SELECTIONS

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PUBLIC WORKS DEPARTMENT.

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PAPERS

RELATING TO

THE KOHIMA AND GAUHATI WATER-SUPPLY SCHEMES AND THE MHOW WATER-WORKS.

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PAPERS

RELATING TO

THE KOHIMA AND GAUHATI WATER-SUPPLY SCHEMES AND THE MHOW WATER-WORKS.

REPORT ON THE KOHIMA WATER-SUPPLY.

1. The whole water-supply of Kohima is worked by gravitation. The supply is obtained (see index map) from a ravine A on the Pute Badzè hill, and is conveyed in an open channel AB for about $1\frac{3}{4}$ miles to the filter tank B, which is situated just above the Executive Engineer's quarters.

2. The filter tank has an area of 240 square feet of filtering material, or a sufficient area to filter $\frac{240}{9} \times 700 = 18{,}667$ gallons in 24 hours or 13 gallons per minute, a quantity which the discharge from the 2-inch pipe only exceeds for a short time after it is thoroughly cleaned and relaid.

Before the water passes through the filtering material, it is screened and allowed to settle in a small settling reservoir, from which it overflows into the filter.

The filtering medium is a column of charcoal, 3 feet to 4 feet wide, and after that 11 feet to 12 feet of broken stone of size varying from 4 inches to $\frac{1}{4}$ inch.

3. From the filter tank two pipes take off. One, a 2-inch pipe BC, takes off to a 10-feet cube iron cistern situated in the fort. This pipe has a total length of 1,990 feet and an effective head of 20·33 feet, thus carrying a discharging capacity into the fort cistern of 15·8 gallons per minute. At the fort cistern, head is broken, as the cistern is practically an open one with a constant flow of water from a waste spout.

4. From the fort cistern two pipes take off—

(*a*) CDE to the north, capable of carrying a discharge of $8\frac{1}{2}$ gallons to its first cistern and nearly 5 gallons to its second cistern per minute, and supplying the civil establishments, bazaar and police lines.

(*b*) CFGH to the south, capable of carrying a discharge of 7·8 gallons to its first and 7·5 gallons to its second cistern per minute, and supplying the military establishments of the station.

5. The branch CDE is a 1-inch pipe throughout its length of 1,428 feet, which is broken at D by a 5-feet cube iron cistern and has its lower length DE, 1,111 feet, terminating in another 5-feet cube iron cistern E situated at the police lines and above the houses of the civil clerical establishments and bazaar. The cistern D supplies the Public Works Department work and clerical establishments. The supply entering D is regulated by stop-cocks in both cisterns C and D, and is maintained as nearly as possible at 6 to 7 gallons per minute. It is capable of a full discharge of $8\frac{1}{2}$ gallons per minute. The supply leaving cistern D and passing along pipe DE to cistern E is regulated by means of stop-cocks in D and E and is limited as near as possible to about 4 to 5 gallons per minute. It is capable of discharging 4·9 gallons per minute. Thus a continuous overflow of about 2 gallons per minute is left from cistern D and 4 to 5 gallons per minute from cistern E.

The population using these two cisterns is approximately as follows:—

Public Works Department and others in the vicinity of cistern D	100
Police and civil establishments, bazaar, &c., from cistern E	500

6. The branch CFGH is a 1-inch pipe between C and G for a length of 1,550 feet and then it is continued as a $\frac{3}{4}$-inch pipe to H, distant 830 feet lower down.

The length CFG is broken at F, distant 896 feet from C by a 5-feet cube iron cistern which supplies the bachelors' barracks of the military lines, and the length FG terminates in

a cistern G (654 feet lower), the overflow from which supplies the married lines and regimental bazaar in cantonments.

The length GH is carried down to the quarters occupied by military officers. It is a ¾-inch pipe closed at its lower end by an ordinary screw-down stop-cock. The pipe is capable of discharging 2¾ gallons per minute, but only the several military officers and their establishments use the water, and when it is not being drawn by them the cock is closed. This pipe GH was supplied in a subsidiary scheme, the original project terminated at the cistern G. The numbers of persons using the overflow from cisterns F and G and stop-cock H is very variable and depends on the number of troops with families located in the barracks. The theoretical discharge of pipe CF is 7·8 gallons per minute, and that of FG 7·25 gallons. The cisterns F and G being both supplied with stop-cocks to regulate the incoming and outgoing discharges, it is possible to lessen or increase the discharges at both cisterns in accordance with regimental requirements. Usually 6 to 7 gallons per minute are passed down to cistern F, and 3 to 4 gallons to cistern G.

7. The second pipe which takes off from the filter tank is a ¾-inch pipe which is let into the filter 1½ feet higher than the 2″ pipe which carries to the fort. This ¾-inch pipe BK is 177 feet long, and with 16 feet head discharges nearly 4 gallons per minute into a small cistern K, which is situated conveniently between the Executive Engineer's and Deputy Commissioner's quarters, and it is provided with a stop-cock which allows of water being drawn from it when required.

8. From cistern K two pipes take off—

First a ½-inch pipe KL, 660 feet long and discharging with head of 95 feet: it is capable of giving a constant supply of 1·85 gallons per minute at the quarters of the Assistant Commissioner.

The second pipe which takes off from the cistern is a ⅜-inch pipe KM, which has a length of 181 feet and head of 62 feet and is capable of giving a continuous supply of 1·37 gallons per minute. This pipe terminates at a convenient point between the Inspection Bungalow and Mr. Pritchard's house and gives a continuous supply to the establishments of both houses.

The lower ends of both the pipes KL and KM are each fitted with an ordinary brass screw-down stop-cock so that the water can be shut off or let on at pleasure.

9. The above is a full description of the water-supply system of Kohima. The scheme works well when the channel runs clear, but owing to the imperfect filtering material and the very muddy water which comes down the channel AB after rain, it is found necessary to shut off the water entering the filter and to maintain the supply at the various points of discharge in the station with the water stored in the filter and in the large iron cistern in the fort. As it is not always possible to shut off the channel when it is running thick with mud, especially in the case of heavy unexpected showers which occur at night, the filter is often fouled with dirty water, which fouls the pipes considerably. At the lowest point on the 2-inch pipe BC is placed a scouring valve which is constantly used to scour out the pipe. But as an instance of how mud gets conveyed along I would note that at the end of a year an accumulation of 6 inches to 9 inches of silt was found in cistern E, and it contained amongst smaller fish one that was about 8 inches long which could not possibly have passed down to the cistern except in the form of a very small spawn.

In the rains, to guard against the fouling consequent of heavy rain at night, the whole water-supply is shut off at dark and re-opened at dawn.

Another drawback to the scheme is the very short supply of water received from the open channel during the dry weather. The ravine A, at head of the channel AB, has been gauged in the driest weather to discharge 35 gallons per minute. But this quantity, by the time it reaches the filter tank, is reduced by absorption and evaporation to 7 gallons per minute. When these conditions occur, it is necessary to change the supply of water from a continuous to an intermittent one, consequently the supply is only open between the hours of 5 A. M. and 10 A. M., and again from 3 P. M. till dark. During the time when the supply is shut off, the filter and cistern C are allowed to fill up as much as possible: much inconvenience is felt by this system, but unless the water were so conserved, the whole would soon run off and matters be much worse.

It is not possible to reduce the waste from evaporation and absorption in the open channel which is dug in the side of a very porous hill. The only remedy is to bring down a pipe all the way from the ravine A. There is sufficient head to allow of a 2-inch pipe being used in order to get more than the supply now calculated on, *viz.*, 16 gallons per minute. The scheme would

cost ₹10,000 to ₹11,000. The water in the ravine A is never muddy and no filtering would be required.

10. The cost of the existing system, as far as completed at present, has been ₹12,760 and is distributed as follows:—

	R
Open channel, only repairs and improvements of an old channel	1,658
Filter	1,834
2-inch pipe BC with 1-inch branches CDE and CFG	4,758
Subsidiary scheme pipe GH	300
„ „ pipes BK, KL and KM	385
10-feet cube iron cistern 4—5-feet cube iron cistern	3,239
Contingencies	586
TOTAL	12,760

11. The formula used for calculations is that given by Box and is—

$$d = \left(\frac{G^2 \times L}{H}\right)^{\frac{1}{5}} \div 3$$

d = diameter of pipe in inches.
L = length in yards.
H = head of water in feet.
G = gallons per minute.

JAMES ROLLO,
Executive Engineer,
Naga Hills Division.

DRAWINGS ATTACHED TO THE REPORT.

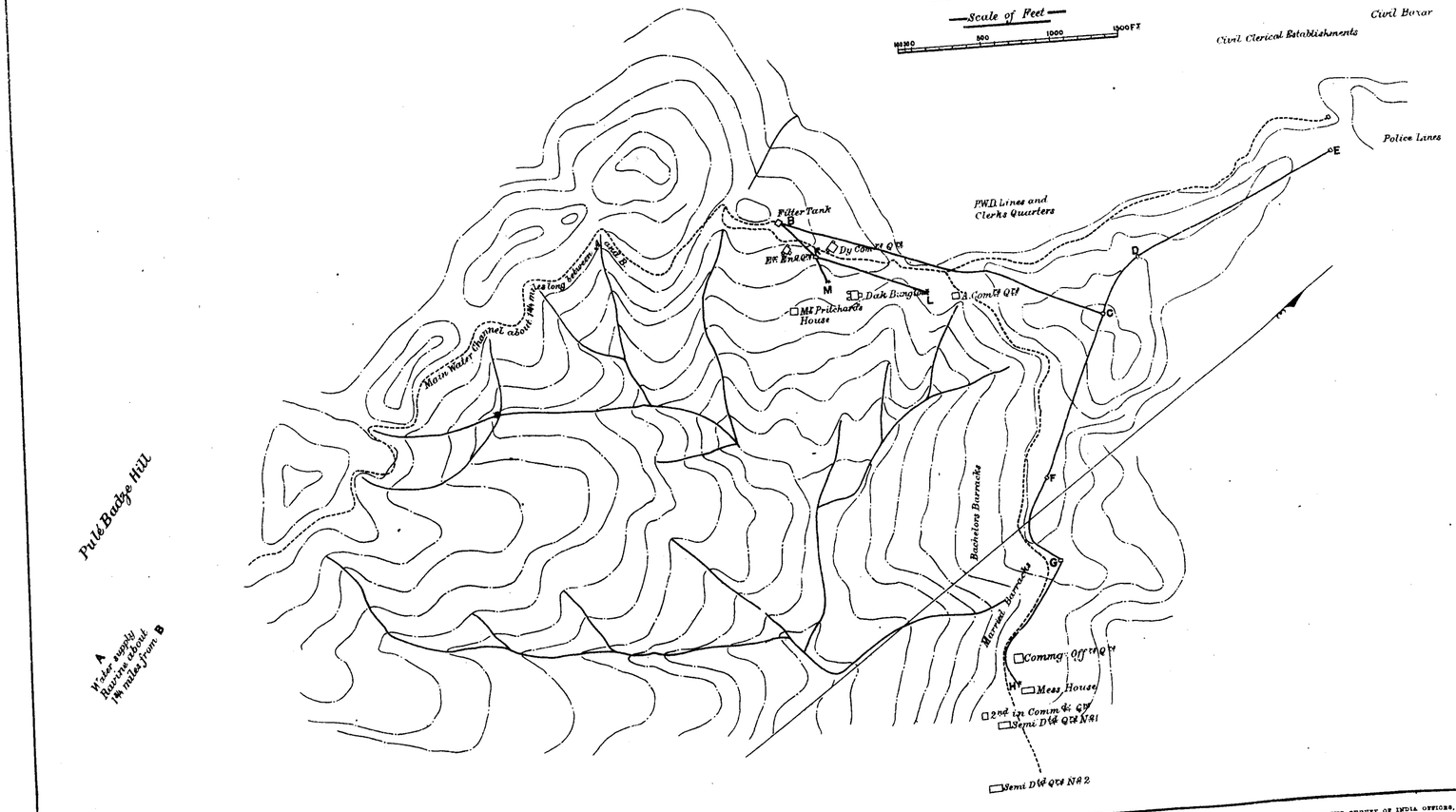
I.—Index map showing general scheme of supply.
II.—Enlarged skeleton plan of distributing pipes and cisterns.
III.—Plan and section of filter tank.
IV.—Section of 2″ pipe connecting filter tank with the cistern in the fortified post.
V.—Plans and sections of north and south 1″ distributaries.
VI.—Plans and sections of subsidiary scheme for supplying Civil Officers' quarters.
VII.— Ditto ditto for supplying Military Officers' quarters.

Note.—Drawings Nos. II, VI and VII have not been reproduced with this Selection.

Sheet No 1

KOHIMA WATER SUPPLY
INDEX MAP

Scale of Feet
0 500 1000 1500 FT



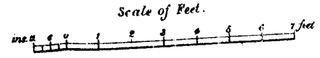
LITHOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, JUNE 1892.

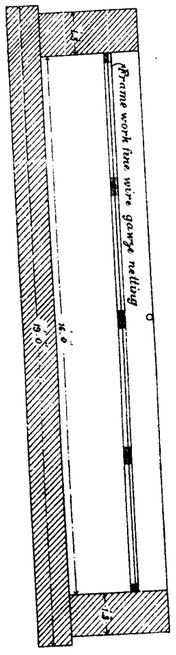
Reg. No. 855, Bengal, Works—6-7-89—500.

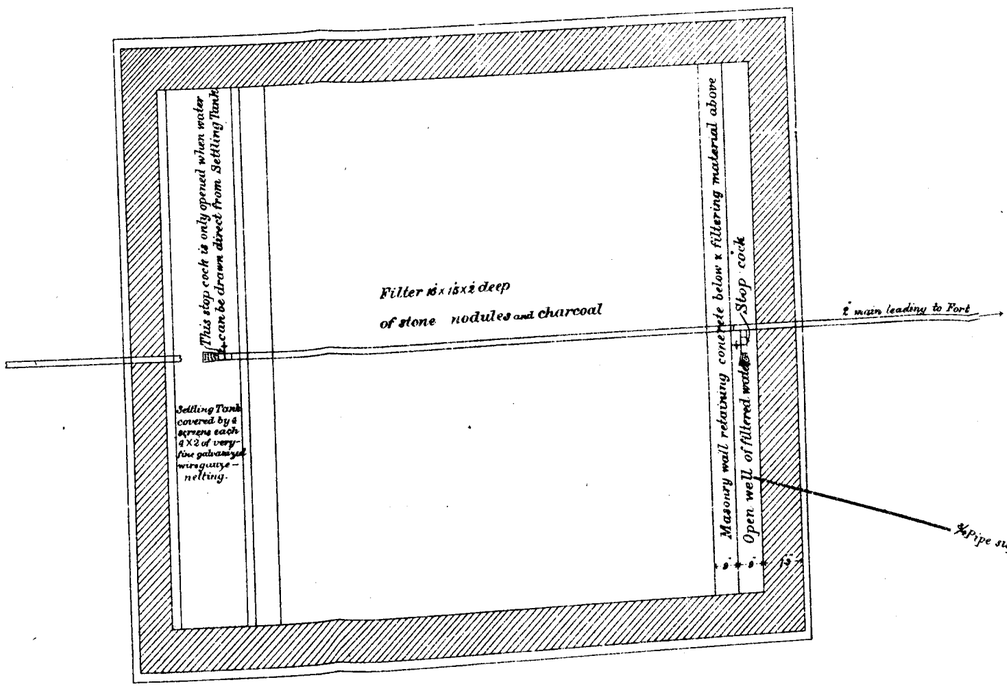
KOHIMA WATER SUPPLY

SETTLING TANK AND FILTER BED

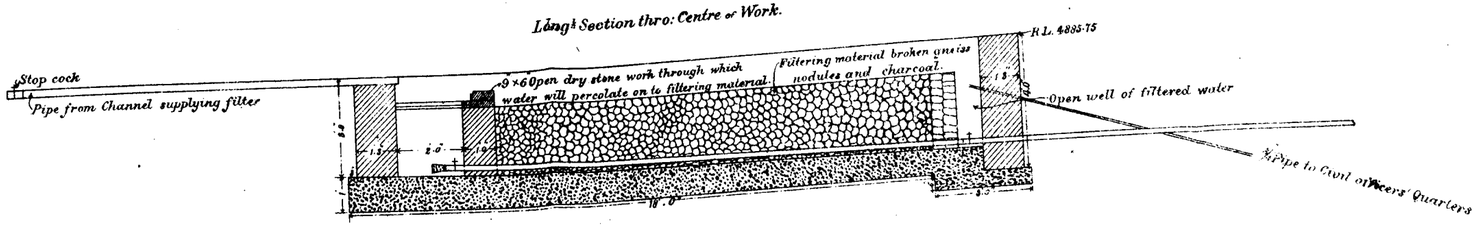
Scale of Feet.







Long^l Section thro: Centre of Work.

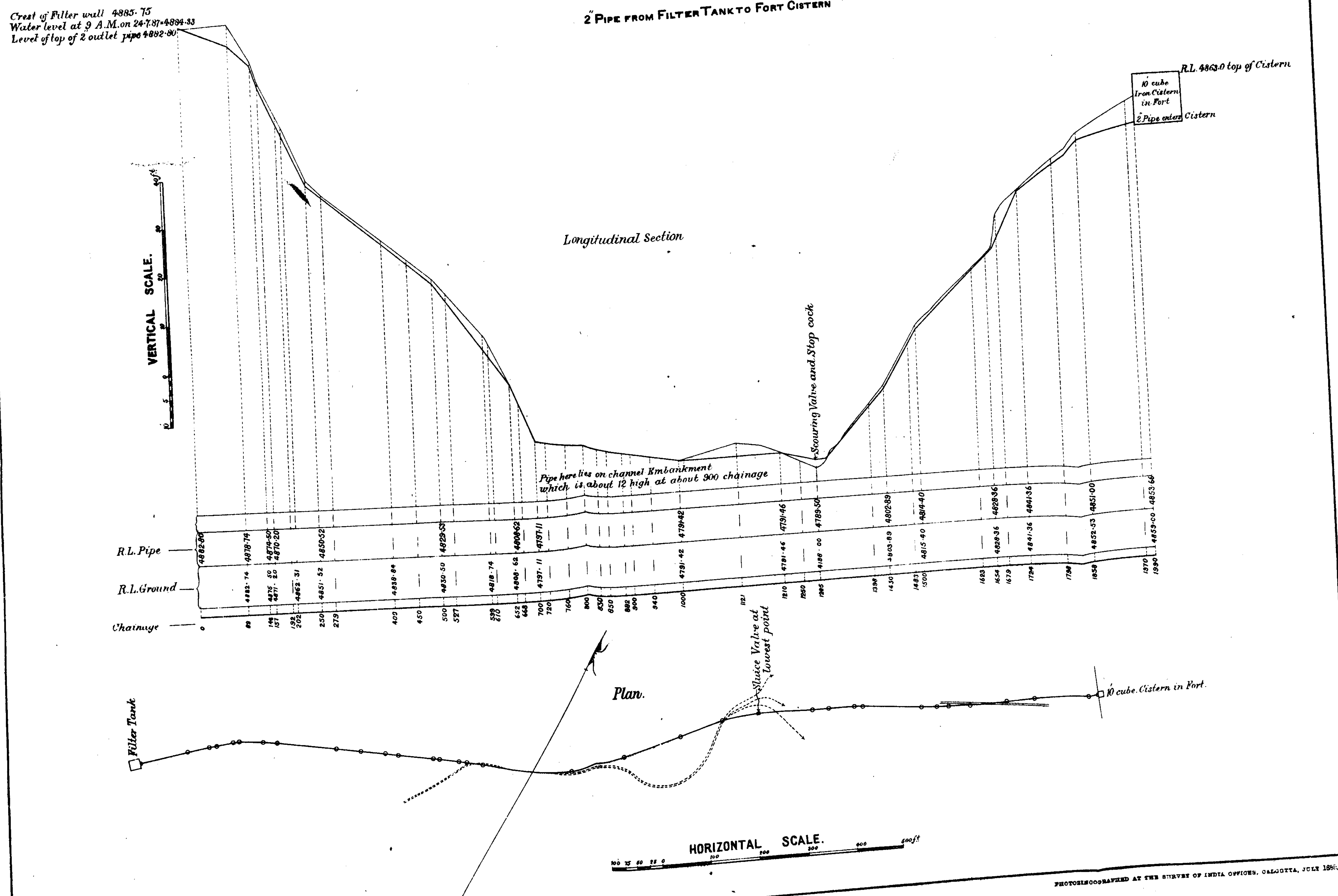


PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, JUNE 1889.

