the cradles in their turn resting on concrete stone or brick foundations built at the expense of the Municipality. Proper mountings for connecting the air main leading from the engines and the air main leading to the town shall be rivetted by the Contractors on to the receiver and a stop valve blow-off tap and pressure gauge shall be supplied and fitted by the Contractors to the receiver.

31. All the necessary steam air and other pipes between the boilers and the engines in the first place between the engines and feed water heaters in the second place and between the feed pumps feed water heaters and boilers in the third place and between the engines and air receiver in the fourth place shall be provided and fixed in their proper positions by the Contractors with all necessary stop valves back pressure valves and other fittings necessary for the completion of the works. The waste waters from the engine shall be collected by the Contractors where necessary by means of steam traps and led into a drain by means of pipes conveniently arranged. The drain shall be constructed at the expense of the Municipality.

EJECTORS AND STATIONS.

32. The Contractors shall supply and erect five Ejector Stations constructed of cast-iron tubbing and fixed at the proper depths so as to connect the inlet pipes to the Ejectors with the adjoining manholes. The excavations pumping filling in and restoring surfaces for the Ejector Stations shall be executed at the expense of the Municipality. The Contractors shall make the joints of the Ejector Stations so that they shall be completely water-tight. Convenient means of access to the station shall be provided by means of a ladder. The entrance from the station at the street surface to be closed with a manhole cover. In the tubbing shall be supplied and erected at each station two of Shone's hydro-pneumatic Ejectors each of 200 gallons discharging capacity together with all necessary pipe connections stop valves sluice valves and other fittings necessary to leave the whole in proper working condition.

33. From the air receiver to the five Ejector Stations the Contractors shall provide and lay air mains varying in diameter from 5 inches down to 3 inches including all trenching restoring surface and other works. The air mains shall be tested before being covered in by means of compressed air up to 60 lbs. upon the square inch and the joint so made that they shall be sufficiently air-tight as to prevent the pressure of air enclosed within the pipes falling below 55 lbs. per square inch during a period of two hours. The air mains shall be provided with eleven 3-inch two 4-inch and one 5-inch stop valves of best quality as well as with all necessary special pipes junctions bends and other fittings so that the whole may be completed in a workmanlike manner.

34 From the Ejectors to the outfall the Contractors shall provide and lay cast iron pipes as sealed sewage mains varying in diameter from 7 inches to 12 inches including all trenching and restoring of surface. The sealed sewage mains shall be provided with ten 7-inch one 8-inch one 9-inch one 10-inch and one 12-inch sluice valves together with all special pipes bends junctions and other fittings necessary to complete the same in a workmanlike manner. There shall also be provided and fixed upon the sewage mains in a convenient position a proper sized air vessel.

35. Should it be deemed necessary to provide and drive piling or execute any other special works in order to properly secure the air or sewage mains where they cross rivers drains or other difficult dangerous or insecure places such piling or other special work shall be executed by or at the expense of the Municipality.

J. STRACHAN, M.I.C.E.,
Engineer and Secretary,
Karachi Municipality.

Karachi, 5th June 1893.

Extract from the proceedings of the Quarterly General Meeting of the Karachi Municipal Corporation held on Tuesday, the 26th November 1895 :—

Submitted for disposal the Engineer and Secretary's final report on the completion of the Municipal Drainage Works in the Native Town and bringing to notice the valuable assistance rendered by Messrs. Markwick, Dewji Maistry and Abraham Reuben, Surveyor, in connection with this work.

With reference to the Engineer and Secretary's final report on the Drainage Scheme for the Native Town, Major Morris proposed :—That the thanks of the Corporation be accorded to Mr. Strachan, Engineer and Secretary, for his valuable services in bringing this important work to a successful termination. The proposition was carried with acclamation.

The further consideration of the subject was deferred together with the remaining subject on the Agenda paper to an adjourned meeting to be held on the 17th December 1895.

Extract from the proceedings of the Quarterly General Meeting of the Karachi Municipal Corporation held on the 17th December 1895 :—

The President in referring to the Engineer and Secretary's report on the Drainage Works for the Native Town said, that reference had already been made to the valuable services rendered by Mr. Strachan in connection with this work. It remained now for him to propose a formal resolution which will include the Employes named by Mr. Strachan in his report, whereupon the following resolution was put forward and carried with acclamation :—

Proposed by Mr. Goolam Hoosein Chagla and seconded by Mr. Sahijram Gungadherdas—

" That the report be recorded. The Municipality take this opportunity of expressing their appreciation of the valuable services of Mr. Strachan and also of the assistance rendered by Messrs. Markwick, Dewji Maistry and Abraham Reuben in connection with the drainage works."

Copy of this report with a set of drawings to be forwarded to the Commissioner in Sind and to the Collector of Karachi.