Reg. No. 855, Bengal, Works.—6-7-89.—600

Kohima Water Supply

2" Pipe from Filter Tank to Fort Cistern



PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, JULY 1888.

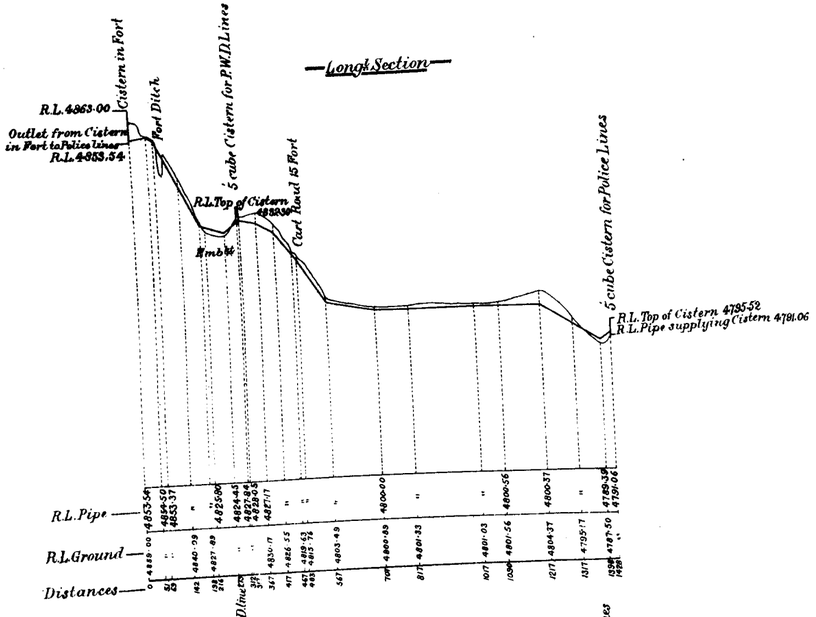
Reg. No 850 Bengal, Works—23-7-88—500

KOHIMA WATER SUPPLY

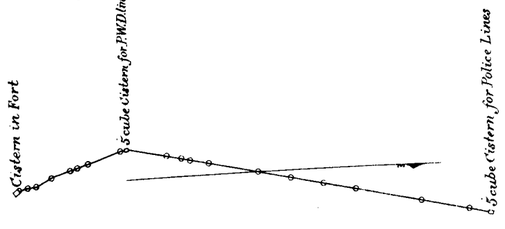
4" PIPES

North Branch from Fort to Police Lines

Longl. Section

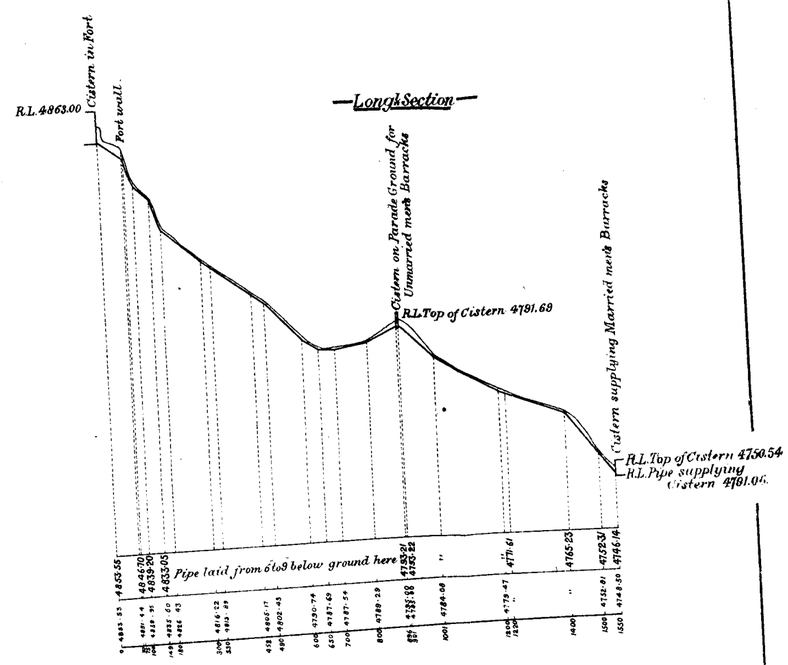


Plan

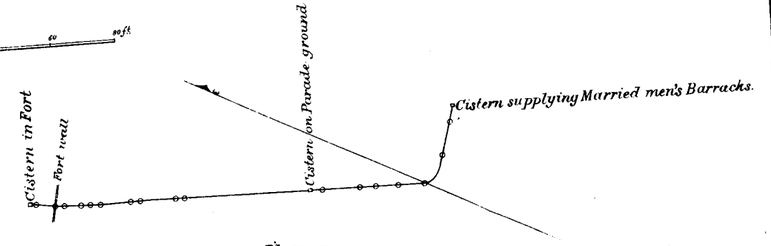


South Branch from Fort to Military Lines

Longl. Section



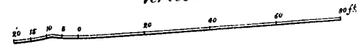
Plan



SCALES

Horizontal

Vertical



PHOTOSLINCOGRAPHED AT THE SURVEY OF INDIA OFFICE, CALCUTTA, JULY 1942.

Reg. No. 855 Bengal Works—23-7-30—200.

BRIEF DESCRIPTIVE ACCOUNT OF THE GAUHATI WATER-SUPPLY.

The original scheme for the Gauhati water-supply, and which was estimated to cost ₹38,214, provided for a well 10 feet in diameter (subsequently increased to two wells, the second being 8 feet in diameter) to be sunk on the left bank of the Brahmaputra at Gauhati near the Sukleswarghât to a depth of 50 feet, or until an ample supply of water filtered into them from the river. These wells were to form practically the main reservoir, over which a pumping engine, capable of delivering 200,000 gallons of water per day, was to be erected, which would throw water by means of a 6-inch delivery pipe into the proposed Storage and Service Reservoir to be built on the crest of what is known as the Dâk Bungalow hill, and from the Service Reservoir the distribution system of piping would be led into the town and civil station, the quantity, *viz.*, 200,000 gallons was fixed upon as representing the requirements of 10,000 head of population at 20 gallons per head. Later on the estimate above referred to was increased to ₹40,501 in consequence of the increased demand for hydrants and private taps, to generally satisfy the requirements of the population.

2. On these lines the scheme was carried out and practically completed by the late Major Willans, R.E., excepting that the pumps were placed in a small well 5 inches in diameter sunk between the 10-feet and 8-feet wells, the pumps being fixed about 20 feet below the surface, the saction pipes being arranged horizontally at a depth of about 24 feet below the surface into the large and small wells, and continued vertically to a depth of about 40 feet in each at first, which vertical lengths had to be subsequently removed in consequence of the wells silting up so rapidly with sand when pumping was attempted.

3. After several trials with the pumps, it was found that the inflow of sand was so great as to effectually choke and seriously damage the pumps, valves, &c., and that the percolation of river water into the wells proved inadequate to supply the quantity required: it became necessary therefore to revise the project, and in December 1886, the following three alternative schemes were drawn up:—

Scheme No. 1.—To dispense with the wells entirely and pump water direct into the storage reservoir from the main channel of the Brahmaputra, where it was proposed to anchor a barge (on which an engine and pumps would be fixed) above the upper ghât at the east end of Gauhati. This plan involved taking up the delivery pipes leading from the wells to the storage reservoir and relaying them: it also necessitated the purchase and laying down of 6,400 lineal feet of additional main pipe along the main road from the storage reservoir to the rocky point above the upper ghat near which the barge would be anchored, the connection between the end of the cast-iron pipes at the rocky point and the pumps being effected by means of a sufficient length of flexible india-rubber pipe to allow of any movement of the barge.

Scheme No. 2.—To dispense with the wells entirely and pump water direct from the river into the storage reservoir by means of an engine and pumps fixed on a barge to be anchored in the river as near as practicable to the storage reservoir on the Dâk Bungalow hill. This plan also involved taking up the delivery pipes and relaying them and providing an additional length of pipe along the top and down the river face of the hill on which the storage reservoir stands, the connection between the one end of the pipe at river bank and the pumps being effected by means of a suitable length of india-rubber pipe to allow for any movement of the barge.

Scheme No. 3.—To utilise the existing wells as intermediate reservoirs, into which water would be pumped direct from the river by a boiler of 12-horse power and a No. 7 pulsometer fixed on a barge to be anchored in the river, as near as practicable tothe wells as the state of the river would allow: this plan simply necessitated the relaying of only a small portion of the delivery pipes from wells to storage reservoir and the removal and re-erection of the engine boiler and pumps in a more convenient engine house sufficiently large to enclose *all* the machinery and the large well, the pumps being fixed in the large well on a strong platform 22 feet 3 inches above zero (zero on the Gauhati water-gauge being 148·76 feet above mean sea level) to admit of their being readily reached and examined at any time, and the wells being connected by means of a syphon pipe laid on the surface horizontally and continued vertically into them to a height of about 15 feet above zero; or 5 feet below the water level, the said water level being maintained at a uniform height of 20 feet above zero. Under this arrangement the pumps would deliver water *direct* from the large well into the storage reservoir, and into the

small well water would be pumped direct from the river by the No. 7 pulsometer, the connection between the barge and small well being effected by a sufficient length of flexible hose, and as great a length of light wrought-iron pipe as can be conveniently used, the whole of the piping from barge to well being so arranged as to admit of its being easily lengthened or shortened as circumstances may require.

4. It was decided on careful consideration to adopt scheme No 3 as being the most suitable as well as economical in all respects, and a second revised estimate was accordingly drawn up and sanctioned, in which provision for the previous expenditure was also made. This revised estimate amounts to R65,897, of which R53,565 represents the cost of the work done by the designer of the original scheme, and the balance R12,332 is for the alterations and additions subsequently found to be necessary to complete the works.

5. These alterations were taken in hand in November 1886, and the works were thoroughly completed and handed over to the Gauhati Municipality in June 1887. The total expenditure stands at R68,457, which has been subsequently reduced to R67,049 on account of a write-back of materials to the value of R1,408 charged for, but not used, so that the excess over the final estimate is only R1,152.

6. The following is a general description of the Storage and Service Reservior on the Dâk Bungalow hill and of the distribution system. Detailed drawings as per margin illustrating the complete pipe system are appended.

I. Index map shewing general scheme of supply.
II. Plan and section of reservoir tanks.
III. Arrangement of pumps and platforms in 10-feet well.
IV. Detailed plan of pump platform.
V. Pumping engine house.
VI. Barge to carry 12-horsepower boiler, pulsometer, &c., length 54 feet, beam 15 feet 9 inches, depth 4 feet.

7. The water is delivered by 6-inch pipes from the large well into a small receiving cistern about 5 feet square and 2 feet deep. This cistern (A) is of concrete, lined with Portland cement, and has two outlets, one delivering on each side of the central dam which divides the settling tanks. The settling tanks are originally two in number, each 150 feet × 125 feet × 2 feet deep, but were divided by a cross dam in 1886. There are therefore four settling tanks now.* These tanks were found to leak very badly at first and had to be repuddled with clay, with the satisfactory result of making B and C practically water-tight and D and E considerably better, but not so good as B and C. As B and C have been found quite sufficient for the supply, D and E have not been used much. F and G are the two filter beds and H the Service Reservoir. These are each 39 feet × 40 feet, built of concrete, and not being lined with Portland cement, leak to some extent from one into the other and still more into the soil below them, the water finding its way out at the foot of the Dâk Bungalow alongside the main road; this leakage apparently neither increases nor decreases and cannot be prevented without emptying the settling tanks, filter beds, &c.

* B, C, D, and E.

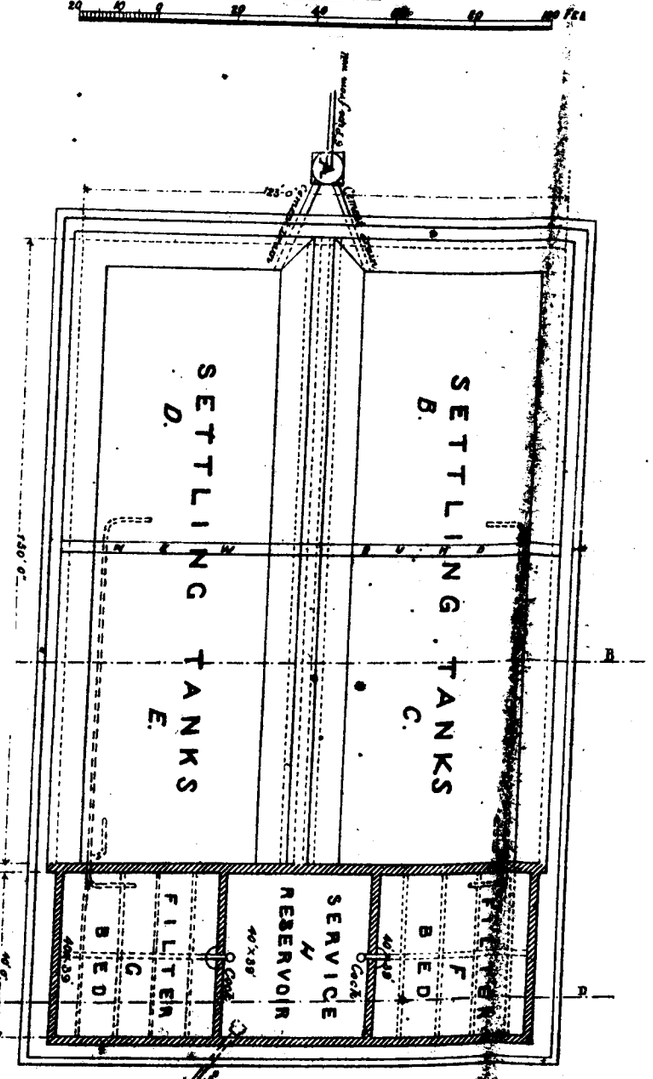
8. The filter beds are provided with a 6-inch layer of broken stone and 18 inches of sand above the stone as the filtering medium; brick tunnels or are laid lengthways and cross the bottom of the filter beds with the object of forcing the filtered water to collect in them and thence through a cock and pipe from each filter bed into the service reservoir. The cocks and pipes are built into the partition walls close to the bottom of the filter beds and service reservoir. The water from the receiving cistern A is let into the settling tanks B or D near the bottom and allowed to settle from tanks B or D: it is drawn off from the surface into tanks C or E (or if necessary into the filter beds F or G) by means of pipes laid along the bottom of the settling tanks and through the cross dams and walls between tanks C and E and filter beds F and G, respectively. These pipes are so arranged that the ends can be raised or lowered as required to suit the height of water in settling tanks. The bottom of the filter beds and Service Reservoir is about 2 feet below the bottom of the settling tanks, consequently the water drawn from the surface of the settling tanks falls on and passes downwards through the filtering medium in the filter beds and from the filter beds into the service reservoir, entering the latter at the bottom.

9. The service reservoir (which on the average contains about 18,000 gallons)—the filtered water is distributed about the town by means of a 4-inch main to the foot of the Dâk Bungalow hill, where, close to the main road, is fixed a water metre; after passing through the metre the supply is diverted into two 3-inch mains, one leading towards the Uzán Bazaar, where it is again diverted into two 2-inch mains at the corner of the main road near the Commissioner's bungalow, one supplying the northern portion of the bazaar by means of one iron tank, two pipes and stand, eight private taps, the other the southern portion by means of three iron tanks, one-stand pipe and ten private taps. A 1½-inch main from the 2-inch southern main distributes the water due south to one stand-pipe and five private taps. From the 3-inch main between the metre and the Uzan Bazaar, one 1½-inch main run south and supplies part of the Pan Bazaar

GAUHATI WATER WORKS

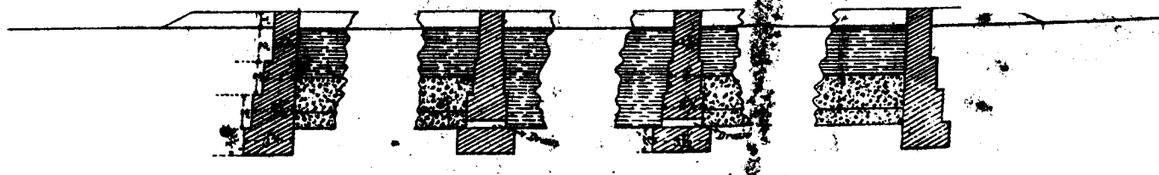
RESERVOIR TANKS

SCALE OF FEET



Section on A.B.

Section on C.D.



Scale of Feet for Sections

GAUHATI WATER WORKS

ARRANGEMENT OF PUMPS & PLATFORMS IN 10FT WELL

SHEET No 3.

SCALE OF FEET

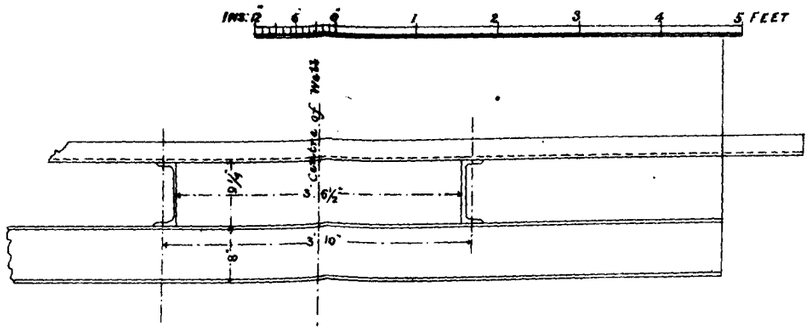
Reg. No. 855, Bengal, Works.—28-6-89.—800.

PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA. JUNE 1890.

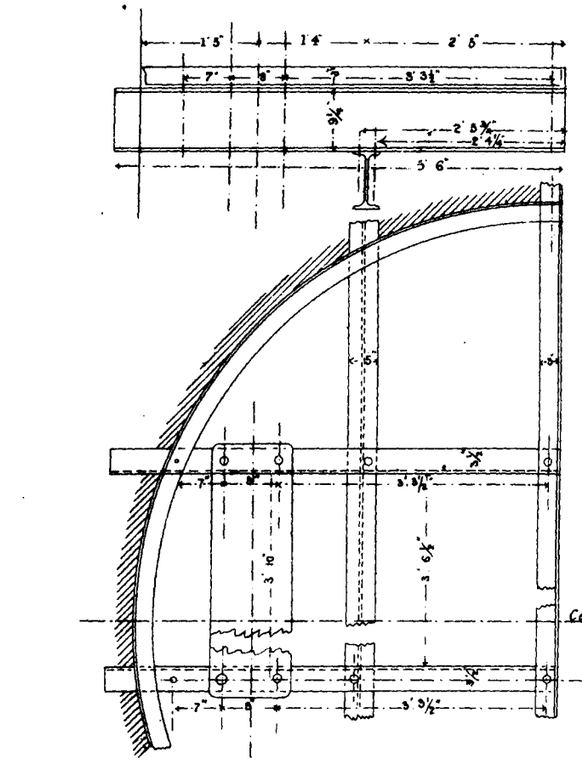
GAUHATI WATER-WORKS

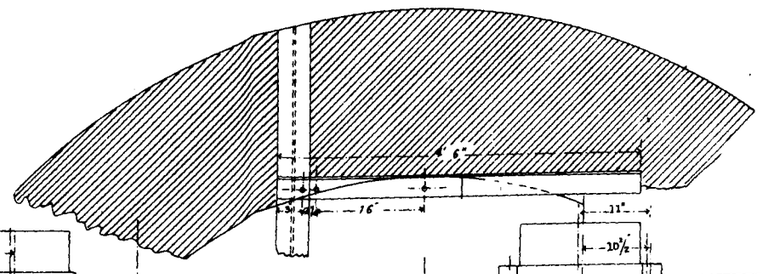
SCALE OF FEET

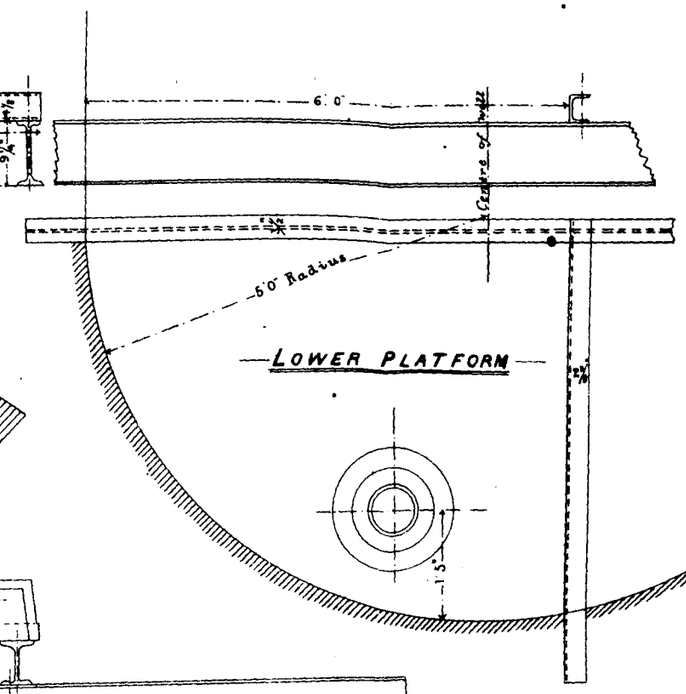
INS: 0 6 9 1 2 3 4 5 FEET



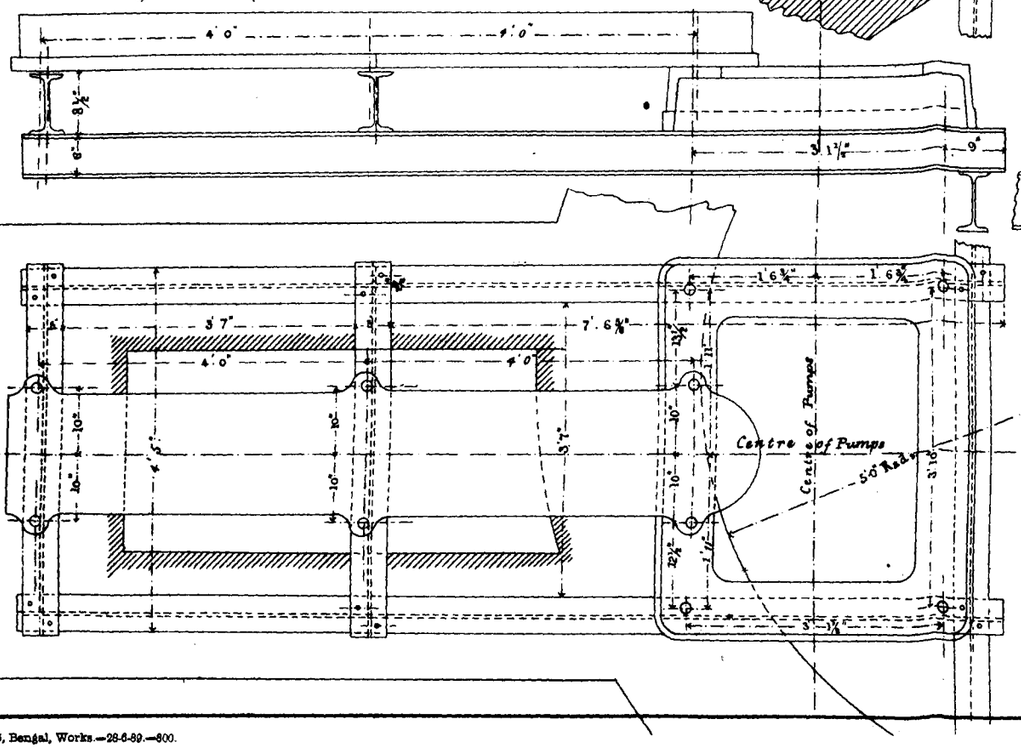
PUMP PLATFORM







LOWER PLATFORM



PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, JULY 1889.

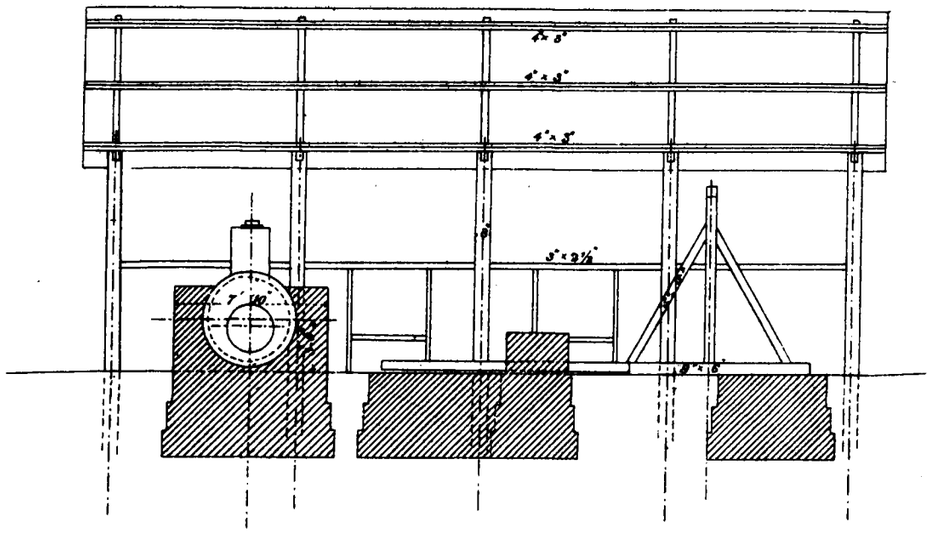
Reg. No. 555, Bengal, Works.—28-6-89.—600.

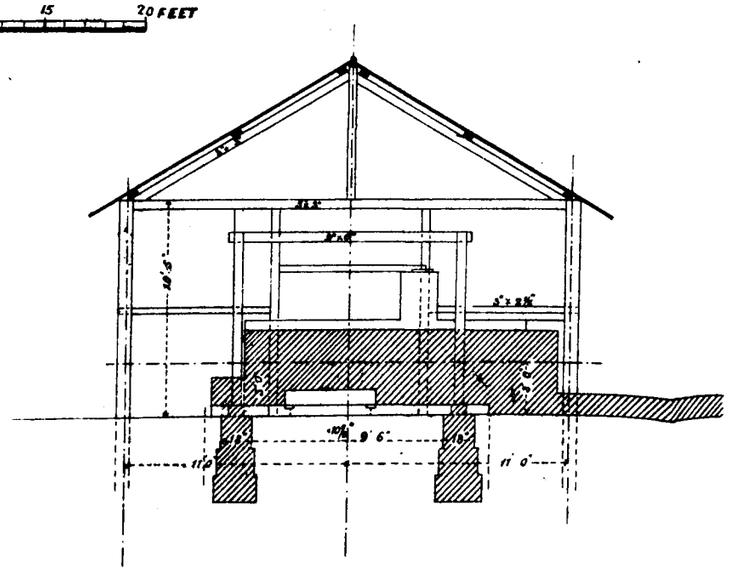
GAUHATI WATER-WORKS

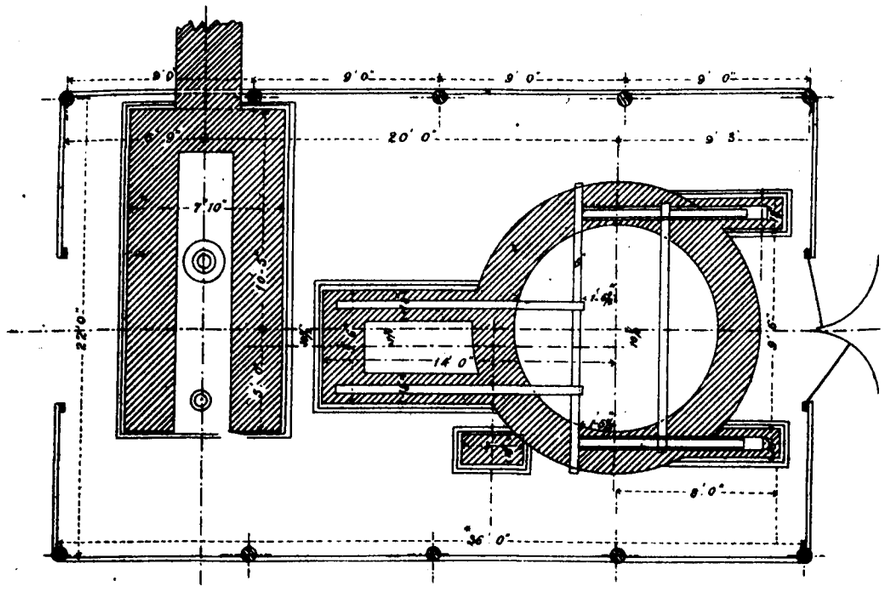
PUMPING ENGINE HOUSE

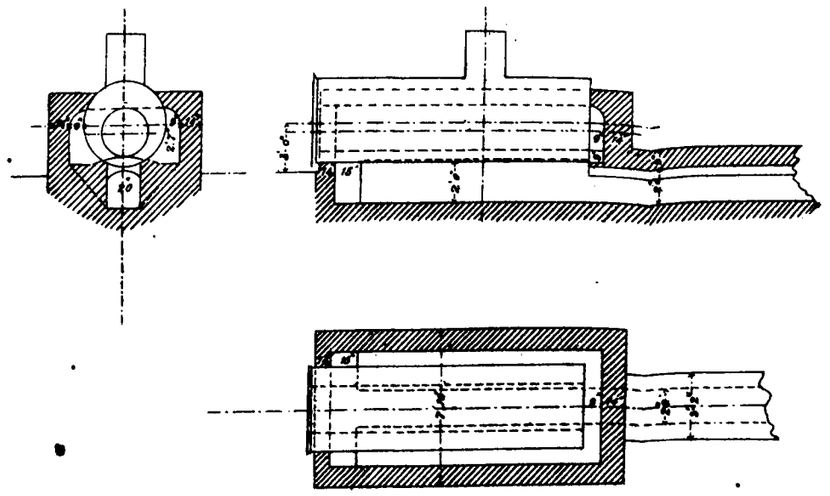
SCALE OF FEET

INS. 12 0 5 10 15 20 FEET









N.B. Centre line of Engine is 11
do. — do. — Pumps from centre of Well } is 10½

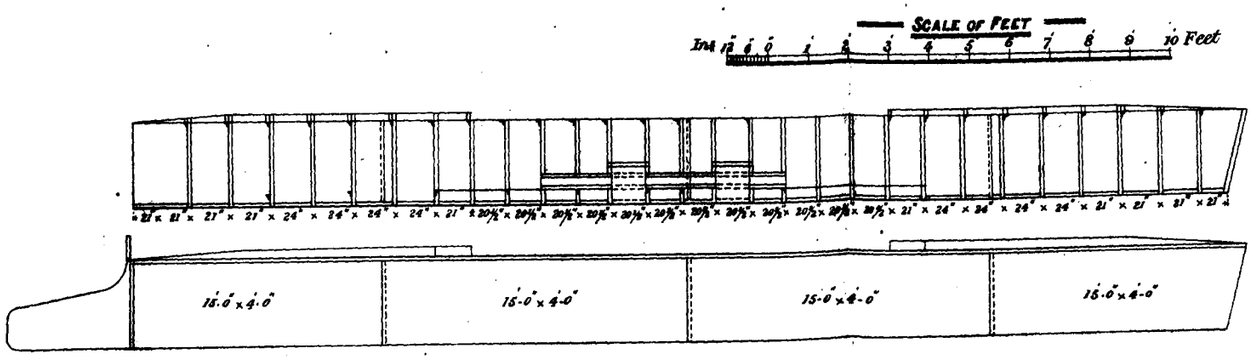
Reg. No. 555, Bengal, Works.—26-6-39.—600.

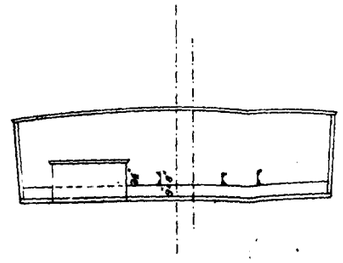
PHOTOLITHOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, JULY 1939.

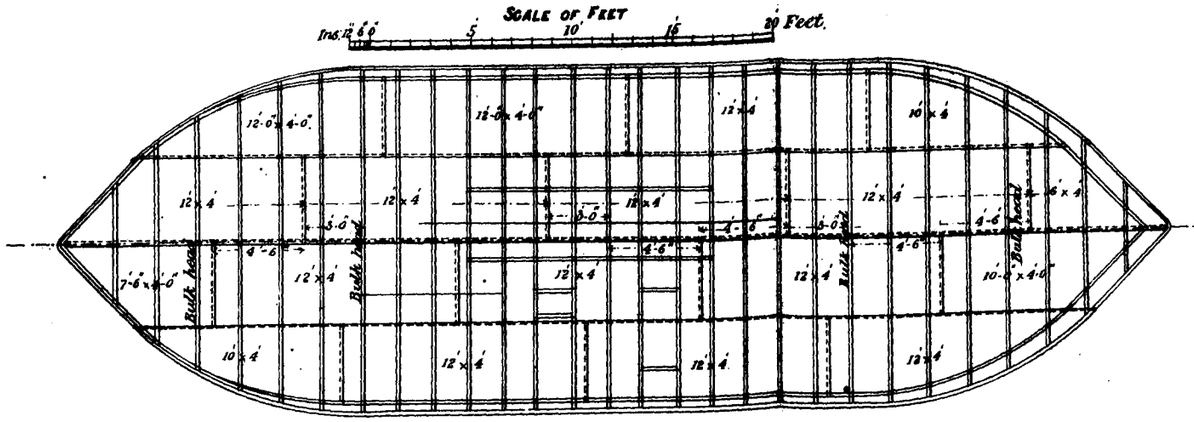
GAUHATI WATER-WORKS

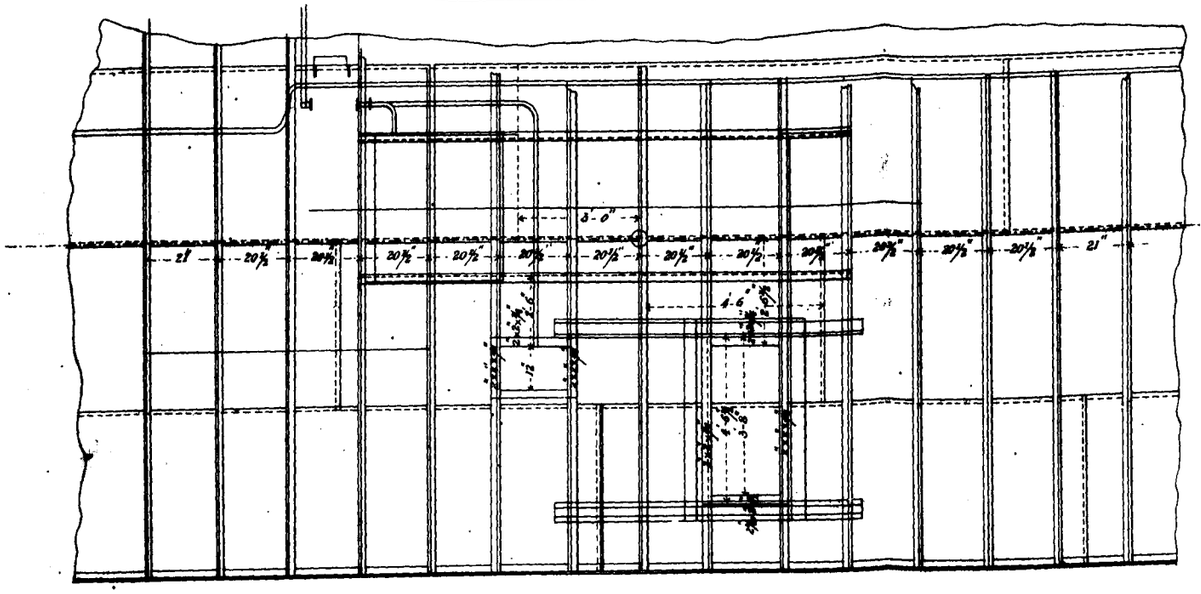
BARGE TO CARRY 12 H.P. BOILER - PULSOMETERS &c

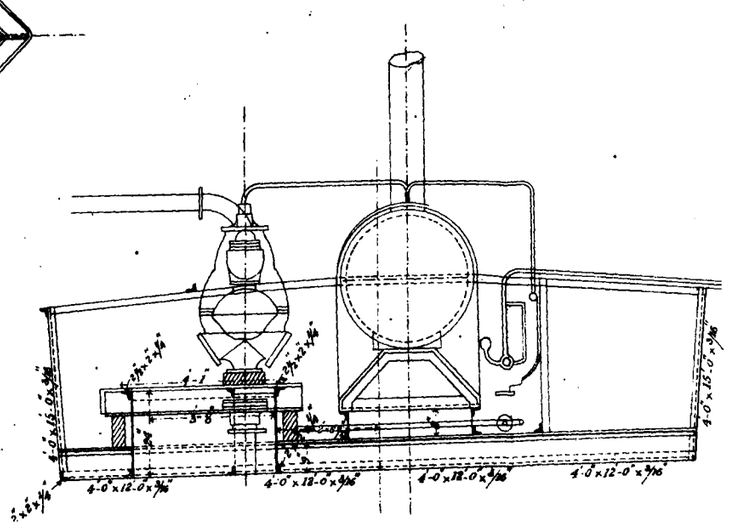
LENGTH 54 FT, BEAM 16-8, DEPTH 4 FT.











PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, JUNE 1889.

Reg. No. 955, Bengal, Works.—28-6-89.—500.

with two stand-pipes and 18 private taps, a 2-inch main runs south down the Shillong road supplying two iron tanks, one stand-pipe and two private taps, and from the 3-inch main, two stand-pipes and nine private taps are supplied direct.

The second 3-inch main runs past the police station and Phánsi Bazaar, following the line of the main bazaar road as far as the jail, thence it becomes a 2-inch main as far as the Maskhoa Musjid, where it divides into two 1½-inch mains, one continued straight on to the mouth of the Bhoroloo river, the other running south to the main Trunk Road. This line of mains supplies eight iron tanks, three stand-pipes and about 84 private taps. From the 3" main near the dispensary a 2-inch main runs south to the police lines, thence as a 1½-inch main westerly to Athgaon, supplying five iron tanks, one stand-pipe and 16 private taps.

The total number of iron tanks is therefore 19, of stand-pipes 13, and of private taps about 152. The 3-inch mains are both provided with stop-cocks near the water metre and the smaller mains, where they branch off from or form continuations of the two 3-inch mains. All the iron tanks are fitted with self-acting ball valves and are constantly full.

F. J. JOHNSTONE,
Chief Engineer, Assam.

REPORT ON THE MHOW WATER WORKS.

Situation of Mhow.

1. The Cantonment of Mhow is situated near the Vindhya range of mountains, not far from the head waters of the Chambal river, on a ridge between the Gumbhir stream on the west, and the Sateir on the east, about two miles above the junction of these streams to the south of the cantonment.

Insufficiency of the present water-supply.

2. Water for the garrison, camp followers, commissariat animals, and for the greater part of the bazaar was procured chiefly from wells, scattered all over cantonments, and varying in depth between 20 feet and 100 feet or more. Many of these ran dry every hot weather, and the constantly recurring scarcity at last overcame the financial difficulties connected with the gravitation scheme finally sanctioned in July 1886.

Proposed improvements in the water-supply.

3. Before this scheme had been suggested, others had been proposed to which it may be as well to refer to in passing.

Well No. 43.

4. Well No. 43, to the south of the British Infantry Lines, although not by any means the deepest nor the lowest in cantonments, generally outlasted all the others. It was used to fill a plunge bath, and to irrigate the soldiers' gardens near it. It was thought probable, therefore, that a considerable enlargement and deepening of this well might result in giving an adequate supply for the troops, if not for the bazaar also. A survey and estimate were prepared, and it was ascertained that the rainfall (after allowing for evaporation and absorption) on the area round this well would be of itself insufficient, and as the well does not appear to tap any distant springs, the project was given up; especially as the cost of pumping the water up to the barracks, and of the maintenance of the engines and pumps, would have at least equalled that of the existing establishment of bhisties, &c.

Dams across the Sateir.

5. After each monsoon, for some years past, several earthen dams have been thrown across the Sateir at different spots between the village of Gararia and the Native Infantry Rifle Ranges. These dams impounded sufficient water for washing purposes and for watering cattle and maintained the sub-soil water at a higher level in the wells on or near the banks of the stream, than would otherwise have been the case; besides giving a supply for the Government and private brick-fields on its banks.

Dams across the Gambhir.

6. The Gambhir flowing past the west of cantonments was not dammed up yearly like the Sateir, because being to windward of cantonments during the hot weather and rains, malaria might have been caused to a serious degree. As it is the medical authorities have been constantly been on the look-out to prevent the formation of any ponds in the neighbourhood of the British Infantry Lines, even for watering the cattle which graze on or near the parade ground.

"Hathi-ka-khoond" sprin in the Sateir.

7. The water dammed up in the Sateir was always too dirty for drinking; otherwise it might have been possible by erecting pumps to have obtained a fair supply from wells sunk in its banks between which, a little above the Goojerkhera bridge, there is a spring below a pool called the "Hathi-ka-khoond," about 10 feet below the bed.

Probable sourc of the spring.

8. This spring is however apparently chiefly supplied from the Sateir itself, and as the successive pools above it, formed by the different dams, are far from clean, the water would require a considerable amount of filtration, as was proved afterwards in 1886.

Supply for the Railway.

9. It might be doubted also whether the supply would have met all the demands; for the Rajputana-Malwa Railway had a steam pump on the banks of this stream some distance higher up; and water enough even for railway purposes could not thence be obtained in 1886.

quacy of proposed ns to the supply.

10. It was therefore necessary to arrange for the more permanent and sufficient supply at a greater distance from Mhow, first proposed in 1875.

Head waters of the Gambhir.

from the of the hir.

11. The Gambhir rises to the south south-west of Mhow near the Janee Pao Hill, which, with its little white temple and a tree or two, is a permanent object in the landscape as viewed from the general parade ground on "one tree hill," in front of the British Infantry Lines. "Janee Pao," one of the peaks of the Vindhya range, has an elevation of 3,979 feet and forms the apex of an amphitheatre of hills which, at a distance of four or five miles from Mhow, close into within about three-quarters of a mile from each other; so that a dam of that length, across the valley between these spurs, impounds the water falling on the area of about 3½ square miles formed by this amphitheatre.

urvey and ontour levels f the catchment area of the roposed lake. lans and stimates.

12. The late Babu Behari Lal, Executive Engineer, was deputed in April, May and June 1875 to make a contoured survey of the Gambhir valley below the "Janee Pao" peak, as well as a preliminary survey of the ground between it and Mhow.

13. Mr. G. A. Anderson, Assistant Engineer, was employed in November 1876 in preparing the fair project, and was sent to Bombay and Poona in May 1877, to examine into the practical working of the Vehar and other water-works, and he prepared, under the direction of the Executive Engineer, Mhow Division, the detailed plans and estimates for the Gravitation scheme.

Financial difficulties.

14. It was chiefly the financial difficulties that deferred the execution of the project for nearly ten years. The Government of India allowed annually a certain proportion of the abkari revenue to be appropriated for the water-works and for railway feeder-roads in Central India. But a sum of only ₹10,000 was set aside for the former, whilst most of the abkari contribution was expended on the latter under the orders of the Local Administration.

Drought in 1886.

15. In February 1886, water was so scarce in Mhow that extraneous sources had to be made use of, or sought for. The wells in the bazaar and nearly all those in cantonments were dry, a few only affording an uncertain supply: two or three feet depth of water filtering during the night into those to the north-west of the fort.

inking new ells.

16. New wells were sunk in this ground, as well as in the right bank of the Gambhir, but even these used to be emptied before night, and the people who flocked to them from the bazaar could not get enough.

Wells and holes a the bed of he Sateir.

17. To supplement this supply, holes were dug in the bed of the Sateir above the Goojerkhera bridge on the Simrole road. The bed of the Sateir itself was not only dry, but the sub-soil water level sank 10 or 12 feet below it, although the dams generally retain water all through the hot weather.

umps and lter.

18. A pump and filter were fitted up in the bed, and a cistern was made to hold the filtered water, so that the poorest residents in the bazaar, who could not afford to pay the price demanded by the bhisties, thus obtained a gratuitous supply as often as they needed it.

Pulsometer pump.

19. A pulsometer pump was fitted up near the Hathi-ka khoond spring, to reach which a large oblong excavation was made in the bed of the river. Sufficient water for washing purposes and for watering many of the animals was thus obtained.

Quality of the Sateir water.

20. Analyses proved that until the water was filtered, it was unfit to drink and even dangerous (and afterwards in 1887, when mules had to be watered at the Sateir, a separate well was dug in the bank, and a filter and cistern were fitted up for them).

External supply for Cavalry horses.

21. For the cavalry horses, a well was dug and a trough constructed close to the bed of the Gambhir, below its junction with the Sateir, near the village of Kooti, about 2½ miles north of Mhow, where a long pool of water afforded a sufficiency by infiltration into the well. Most of the horses were watered at this well at least once a day.

Artillery horses and transport animals.

22. The artillery horses and cattle, and some of the transport animals, were watered at open boolis or wells, used by the peasantry for irrigating their fields below the village of Koodria, to the south-east of cantonments, troughs being made and the wells deepened from time to time as required.

External supply for the troops.

23. At one time it was thought that the Cavalry and Artillery might have to be sent to the Narbuda river, 36 miles off. The Narbuda itself was lower than it had been known to be for many years.

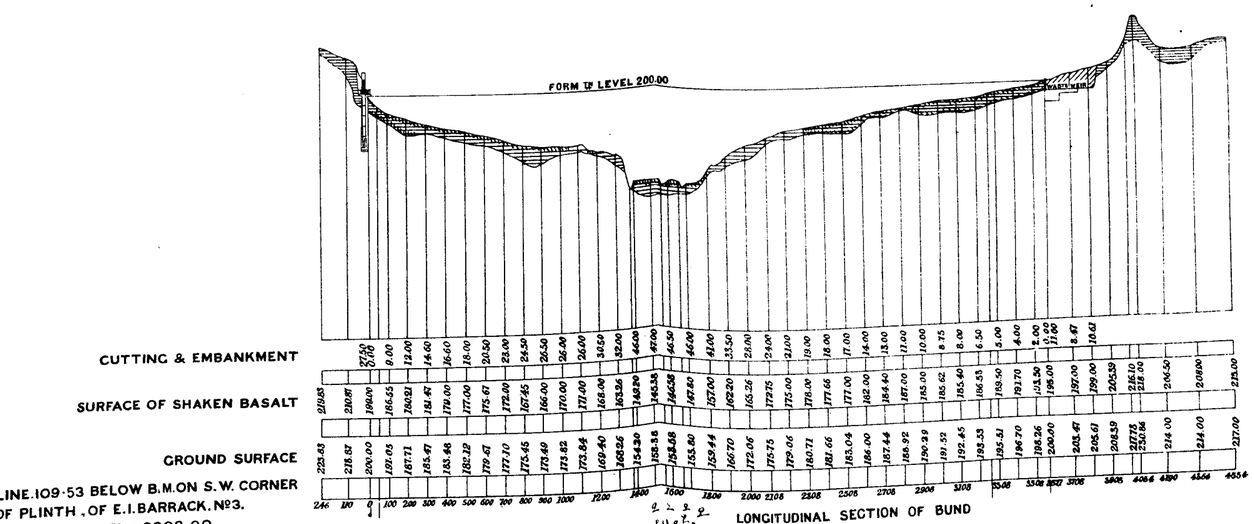
24. Selected pucca boolis or masonry-lined wells in the fields beyond Koodria, were also deepened and cleared, so as to act as a reserve for the troops should the supply in cantonments utterly fail.

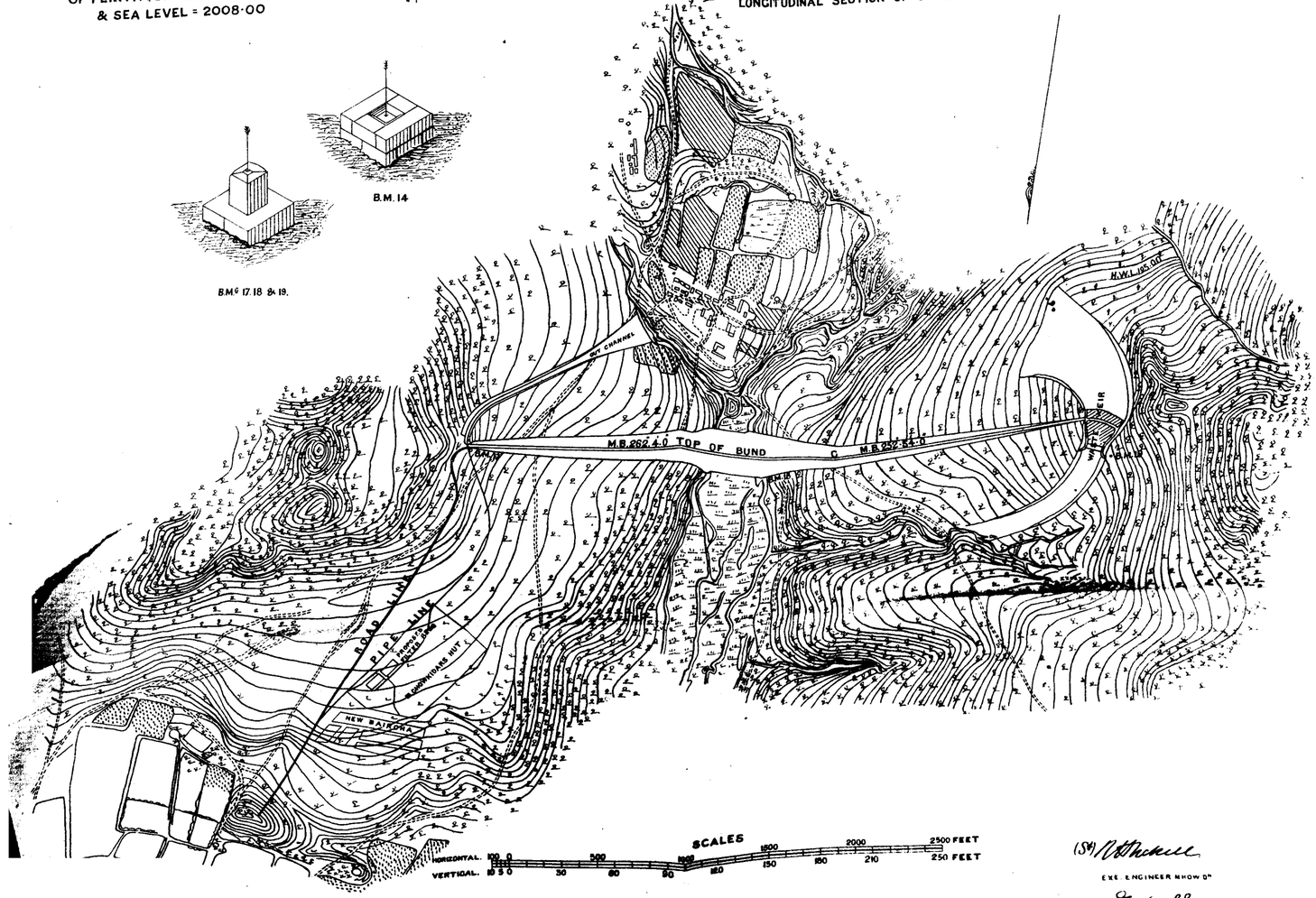
Cultivator's wells improved during the drought.

25. The cultivators were quite willing and indeed anxious to allow the animals to be watered at their wells, for the benefits they themselves received, in the clearance, deepening, and improvement of their boolis.

MHOW WATER SUPPLY

GENERAL PLAN SHOWING BUND PLAN & SECTION





(Sd.) R. Bethell
EXE. ENGINEER MHOW Dn.
Feb. 88.

PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, JANUARY 1890.
Reg. No. 1068, India, Works.—30-12-89.—800

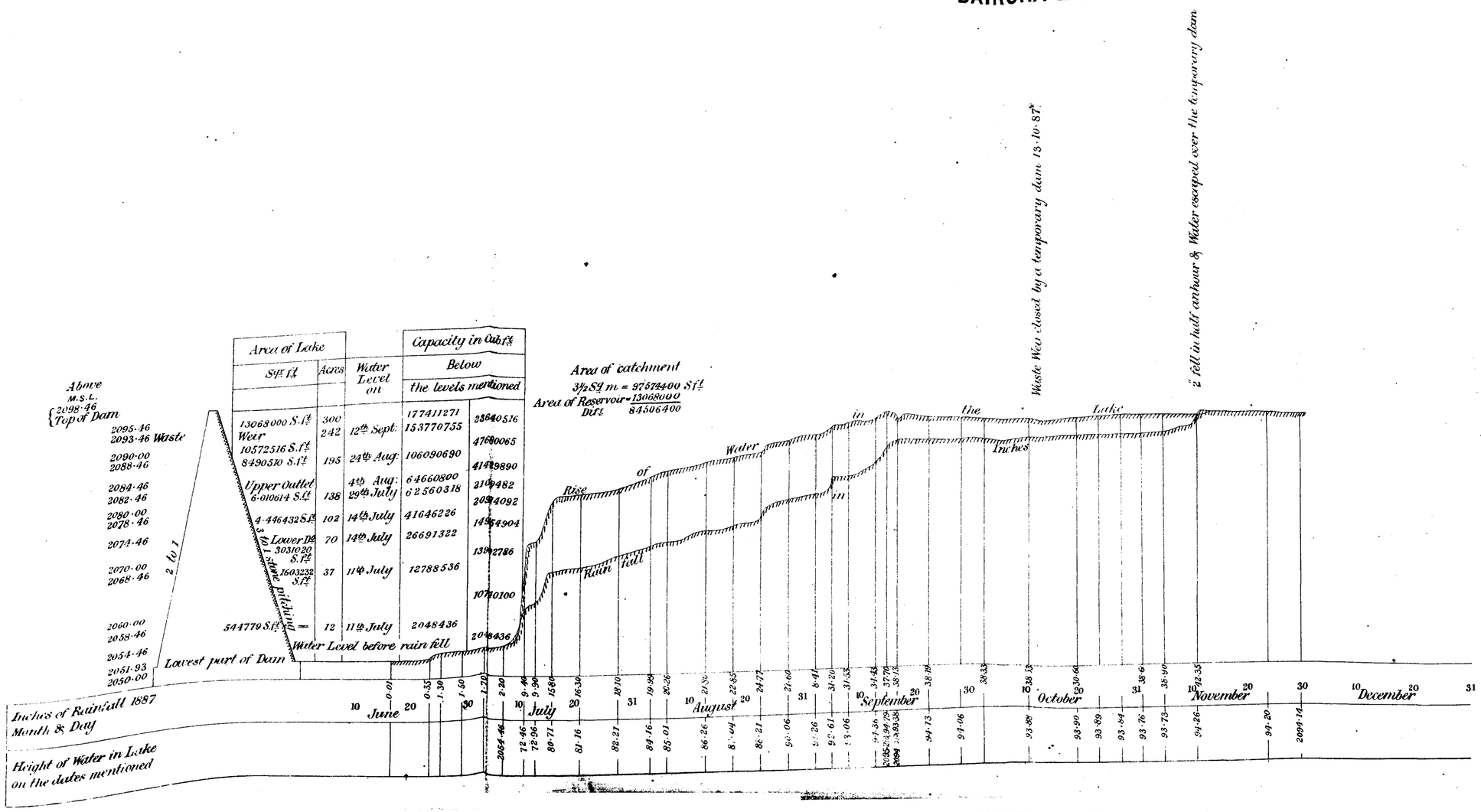
MHOW WATER WORKS

DIAGRAM SHOWING

RAINFALL AND CONSEQUENT RISE OF WATER

DURING THE MONSOON OF 1887 IN THE

BAIRCHA LAKE



PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICE, CALCUTTA, JANUARY 1890.

Reg. No. 1063, Indian Works.—33-12-89.—300.

Table shewing the percentage of rain fall stored and lost.

Read.g Levels	Area whole Catchment	Rain fall Date 1887	Rain fall Quantity in Inches	Total Volume of Water falling on the whole Catchment Cubic Feet	Stored in the Lake Cubic Feet	Percentage Stored	Percentage Lost
				306546240	177411271	57·8	42·2
2098·46							
93·46		12th Sept.	32"	260198400	153770755	59·1	40·9
88·46		24th Aug.	25"	203280000	106090690	52·1	47·9
84·46	97574400 Square Feet	4th Aug.	20"	162624000	64660800	39·76	60·24
82·46		29th July	18·4"	149614080	62560318	41·8	58·2
78·46		14th July	15·1"	122781120	41646226	33·1	66·9
74·46		14th July	10·8"	87816960	26691322	30·4	69·6
68·46		11th July	8·5"	69115200	12788536	18·5	81·5
58·46			6·33"	51470496	2048436	4·	96·
54·46							
51·83							
2050·00							

N.B. The "Percentage Lost" in the Table would actually be much less than is shewn, as in most cases the showers did not fall on the whole area of the catchment. As only one raingauge was used the rain fall on the whole catchment area could not be accurately ascertained but the percentage of loss became [illegible] on the 13th 1887 the influx made up for all loss, as the water level remained above R.L. 2093·46 or above the waste weir Level

MHOW WATER WORKS

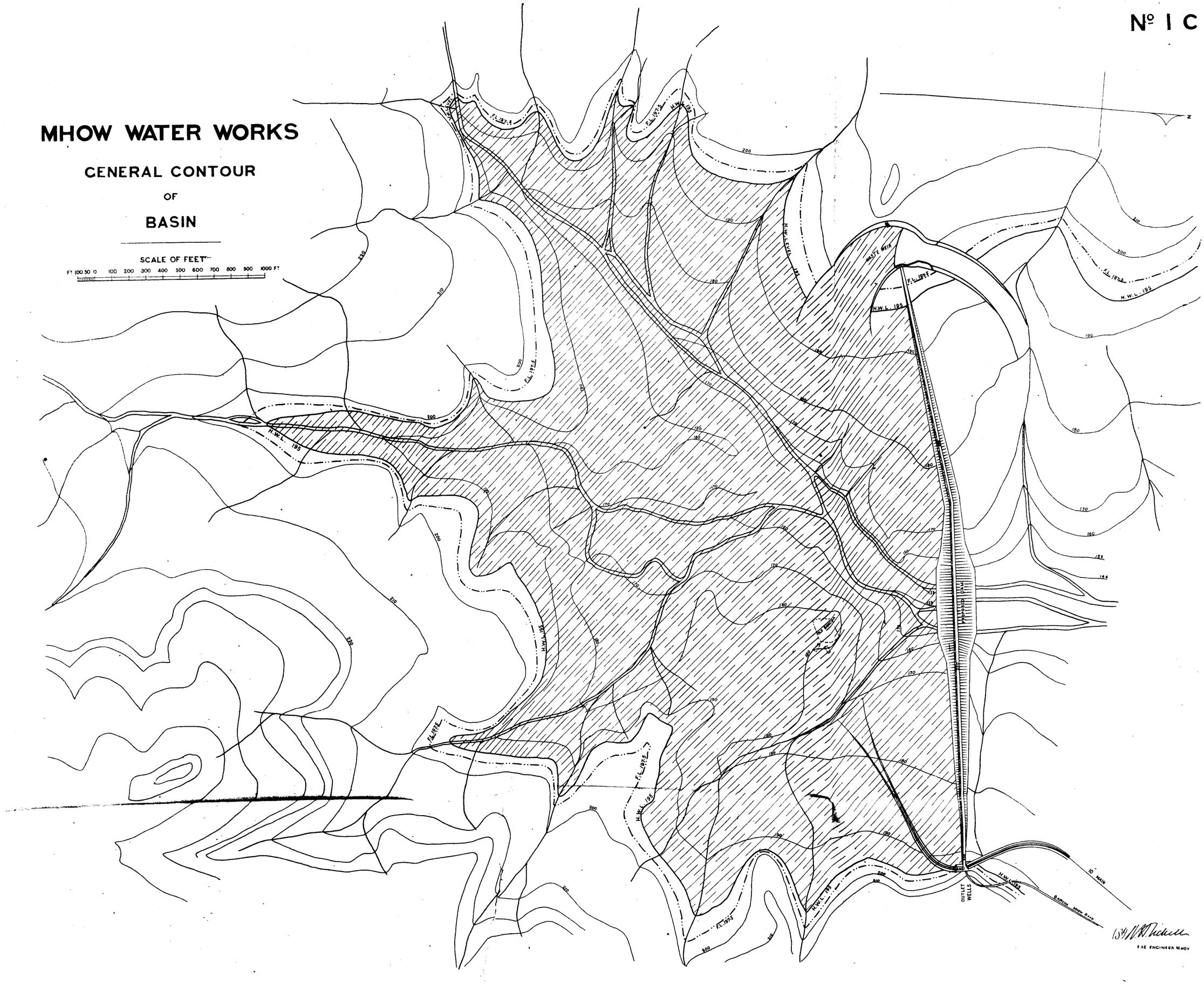
GENERAL CONTOUR

OF

BASIN

SCALE OF FEET

FT 100 50 0 100 200 300 400 500 600 700 800 900 1000 FT



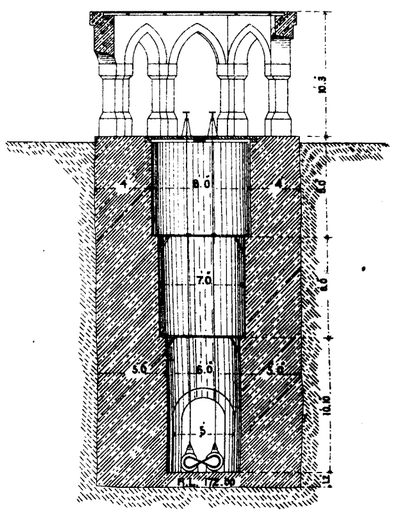
13/4/11 W. R. Pickwell
EXE ENGINEER MHOW

PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA DECEMBER 1889.
Reg. No. 1018, India Works—R-212-20-000

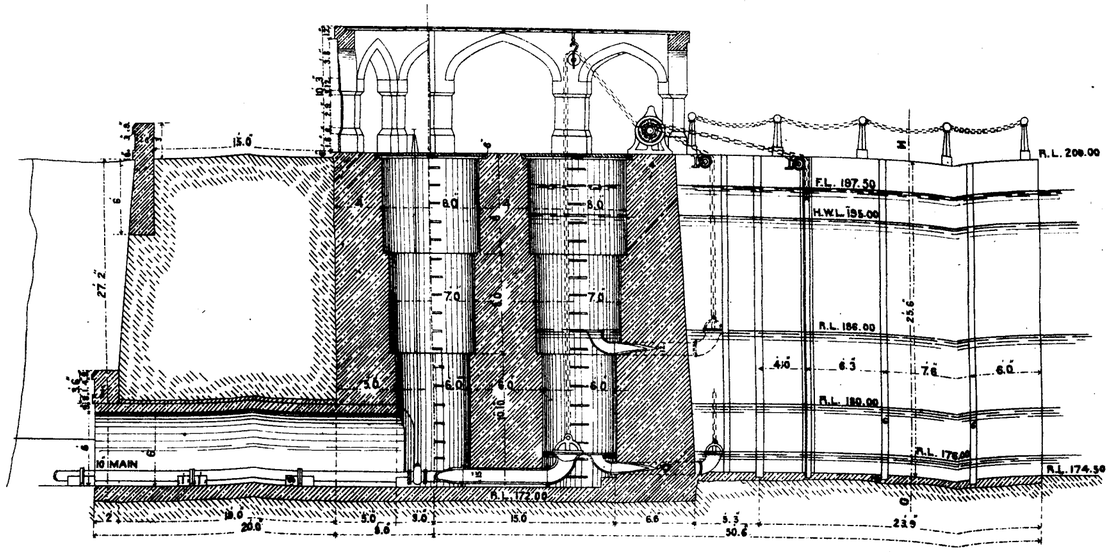
MHOW WATER SUPPLY.

OUTLET WORKS

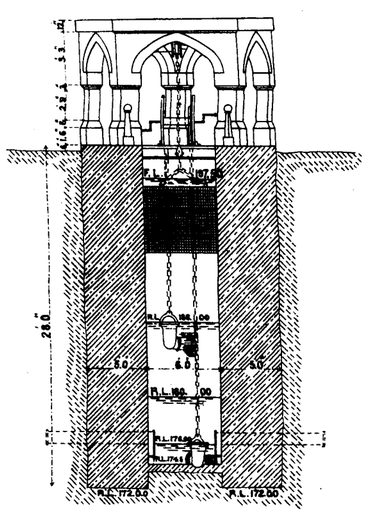
SCALE OF FEET



SECTION ON E. F.

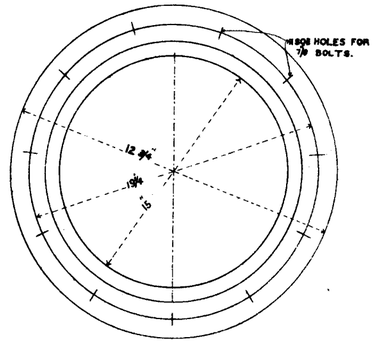


LONGITUDINAL SECTION ON A.B.C.

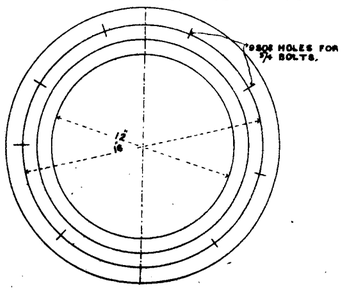


SECTION ON G. H.

DETAIL OF FLANGE FOR THE 15" PIPES.

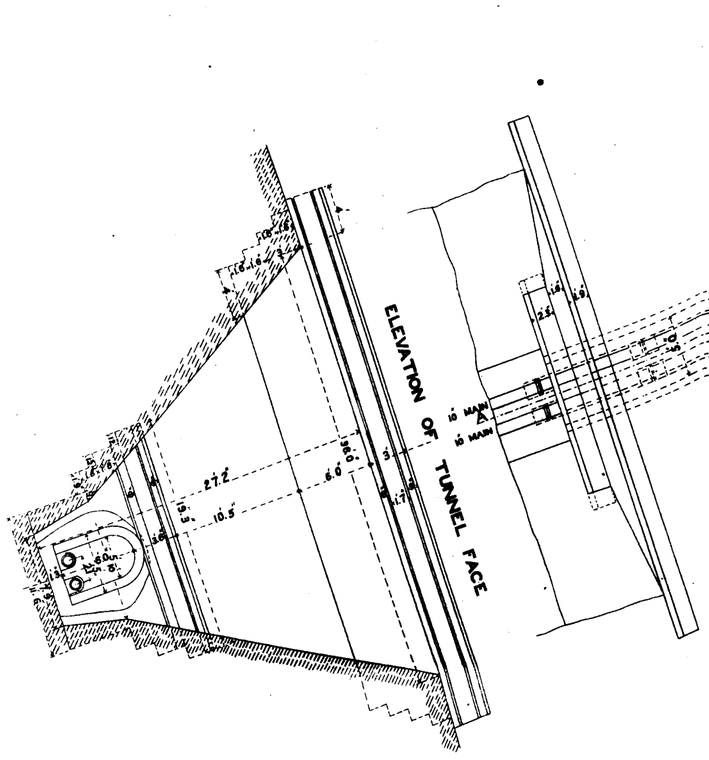


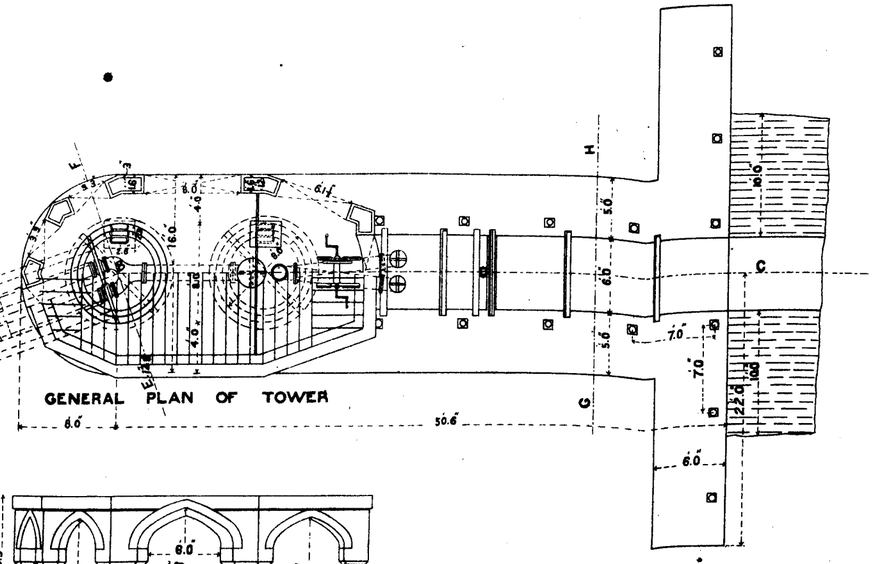
DETAIL OF FLANGE FOR THE 12" PIPES

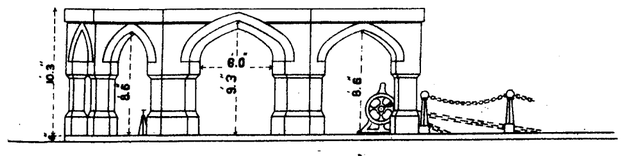


SCALE FOR DETAIL OF PIPES.

INCHES 12 11 10 9 8 7 6 5 4 3 2 1 0 — 1 FOOT







WEST ELEVATION OF TOWER

PHOTO-LITHOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA DECEMBER 1889.

Rep. No. 1018, India Works—8-12-89—800

No. 4

MHOW WATER SUPPLY

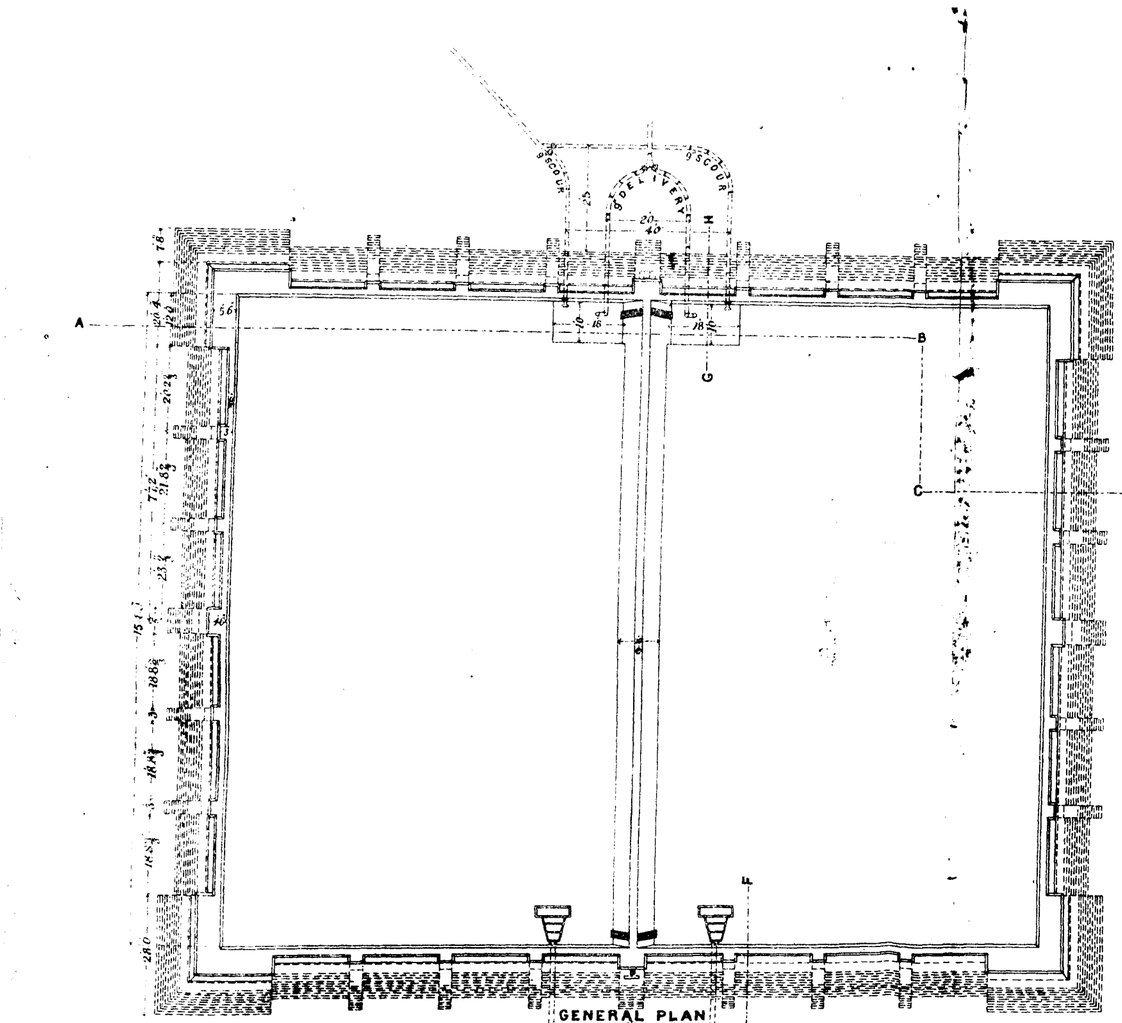
SERVICE RESERVOIR ON E.I. HILL.

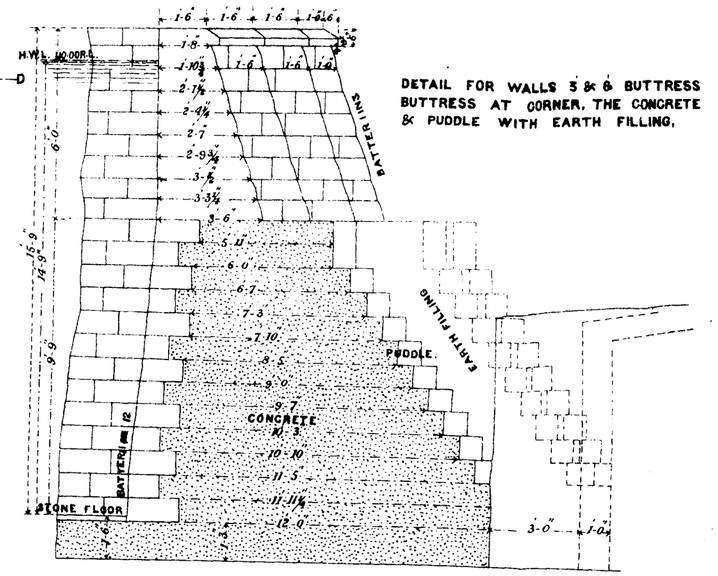
SCALE

FEET 20 0 20 40 80 80 100 120 FEET

SCALE FOR DETAIL

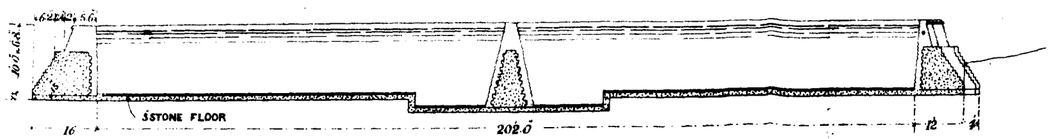
12 0 1 2 3 4 5 6 7 8 9 10 11 12 15 FEET





DETAIL FOR WALLS 5 & 6 BUTTRESS BUTTRESS AT CORNER, THE CONCRETE & PUDDLE WITH EARTH FILLING.

SECTION ON A. B. C. D.



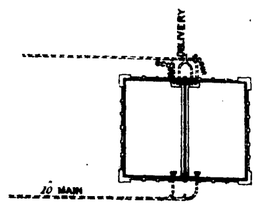
EAST ELEVATION

SECTION ON E.F SECTION ON G.H.

Mean Sea Level

Centre of Main pipe ... 1995.54
DR Sluice pipe ... 1985.95
Reservoir floor ... 1988.41
DR Silt well ... 1985.00
Centre of Delivery pipe 1995.54

PLAN OF RESERVOIR SHOWING THE ROUND SIDES SLOP



(Sd) W.H. Packard

EXE. ENGINEER MHOW DN.

for 22. 88.

PHOTOTINCOGRAPHED AT THE SURVEY OF INDIA OFFICE, CALCUTTA, JANUARY 1890.

Reg. No. 1048, India, Works.—23-12-89.—800.

MHOW WATER SUPPLY

SERVICE RESERVOIR OUTER WALLS FIGS 1 TO 5

WALL DIAGRAMS

SCALE OF FEET

INS 12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 FEET

Fig 1 Forces 400 lbs to 1"

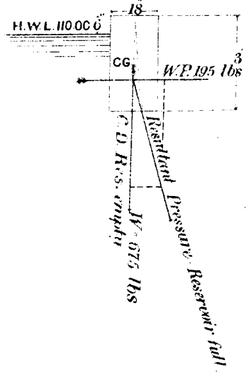


Fig 2 Forces 400 lbs to 1"

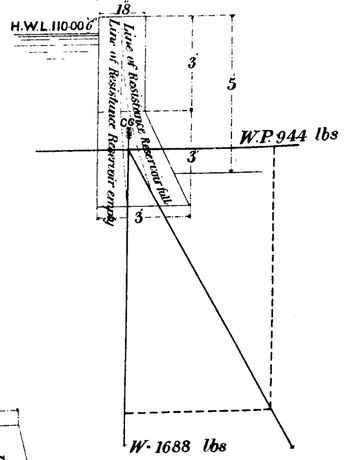


Fig 3 - Forces 800 lbs to 1"

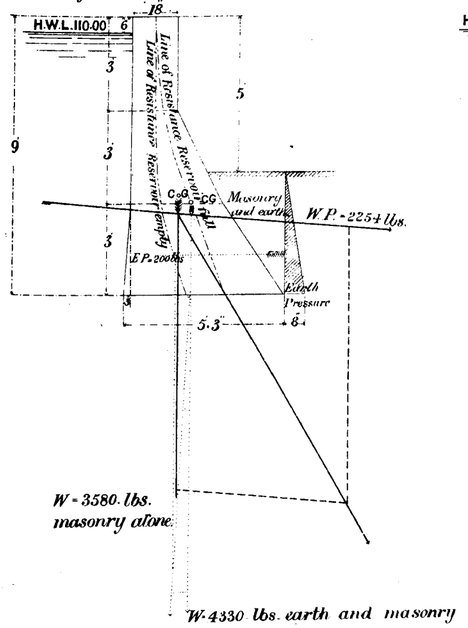


Fig 4 Forces 2000 lbs to 1"

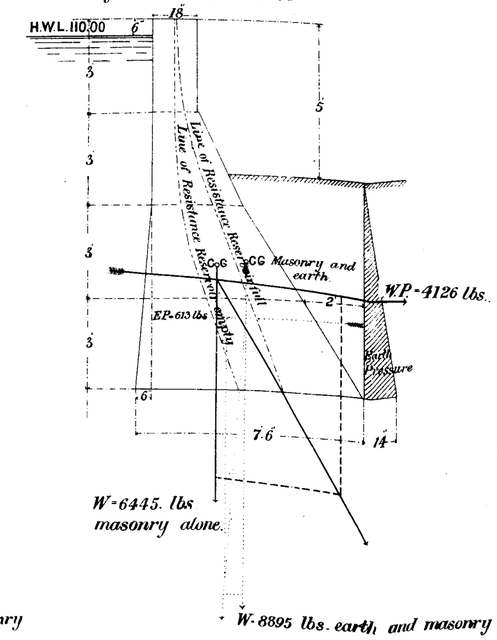


Fig. 5 - Forces 3000 lbs. to 1"

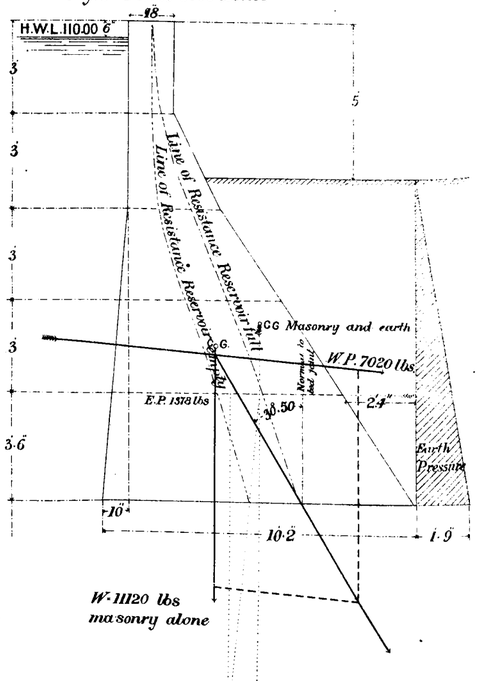


Fig 6 Service Reservoir Dividing Wall
Scale of Dimensions 2 to 1"
Scale of Forces 2000 lbs. to 1"

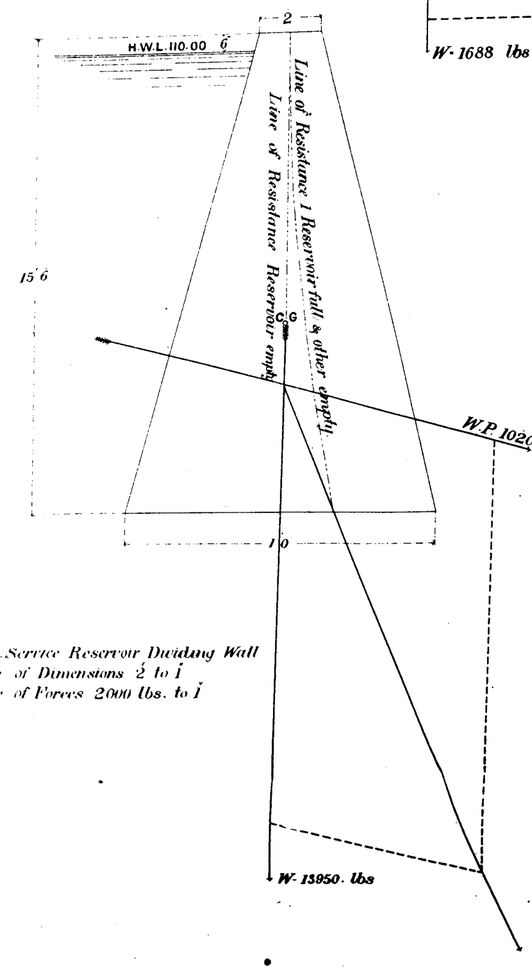


Fig. 7 Service Reservoir Dividing Wall, as designed.

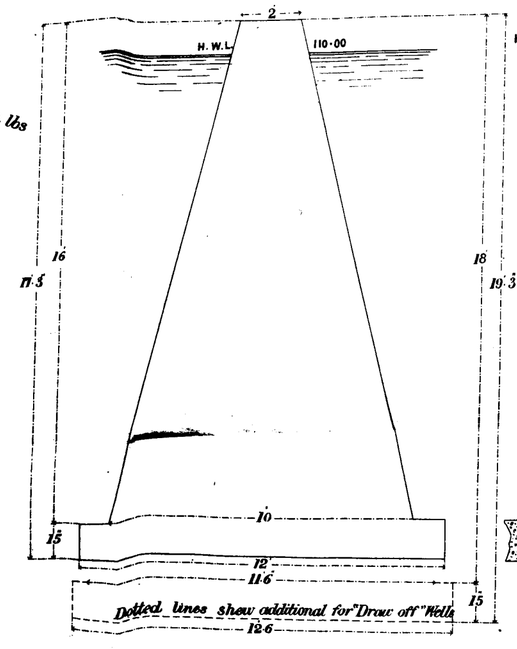
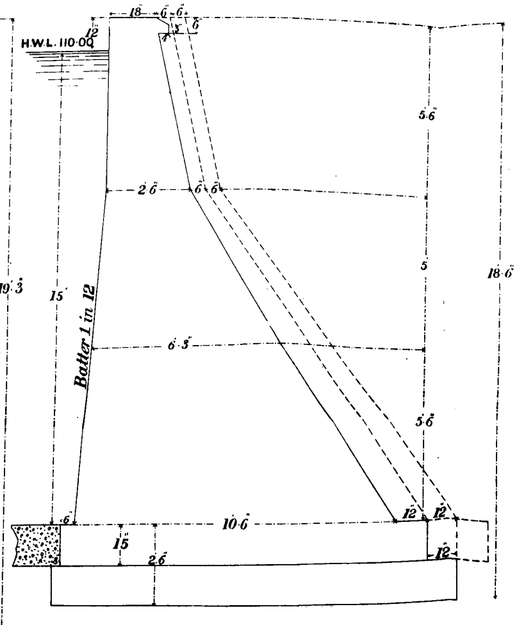


Fig. 8 Service Reservoir Outer Walls 6 and 3 Buttresses shewn in dotted lines



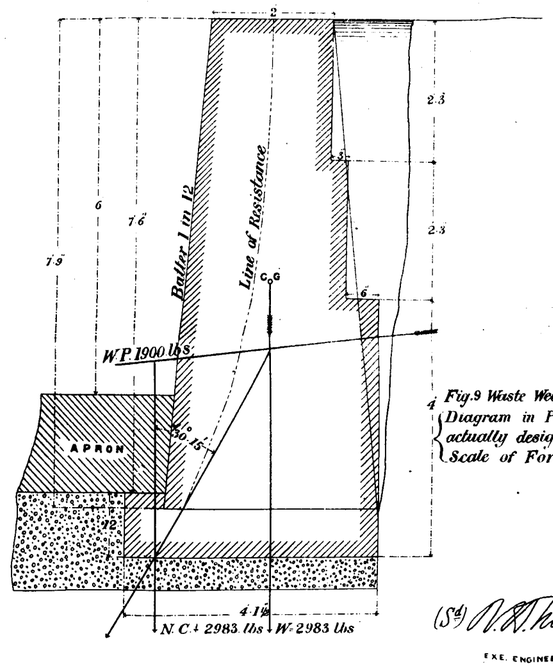


Fig. 9 Waste Weir Retaining Wall Scale 1 to 1
Diagram in Plain black lines Wall as actually designed, shewn in shaded lines
Scale of Forces 1000 lbs to 1".

(Sd) N.R. Thickell
EXE. ENGINEER MHOW DR.
Oct 20. 88.

THOS. GOODWIN, PLEE AT THE SURVEY OF INDIA OFFICE, CALCUTTA DECEMBER 1889.
Reg. No. 1048, India, Works.—19-12-89.—600.

PLAN OF THE GAMBHIR BASIN

UP TO

MHOW

Nº 5 B

SCALE

FEET 1320 660 0 1320 2640 3960 5280 6600 7920 9240 10560 11880 13200 14520 15840 FEET

0 ¼ ½ ¾ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 MILES

N

TOORCHHANA

DUMARTALAI

BEDUR

TOORUN

MAIN

JANEPAO TEMPLE

TARN CHIA

PROPOSED DAM No 3

BAIRHCHA

CHOWKIDARS HUT

PROPOSED FILTER BEDS

KILLODE

PULLASIA LASIA

TO MHOW VIA PUL

PROPOSED PIPE LINE AND ROAD IN PROGRESS

MR BEHAREELALL

CANTONMENT BOUNDARY

B.P. Nº 88

MHOW

(Sd) [illegible]
EXE. ENGINEER MHOW DR

Oct 17. 88.

PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, NOVEMBER 1889.

DISTRIBUTION OF DELIVERY PIPES

HYDRANTS &c^A IN CANTONMENTS

AND BAZAR

MHOW

SCALE OF FEET

FEET 00 0 100 200 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 FEET

No

F.P. — Fire Plugs — 121
S.V. — Stop Valve — 44
S.W.P. — Street Watering Post — 5
B.S.P. — Bazaar Stand Post — 9
B.K.S.P. — Barrack Stand Post — 16
— Stand for 8 Taps — 1
— Fountain — 55

(Sd) N.A. Tickell

EXE. ENGINEER MHOW

Dec 17.

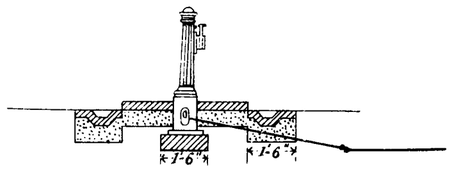
PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, NOVEMBER 1889.

Reg. No. 1048, India. Works.—23-11-89.—800.

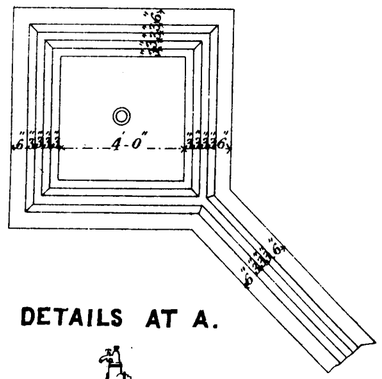
DETAILS
OF
MHOW WATER WORKS

No. 6 A

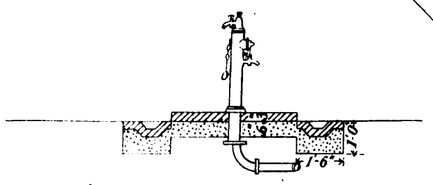
DETAIL G.
BAZAR STAND POST



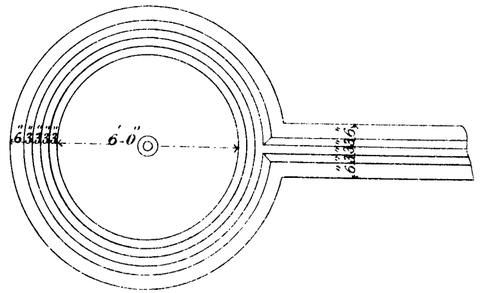
PLAN



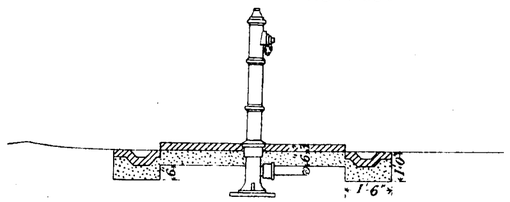
DETAILS AT A.



DETAIL Z.
PLAN

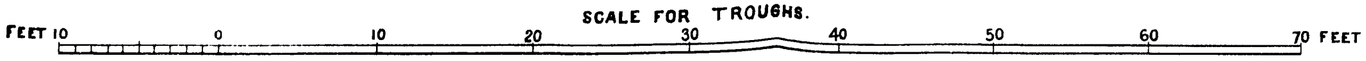


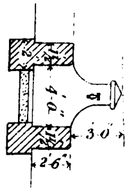
STREET WATERING POST



SCALE FOR STAND POSTS.

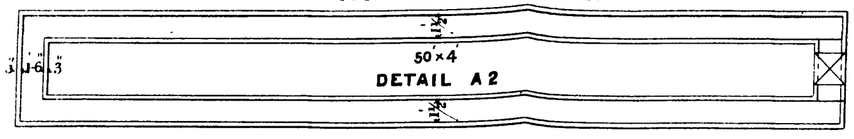
SCALE FOR TROUGHS.





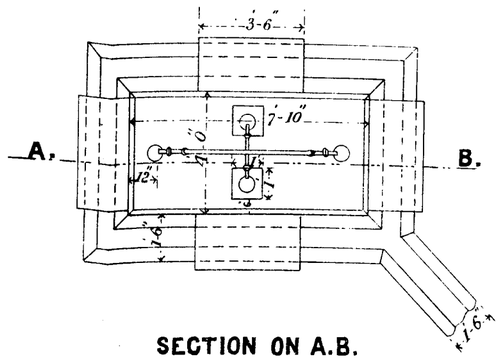
SECTION ON C.D.

TROUGH FOR R. H. A. STABLES.

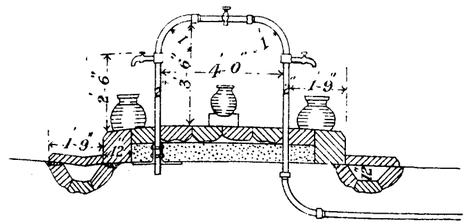


DETAIL A 2

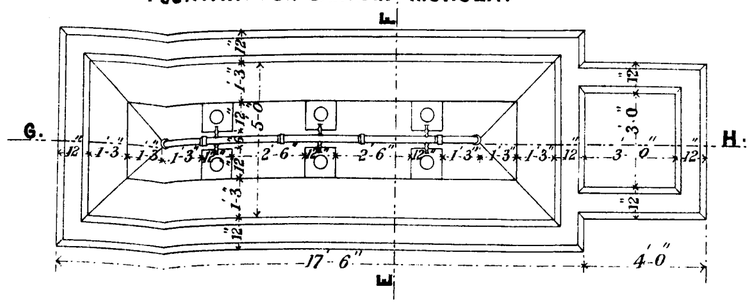
DETAIL AT K.



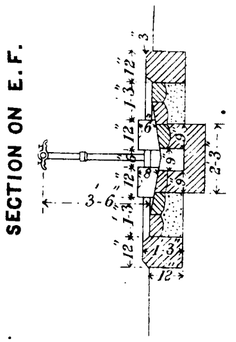
SECTION ON A.B.



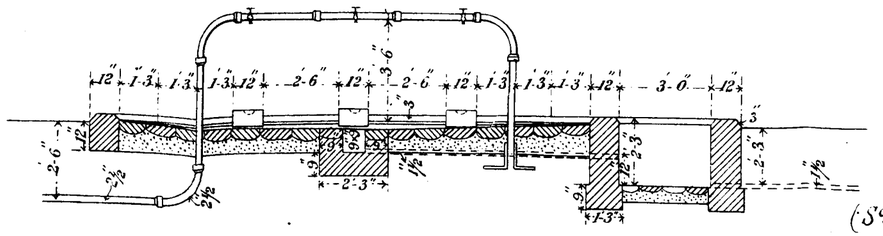
PLAN
OF
FOUNTAIN FOR SARWAN MOHULA.



SECTION ON E.F.



DETAILS AT H.
SECTION ON G.H.



(Sd.) A. H. Russell
EXE. ENGINEER MHOW
Jan 28/88.

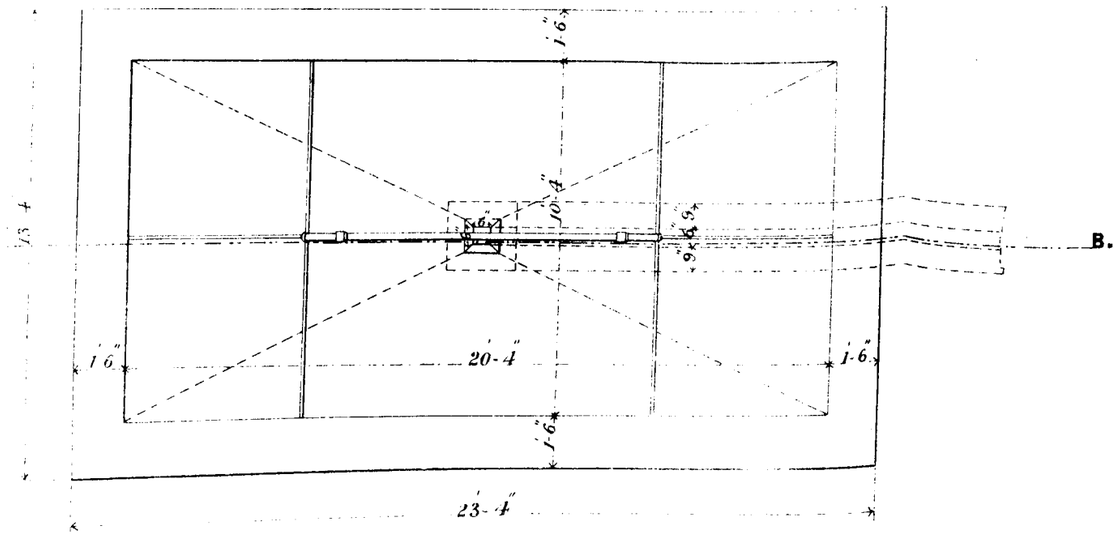
PLAN OF BATHING FOUNTAIN

FOR

BAZAAR

DETAILS AT I.

PLAN



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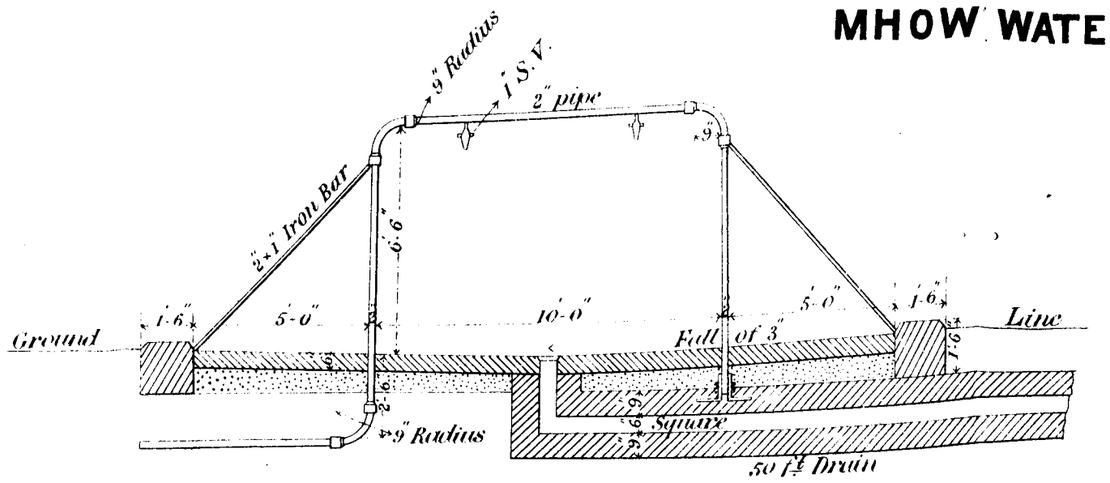
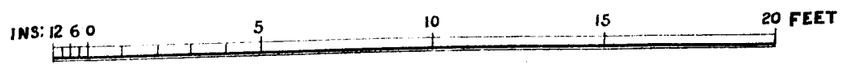


SCALE OF FEET

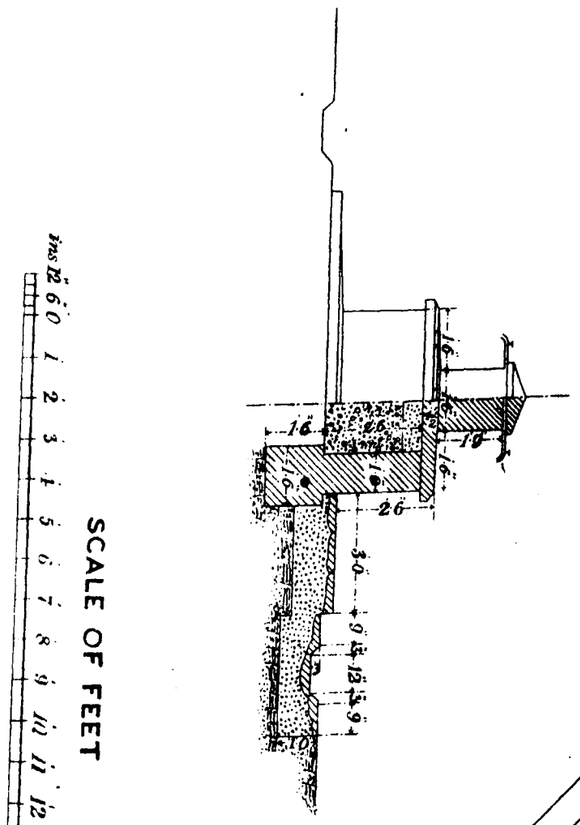


DETAILS
OF
MHOW WATER WORKS

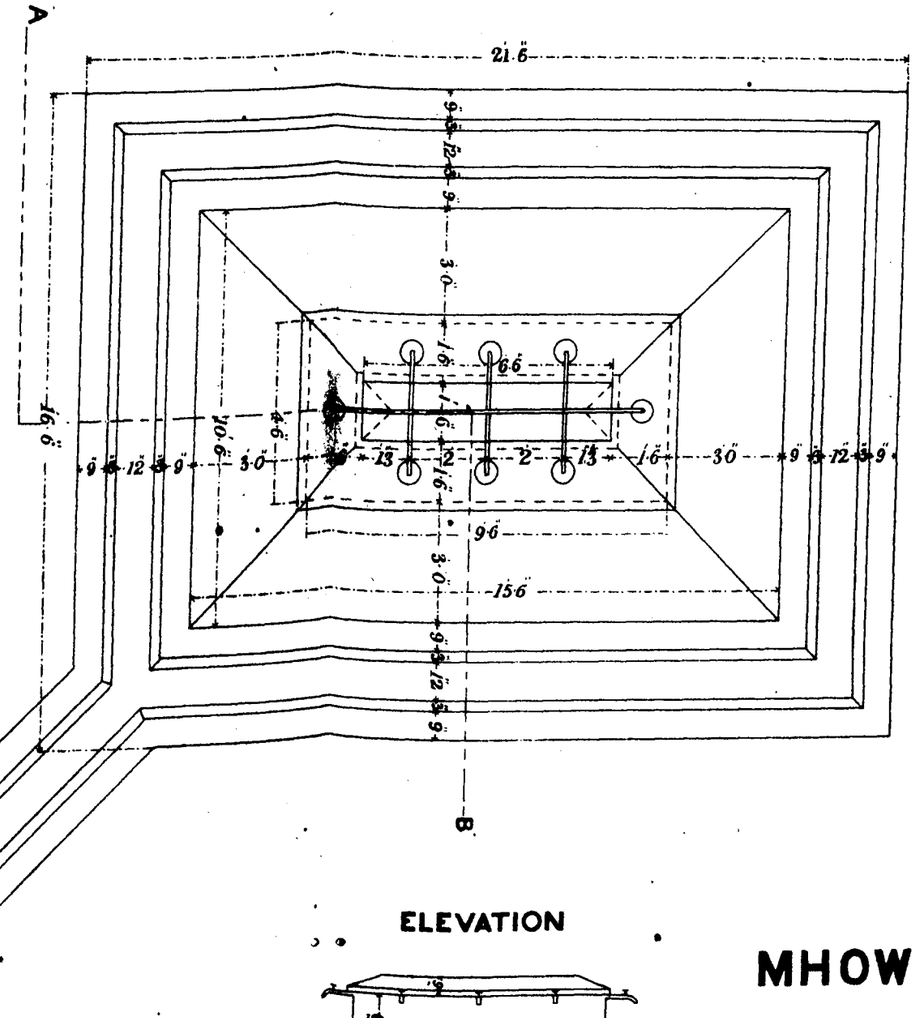
PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, JANUARY 1890.

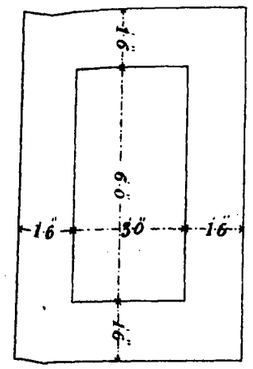
Reg. No. 1098, Indian Works.—13-1-90—800

DETAILS AT F.
STAND FOR 8 TAPS

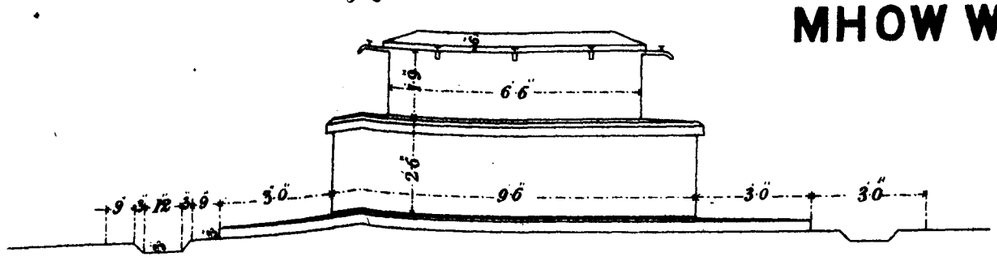


½ ELEVATION & ½ SECTION ON A B





ELEVATION



DETAILS OF MHOW WATER WORKS

(Sd) N.A. Trevor
EXE. ENGINEER MHOW DN
Oct 26-88

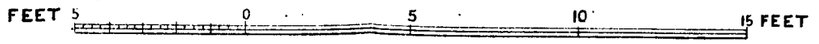
PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICE, CALCUTTA, JANUARY 1890.

Reg. No. 1068, India, Works.—26-12-89.—800

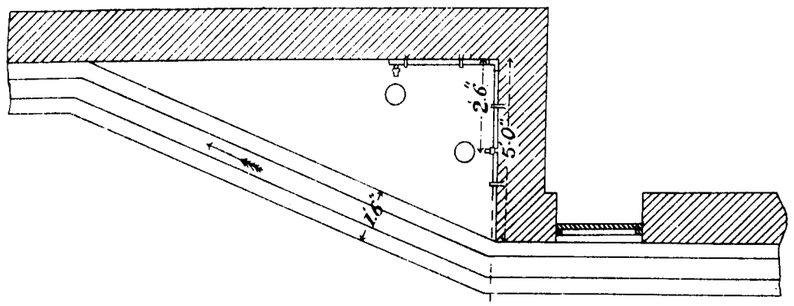
DETAILS
OF

MHOW WATER WORKS.

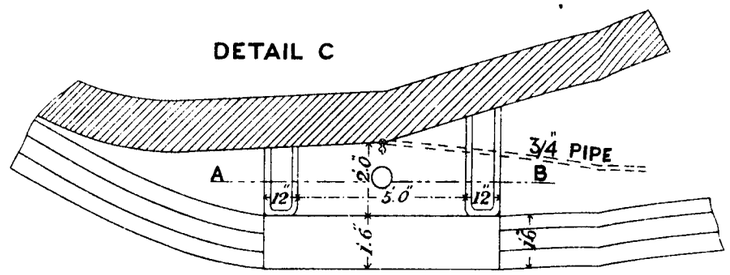
SCALE OF FEET



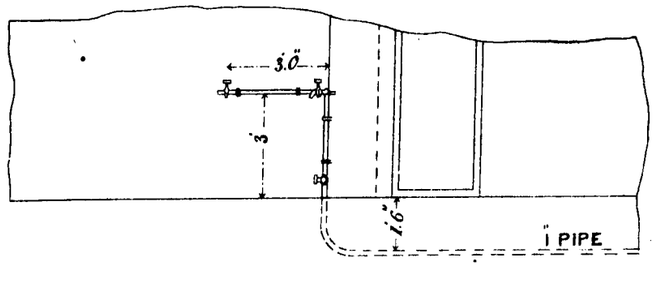
DETAIL B.



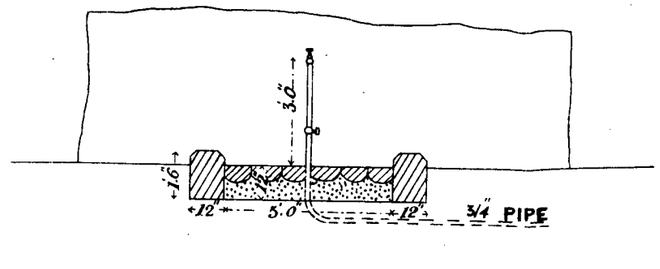
DETAIL C



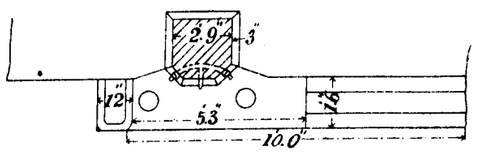
ELEVATION OF B.



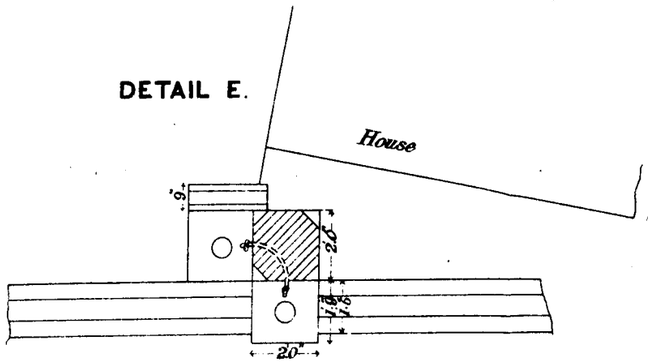
SECTION ON A.B.



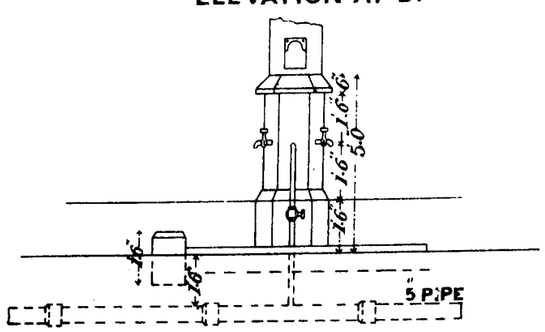
DETAIL D.



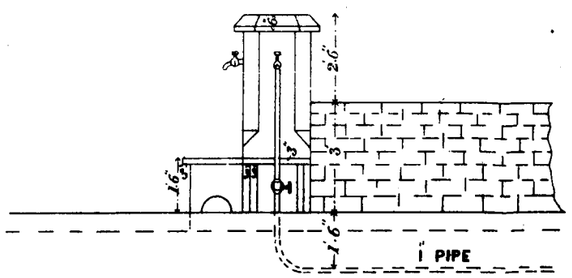
DETAIL E.



ELEVATION AT D.



ELEVATION AT E.



(Sd) N. Thackeray

PHOTOLITHOGRAPHED AT THE SURVEY OF INDIA OFFICES, CALCUTTA, JANUARY 1890.

Reg. No. 1046, India, Works.—28-12-89.—800.

26. Other transport animals were picketted near the Patalpani Railway Station, close to which three or four small dams were thrown across the stream before it fell over the "Little Falls," and troughs were made below two of these dams. **Dams near Patalpani Railway Station.**

27. By these means the effects of the drought of 1886 were scarcely felt except in the great inconvenience of having to go so far for water. Neither the health of the troops nor of the bazaar residents seems to have suffered at all in consequence.

28. All this scarcity emphasized the necessity for procuring a more trustworthy and independent supply for Mhow, and the Government of India was induced in July 1886 to sanction the estimate which had been prepared nearly ten years before.

29. In 1887, another drought was threatened, and as nearly all the bazar wells failed again, another well was sunk in the left bank of the Sateir below the Goojerkhera bridge, Norton's well tubes being inserted, as the bank there is not so hard as in other parts, and filters and cisterns were provided, so that the poorest could get good water. The dams had however been thrown across the Sateir earlier than usual after the rains of 1886, and so had retained sufficient water for washing purposes. **Drought in 1887.**

General scheme for supplying Mhow with water.

30. The general scheme for supplying Mhow with water included the undermentioned works :— **Gravitation scheme for the supply of Mhow.**

No. 1.—An earthen dam, about 4½ miles from Mhow limits.
„ 2.—A waste weir, with inlet and escape channel at the west end of the dam.
„ 3.—Inlet and outlet wells and cuttings at the east end of the dam.
„ 4.—A Service Reservoir near the British Infantry Barracks.
„ 5.—A 10-inch main pipe about 4½ miles long from the outlet well to the Service Reservoir.
„ 6.—Delivery and distribution mains and pipes between the Reservoir and the Cantonment Railway and bazaar.
„ 7.—Compensation to the villagers of Baircha, within the catchment area.
„ 8.—Bungalow (temporary) at the head works.
„ 9.—A road along the pipe line between Mhow and the dam.

Details.

31. The report and details of the sanctioned estimate show more fully what work was to be done, and the calculations connected therewith. **Sanctioned estimate.**

32. It was proposed to have smaller Service Reservoirs in the fort, as well as in the Cavalry and Native Infantry Lines and the bazaar, but the cost of these would have swelled the estimate considerably, so further consideration of them was left for the future. **Proposed future additions.**

33. One reservoir should however be constructed in the fort as soon as possible after the opening of the works. **Reservoir particularly necessary in the Fort.**

Plans and Sections.

34. The plans and sections accompanying this report are the following :— **List of Plans and Sections.**

No. 1.—Longitudinal section of Baircha.
„ 1A.—Bund cross sections.
„ 1B.—Progress section.
„ 1C.—Contoured plan of tank.
„ 2.—Waste weir.
„ 3.—Outlet wells.
„ 3A.—Outlet channel.
„ 4.—Service Reservoir.
„ 4A.—Service Reservoir stress Diagrams.
„ 5.—Road section.
„ 5A.—Culverts.
„ 5B.—Road and dam and grass Kooran.
„ 6.—Distribution plan of pipes.
„ 6A, B, C, D.—Details of distribution pipes.
„ 7.—Sheets of photographs of completed works.
„ 7A.—Waste weir showing half of upper lips and part of retaining wall, water level in tank one foot below top of upper lip.
„ 7B.—Tank and earthen dam from the waste weir end shewing outlet tower and Assistant Engineer's Bungalow in the distance.

Note.—Drawings Nos. 1A, 2, 3A, 5, 5A, 7, 7A and 7B have not been reproduced with this Selection.

No. 7C.—Tank and dam from the outlet works end.
„ 7D.—View of the tank and dam from below the Assistant Engineer's bungalow.
„ 7E.—Outlet tower, bridge over tunnel, and dam from the end of the Mhow-Baircha Road.
„ 7F.—Outlet works from a point on the banks of the outlet channel.
„ 7G.—Outlet works, tunnel, bridge over tunnel, and outlet cutting for the 10-inch main to Mhow.
„ 7H.—Mhow-Baircha Road.
„ 7I.—The Service Reservoir in the lines of the European Infantry Regiment, Mhow.
„ 7J.—Wrought iron tank of No. 3 European Infantry Barrack Roof, Mhow, for the water-supply of the European Infantry Barracks.
„ 7K.—Stand of eight taps in the market place, Mhow Bazaar.
„ 7L.—Common type of stand with three or four taps erected in several of the bazaars at Mhow.
„ 7M.—Stand of four taps for bathing purposes for the Native Infantry Lines at Mhow.
„ 7N. Bhoras temple, Mhow Bazaar, one of the buildings supplied with water.
„ 7O. Mhow Water-works "Past and present."

Daily Supply required.

35. The scheme proposed to ensure a supply of 15 gallons per diem for a population of 26,000, with an addition for the Railway, is as follows—

	Gallons.
Bazaar residents, 20,000 @ 15 =	300,000
Troops and camp followers, 6,000 @ 15 =	90,000
Railway	25,000
TOTAL	415,000

or 66,400 cubic feet daily.

Allowing for evaporation in the Service Reservoir, the total in round numbers would be 25,000,000 cubic feet annually.

Rainfall at Mhow.

36. The rainfall at Mhow varies between 22 and 40 inches, 32 being the average. This, after deducting one-third for absorption, would amount to 173,465,000 cubic feet of water, so that the lake can be filled in one year easily.

Capacity of the lake.

37. The capacity of the lake below R. L. 2,085·46 or 8 feet below the weir crest thus

	Cubic Feet.
allowing 8 feet for evaporation is	71,305,000
At R. L. 2,084·46, the higher outlet, it is	64,660,800
Difference	6,644,200

or about three months' demand.

At R. L. 2,074·46, the lowest outlet, it is*	26,691,322
or between the two outlets *	37,969,478
Actually required	25,000,000
Surplus	12,969,478

or six months' extra supply, even if the water level in the lake should, after any monsoon, not be higher than the higher outlet. The rate of evaporation and absorption is not yet known, though observations are being taken which will be valuable; and as there has been no drought from the lake between the time of its first filling to the weir level, up to the opening of the water-works, the actual daily and monthly loss between the monsoons of 1887 and 1888 can be almost accurately ascertained.

38. Up to the end of January 1888, the inflow had maintained the water level up to that of the crest of the weir. It may here be mentioned that, during the monsoon of 1887, the lake was filled before the 20th September 1887.

The Dam.

Dam as designed.

39. The dam as designed was to be of earth, with a puddle wall in the centre, 5 feet wide at the top, and a batter of 1 in 12. The bank of two parts small moorum mixed with one part of black soil, freed from stones, roots, and other foreign substances, was to be carried

up in layers not exceeding 12 inches deep, rather inclining on both sides towards the puddle walp, which itself was to be founded on the sound rock below the dam, and to consist of prepared and screened clay puddled in layers of 9 inches.

Slopes.

40. The water slope of the dam was to be 3 to 1, pitched with trap stones, about 12 inches deep by 9 inches square, laid by hand and hammered with wooden mallets at least 4 inches into the slope. The outer slope was to be 2 to 1 sown with grass.

Roadway of Dam.

41. The roadway or crest of the dam was to be 12 feet wide, and to be metalled for the full width, with broken trapstone consolidated in two coats, each 3 inches deep.

Puddle wall and consolidation of the embankment.

42. The clay was to be puddled by men's feet, and the dam was to be consolidated by any or all of the means mentioned, *viz.*, by the trampling of men, cattle, or elephants, or by rollers (including steam rollers) or rammers, water being plentifully supplied. The surface soil at the site of the dam was to be dug out to the depth of a few inches.

43. The extreme height of the dam above the bed of the Gambhir was to be 48 feet, and its extreme length 3,622 feet.

Waste Weir.

44. It was proposed that a curved waste weir at the west end of the dam should have a chord 300 feet long and 315 feet on the curve, to discharge a rainfall of 4 inches in the first hour, 2 inches in the second hour, and 1 inch in the third hour, or a total fall of 7 inches in three hours, with a maximum rise in the lake of 30 inches, at a cost of ₹84,531; or for a weir of 200 feet chord, ₹54,531, with a maximum rise of 33⅓ inches over the crest. The longer weir was sanctioned with the estimate. A rainfall of 14 inches in 16 hours was registered at Indore on the 20th-21st June, 1870.

Escape channel.

45. A curved inlet channel was to be cut above the waste weir, narrowing as it approached it. The escape channel below the weir was to be in cutting 120 feet wide, having a fall of 1 in 20 with a sufficiently hard bed to resist ordinary scour. This cutting was to extend to a small tributary which falls into the Gambhir just below the dam.

Lower weir.

46. A lower weir was to be constructed at the commencement of the 1 in 20 fall, the flanks of both weirs being connected by curved training walls of masonry.

Inlet and Outlet works and Channels.

Inlet and outlet wells and channels.

47. The inlet and outlet works were to take the form of a double well built in hard trap, at the east end of the dam, the inlet well being connected with the lake by a curved supply channel, with its bed at 25½(*a*) feet below the crest of the dam or 20½ feet below the weir crest. The inner well was to be connected with this channel by two 12-inch inlet pipes respectively, 24(*b*) and 14(*c*) feet below the crest of the dam.

(*a*) R. L. 2,072·96.
(*b*) R. L. 2,074·46.
(*c*) R. L. 2,084·46.

Level of lowest outlet pipe.

48. To ensure greater purity, it was first considered undesirable to draw off water from the supply or inlet channel at less than 5½(*d*) feet above its bed. But to meet unforeseen calls and to allow of silt being drawn off, it was finally decided to have the lowest draught 1½(*d*) feet only above the bed.

(*d*) R. L. 2,078·46.

49. In the dividing wall between the inner and outer well, a pipe was to be fixed, to the end of which, in the outlet well, the 10-inch main was to be connected, so that access to the junction could be obtained at any time.

10-inch Main.

10-inch delivery main.

50. The 10-inch main passing from the outlet well, through a tunnel about 200 feet long, was to be laid in the cutting beyond it, and thence to Mhow, at a depth of about 3 feet below the surface, with the necessary air stop and scour valves: one of the air valves was to be fitted at the crest of a spur up which the 10-inch main at a distance of about 18,000 feet from Mhow was to be taken.

Service Reservoir.

Service Reservoir.

51. The Service Reservoir was to have been built to the east of the British Infantry Barrack No. 4, almost on the highest part of the parade ground, so as to lose as little head as possible, and was to be large enough to hold seven days' supply for the troops and bazaar, divided into two compartments, to facilitate cleansing and repairs.

Reservoir walls.

52. The walls were to be of solid rubble masonry set in hydraulic lime, the stones for the inner and outer faces and for the corners being roughly hammer dressed to the slope and shapes required, and the joints pointed on all the exposed faces.

Reservoir Floor.

53. The floor was to be of hydraulic concrete, in two layers of 7 inches and 8 inches.

Reservoir Roof as proposed, but not sanctioned.

54. A roof was also proposed consisting of a series of brick arches resting on iron girders (of which a large number happened to be in stock at the time) supported by masonry pillars.

The stock price of the girders was rather heavy, and the cost of the roof thus became very high. The roofing was therefore not entered in the abstract of the estimate as submitted for sanction.

Iron Cistern.

High service for British Infantry Barracks.

55. An iron cistern was to have been fitted on to the verandah roof of No. 3 British Infantry Barrack to supply the upper stories, as many of these could not otherwise have been served by gravitation.

Daily Supply in the Reservoir.

Daily delivery at the Reservoir.

56. It was calculated that the 10-inch delivery main would supply 66,940 cubic feet to the Service Reservoir in 19 hours with a head of 66 feet, so that, with a constant service, more than the daily requirements of 66,400 cubic feet could easily be met.

Baircha Village.

Demolition of Baircha Village.

57. The houses in the village of Baircha were to be dismantled, the soil in, under and around them being dug up and removed to some place below the dam, compensation being paid for trees, wells, and houses.

Engineer's Bungalow.

Engineer's temporary Bungalow.

58. A small temporary bungalow was to be built for the Engineer in immediate charg of the head works.

Temporary Road.

Temporary road along the pipe line.

59. A temporary road 16 feet wide was to be constructed along the line of the 10-inch main between Mhow and the dam, chargeable to the contingencies of the estimate.

Estimated Cost.

60. The total cost of the work, exclusive of the roofing of the reservoir and of Establishment, but including contingencies, was to be ₹5,70,536, made up as follows :—

	₹
Earthen dam at Baircha	1,54,815
Waste weir 300 feet long, including inlet and escape channels	84,532
Inlet and outlet works	13,514
Service reservoir without roof	44,064
10-inch Main from the outlet well to the Service Reservoir	1,46,676
Distribution in Mhow	1,20,798
Compensation to Baircha	1,905
Assistant Engineer's bungalow	1,232
GRAND TOTAL	5,70,536

Provision of Funds.

Financial measures originally proposed.

61. To meet these charges, it was at first proposed that Government and the residents should pay in proportion to the value of house property in the cantonment and bazaar.

Population and value of house property.

62. The census of the population gave the following results :—

	No.
Bazaar residents	14,799
Troops and camp followers	7,478
TOTAL	22,277

or in the proportion of about 2 to 1.

Population and value of house property.

But taking the value of house property the result would be—

	₹
Value of houses in the bazaar and of Officers' bungalow	15,33,562
Government buildings	49,33,453

or about 1 to 3.

Proportion of the cost to be borne by Government.

63. It was suggested that Government should bear half the cost, part of which half should be debited against the Holkar and Scindia-Neemuch Railway, sub-dividing the cost roughly thus :—

	₹
Bazaar	3,00,000
Railway	90,000
Government in the Military Department	1,80,000
	2,70,000
TOTAL	5,70,000

and that Government should advance ₹3,00,000 to the Municipality (Cantonment Committee) at 4 per cent. interest, the principal to be repaid in ten (or more) instalments of ₹30,000 each from the Abkari Revenue, then at the disposal of the Local Administration, and that the interest should be covered by a water rate levied on the registered value of all houses in the bazaar and of officers' bungalows thus :—

	₹
Officers' bungalows varying assessments according to rental	2,820
Houses in the bazaar according to rental	20,156
TOTAL	22,976

of which it was roughly calculated ₹5,000 might be absorbed in working expenses, leaving the rest to cover the interest.

Decision of the Government of India.

64. The decision of the Government of India will be found in Military Department letter No. 2383, dated 1st June 1886. But it was represented by the Cantonment Committee that no rate could be levied until water was supplied; and therefore Government was urged not to ask for interest on the loan till water should actually be laid on in the cantonment and bazaar.

Proportion of cost to be borne by Government as finally decided.

65. In sanctioning the estimate, the Government of India contributed ₹3,00,000 as its only and final share of the cost, disdaining all further responsibility, and lent ₹3,00,000 to the Cantonment Committee at 4½ per cent. interest from July 1886, provided that a sinking fund was also established to clear off the principal.

Method for paying the interest of the loan and for establishing the sinking fund.

66. The methods whereby the Cantonment Committee proposed to repay the loan and interest are shewn in the Proceedings of the special committee assembled in February 1887 to revise the taxation of Mhow.

Preliminary Operations.

Method of construction.

67. The actual method of construction, where different from the original specification, and a few of the difficulties encountered in the execution of the project, may now be considered.

Mhow Water-works Division.

Mhow Water-works constituted a separate Division.

68. The Mhow Water-works Division was constituted in July 1886 under the direct superintendence of Colonel Thomason, R.E., Superintending Engineer, and Secretary to the Agent Governor General for Central India in the Public Works Department, who took a great personal interest in it, and who placed Mr. D. M. Litster in executive charge.

Contractor for the dam and head work.

69. Mr. Gustadjee Cooverjee, Contractor, undertook to complete the dam and head works before the monsoon of 1887.

Arrangements made for carrying out the work.

70. Arrangements had to be made during the monsoon, 1886, for the hutting, feeding, and sanitary affairs of about 3,000 labourers, besides buffaloes, donkeys and cattle.

Huts.

71. Sites for rows of huts were selected below the east end and west end of the dam, and on the spurs in prolongation of the east end, and were so arranged as to secure ventilation and cleanliness.

Hospital and Dispensary.

72. A hospital and a well furnished dispensary of a temporary nature were established under the charge of a native doctor and dresser.

Sanitary arrangements.

73. It was found almost impossible to make the natives resort to the sites selected for latrines, as they preferred to go into the adjacent fields; so sweepers were employed to cover the excreta with earth, as well as to keep the lines clean.

Contractor's responsibility.

74. The Contractor was made primarily responsible for cleanliness and order in the lines, and to assist him in maintaining order some policemen (for whose services he paid) were sent to him from Mhow. The heads of the different gangs were answerable for order and cleanliness amongst their men.

Magisterial Powers.

Magisterial powers, to a small degree, were conferred on Mr. Litster, to enable him to settle petty cases on the spot.

Obstacles to cleanliness.

The chief obstacles to cleanliness were the large quantities of litter and manure in and about the buffaloe and donkey lines, the reasons for the constant removal of which their owners could not understand, especially as, during the monsoon the litter, &c., could not well be removed at once to the fields.

Water-supply for the labourers.

75. The labourers were encouraged, as far as possible, to obtain drinking water from wells in the fields below the dam, or from fresh holes dug near the bank of the river as frequently as was necessary, men being separately employed for this purpose or for providing water near the huts or on the work.

Food supply.

76. Buneahs were induced to settle amongst the gangs by being allowed to sell grain at a lightly higher rate (about equivalent to that caused by the extra five miles or so of cartage)

than prevailed at Mhow, though many men and women preferred to go thither once a week or so for their own supply. The grain exposed for sale by the Buneahs was inspected periodically.

77. As the flow of the Gambhir at the site of the dam ceases generally about March, it was necessary to secure water for puddling purposes as well as for watering the layers of earth in the embankment. Earthen dams were therefore constructed across smaller tributaries of the Gambhir above the site of the main dam as soon after the rains as possible. These were breached by floods more than once, notwithstanding that escape channels were provided and the necessary repairs somewhat delayed the commencement of the Baircha dam.

78. A small dam was also formed a few feet above the main dam from the soil and moorum taken from the puddle trench, whilst the latter was being dug with a space between it, and the inner slope of the dam, which was afterwards filled up partially by spoil from the excavation of the inlet channel to the wells, thus giving additional width and weight to the deepest part of the dam, at the same time that water was thus kept close at hand for wetting the layers of the embankment.

Construction of the Dam.

79. The surface soil was cleared from nearly the whole site of the dam. The puddle trench was then commenced in the moorum soil and excavated to the firmer rock below.

80. Since clay of suitable quality could not be found in sufficient quantities near the site, fine black soil, sifted, where necessary, and freed from stones, &c., was used instead of clay for that portion of the puddle wall which was actually done. This soil was thrown into the trench in layers about 12 inches deep, and after being saturated with water was trampled on and puddled by men walking up and down in it.

81. After the puddle had filled the trench, the embankment was begun. The consolidation of the dam was carried on at first, chiefly by elephants walking to and fro over it. But this was very hard work for them, as they sank so deep in the earth, and so after a time steam road rollers were gradually used. Two of these had to be employed, one on either side of the puddle wall, to which it was soon found that they could not approach near enough, thus leaving the centre of the dam less thoroughly consolidated than the rest; and it was feared that unequal settlements might hereafter occur.

82. It was therefore decided not to continue the puddle wall, but to roll the whole width of the embankment evenly with the steam road rollers—these weighing 15 and 18 tons respectively, compressed in 12-inch layers to a thickness of 8 inches or 9 inches, making the surfaces so hard that carts and cattle could move about the embankment without making any impression except where the surface was too wet. They could not be worked, however, over those portion of the puddle wall which had actually been laid, until the superabundant moisture had been evaporated or absorbed, and by the time it was sufficiently dry, cracks began to shew in the upper layer of puddle, so that the steam rollers could not roll this down evenly with the rest. It would perhaps have been better not to have put any puddle at all.

83. By degrees the steam rollers could be driven over the whole width of the embankment, and while the width was great enough, they were first driven backwards and forwards across the width, each roll overlapping the last and then lengthways along the dam. As the dam rose higher and the width was reduced, the rollers could only work in the direction of the length of the dam.

84. Buffaloes, bullocks, donkeys and country carts were chiefly employed in carrying the black soil, which was dug from the surface, or from shallow pits, both above and below the dam, and was generally damp enough not to require wetting. Tufts of grass, stones and moorum were taken out of it, and it was carried in rope or "salita" baskets which were tipped off the animals' backs on to the last completed layer after the rolled surface of the latter had been sufficiently moistened to make the fresh earth adhere to it. The little conical heaps of earth were then levelled by men with phowras, and the steam rollers worked it down whilst it was still damp.

85. Along the eastern end of the dam tram rails were laid on the bank last completed, and earth-laden trucks were drawn along them by buffaloes and bullocks. These tramways were continued to the pits whence the earth was dug. The tramways were laid parallel to each other, and sufficiently far apart to allow a steam roller to work between the sets of rails, and when the earth had been levelled by hand the steam roller consolidated it. The tram rails were then taken up and relaid on the rolled portion, the place where they had last lain being filled up with earth and rolled in the same way.

86. The trapstone pitching was carried on, so as not at any time to be more than a few feet below the top of the bank. Trapstone pitching of the water slope.

87. It was intended that the spoil from the cutting for the inlet channel should be used as a footing for the exterior slope of the dam. But it would have cost a good deal to deposit it there, and so some of it was thrown into the hollow between the small dam and the toe of the water slope. The remainder should, however, be removed in time from the vicinity of the inlet cuttings, as it takes up water space, and may also be gradually washed back into the channel itself. Spoil from the inlet channel.

88. The Baircha dam was commenced in November 1886, and by the time the first monsoon shower fell in June 1887, it was completed,* except a small portion near the western end, which was purposely kept lower than the rest, till the waste weir should have been practically finished in order that an escape might be quickly formed, if necessary, near this end, where plenty of moorum lay close at hand, to act as a pitching and protection for the sides of the escape. Time taken in constructing the dam.

* E. L. 2,098·46.

89. The top of the dam, under the metalling for a depth of about 12 inches was filled up with surplus moorum, and was rolled to act as soling coat for the metal which was laid and consolidated during the rains of 1887. Roadway over the dam.

90. There was very little leakage indeed through the dam, except at the points marked on the section† whence a little water escaped, but without carrying with it any of the earth of the dam as far as could be ascertained. In order to obviate any future risk of its doing this, the leak on the outer slope was covered with large sized moorum. This moorum was laid against the dam at a slope of about in 5, overlapping the leak about 5 feet on either side, as well as above it. Nearly all along the outer foot of the dam, leakage occurred also, apparently by filtration between the original soil and the bed of the dam. The dam itself was elsewhere very water-tight, and unless it is allowed to dry too much, or too quickly, especially in the hot weather, the leakage is not likely to increase, as black soil is so retentive of moisture when damp. Tightness of the dam.

† Plan No. 1 C.

Waste Weir.

91. The plans and sections of the waste weir‡ and of the inlet and escape channels will best shew the differences between the original design and the work as finally carried out. The upper weir has a chord of 240 feet, and a projection above the bed of the escape channel of about 1½ feet, and there are differences also in the longitudinal section. One training wall, that on the side next the dam, was considered sufficient, as the rock on the other side is hard enough to resist some degree of scour, and even if it be cut away a little, from time to time, there will be no immediate danger to the west end of the weir. This training wall was completed before the rains, except the coping, which was laid in December 1887, when the upper weir was also completed. Waste weir.

‡ 2.

92. The cutting for the escape channel is about 8 feet below the natural surface, for a sufficient length to prevent overflow in the direction of the dam. The escape channel was sufficiently far advanced by June 1887 to allow floods to pass down it, and early in September 1887 the lake overflowed. Escape channel.

93. In October 1887, a temporary dam about 2 feet high was thrown across the outlet channel above the site of the upper weir, to permit the construction of the latter, and to maintain the water in the lake at a higher level as long as possible, so as to cover some of the loss by evaporation and absorption. Temporary dam above the waste weir.

Inlet and Outlet Wells and Channels.

94. The masonry of the inlet and outlet wells, and of the lined portion of the inlet channel, was of solid coursed rubble, set in selenitic mortar, built close against the rough faces of the almost vertical wall of rock, in the cuttings made for them, because if puddle had been used between the back of the masonry and the face of the excavation, as originally designed, some springs in the fissures of the rocks would in time have softened the puddle and washed it out, leaving hollow spaces between the masonry and the rock.

95. The vertical channels, about 6-inches wide, were left in the sides of the inlet channel for the insertion of strainers; as well as to facilitate the insertion of shutters or timbers for puddle walls, should it be necessary at any time hereafter to obtain access to the lake end of the inlet pipes. Strainers in the walling of the inlet channel.

96. The inlet and outlet wells, including the roof over them, were completed in January 1888, except the timber covering and the fixing of the screw lifting gear for the 18-inch valve, Completion of the Inlet and outlet wells.

and the cement pointing of parts of the inner faces, which were covered with water before it could be finished. The wells are however very water-tight. The wells were finally completed in February 1888.

97. The outlet pipe was cast as a 15-inch branch pipe with the bell mouth in the inlet well and two 12-inch branches opening into the outlet well, so that two mains, or one main and one scour pipe, could be hereafter bolted to its ends, instead of only one. The outlet channel through and beyond the tunnel had to be lowered to keep the mouth of this larger and deeper pipe at the proper level; and separate lifting gear was also required, as the pressure on the valve would now and then be greater than could be safely overcome by the crab winch used for lifting the valves of the two inlet pipes.

98. The tunnel from the outlet well was made only 20 feet long, the east approach to the dam being immediately over it, and it was lined with coursed rubble at the sides with a dressed stone arch, the floor being concreted. The fissures in the rock were so numerous that the tunnel leaks a good deal. Open cutting was therefore substituted for the rest of the tunnelling, for the 10-inch main; and about 700 feet from the present end of the tunnel an outlet has been cut for the scour water, so as to divert it more directly into the Gambhir, instead of letting it run down the cutting towards the road, and the village of new Baircha.

Service Reservoir.

99. The Superintending Engineer considered it advisable to alter the design for the Service Reservoir so far as the position of the delivery and distribution mains and the materials for the walling were concerned. The plans * shew the sections of the walling.

* No. 4.

100. Concrete with selenitic mortar and a facing of coursed rubble was substituted for random rubble for the sake of economy. Concrete mixtures and mortar mills were erected on ground near the site of the reservoir.

101. As a rather large quantity of water was required for the concrete, pulsometer pumps and boilers were fitted up on the right bank of the Gambhir, close to the lime-kilns near Goalipoora, and a dam was thrown across the stream. Water was pumped up thence into a cistern built close to the circular road, whence another pulsometer pump forced it up to another tank at the site of the work, spare 2-inch pipes being used.

102. Most of the machinery had been used previously in the reconstruction of the bastions of the Mhow Fort which had recently been completed.

103. The excavation for the Reservoir was cut in fairly hard moorum, and the spoil therefrom was spread out all round the outer walls in long slopes.

104. The concrete made of trapstone metal, not all of the hardest kind, but such as is used for the Mhow roads, was mixed as required, and thrown at once into the walling and rammed by men. The interior face of the walling was of coursed rubble trapstone averaging 1 foot in thickness, with a batter of 1 inch, the backing being of concrete. The sides of the excavation were nearly vertical, and to allow of the proper curve being given to the back of the walls, clay walling was placed in steps between the face of the excavation and the concrete, so that the latter might be rammed without spreading.

105. The walling with its inner face of stone and backing of concrete was, as a rule, carried up course by course with an internal batter of 1 in 12 up to the ground level, and above this, it was constructed all through of coursed trap rubble stone. A coping of Neemuch slabs was also provided, the cost of which was much greater than one of trap stone would have been.

106. It was found that the concrete in the floor, even after it had set, would not hold water long, and even if it had been plastered with Portland cement, the latter would have been insufficient to prevent percolation even if cracks could have been prevented over so large an area. So slabs of Neemuch stone were set in mortars on the concrete floor, and the joints in the flooring and walls were afterwards pointed with cement.

107. The selenitic mortar used in the concrete was mixed in the following proportions:—

Ingredients.	For concrete.	For coursed rubble.
Charcoal-burn kunker lime	5 c.ft.	5 c.ft.
Sand	5 „	5 „
Soorkhi	2½ „	2½ „
Gypsum	¼ „	.....

All the ingredients were ground dry separately and were used immediately after being thoroughly mixed with the stone in the proportion of 1 of mortar 2½ broken stone.

108. The Service Reservoir was commenced in December 1886, and was completed, except a course or two by the end of March 1887, when Mr. Litster went home for two years' training, and the water-works were placed under charge of Colonel Gibbs, Executive Engineer, with Mr. Tickell, Assistant Engineer, to superintend the two Subdivisions from May 1887, Colonel Thomason still taking a direct interest in the work.

109. The revised design for roofing the Reservoir, provided for trapstone pillars supporting brick arches, on which flat concrete arching would rest. But the necessity of securing cleanliness being fully recognized by the Cantonment Committee, sanction to it was deferred, because it was proposed to construct filters in or near the Service Reservoir or near the inlet wells at the head work.

Proposals for using the Head still available at the Reservoir.

110. Colonel Thomason had also some idea of using the head of water still available at the Reservoir either for commissariat flour mills, or for electric lighting, and had made enquiries with these ends in view. The question of the roofing was therefore deferred for the present. A branch pipe with a butt joint has however been fixed in the delivery main outside the Reservoir, on the east side, so that a turbine can be connected with it hereafter.

10-inch Pipe line and road.

111. The plans shew the pipe line as actually laid out. To avoid the steep ascent over the spur, about 1,800 feet from Mhow, the line was diverted round the foot of the ridge, a horizontal curve being thus only required instead of a vertical bend. In order that there should be only descending gradients in the pipe line, between the outlet well and No. 1 Culvert below the Circular Road, a cutting with a maximum depth of 17 or 18 feet was made. Thus between the outlet well and Culvert No. 1 there is no ascending gradient, and between Culvert No. 1 and the Reservoir there is no descending gradient. The positions of the scour, valves, &c., on the main are shewn on the plans.*

* Nos. 5, 5A, and 5B, width of road along the pipe line.

112. The Superintending Engineer ordered that the road along the pipe line should be made 30 feet wide with 10 feet of metalling, or nearly twice the width of the road originally proposed. The gradients of the pipe line, and the prevention of cross drainage at inconvenient points necessitated a much higher embankment than would otherwise have been planted.

113. An estimate of ₹37,589 was made out for a 30-feet road, and the work has been carried out on the savings of the water-works estimate.

114. The first half mile or so of the road, beyond the Circular Road, was made at the sole expense of Mr. Gustadjee Cooverjee, the Contractor, who undertook to make also at his own expense a branch road from it to the Parsee Tower of Silence, on the understanding that the Cantonment Committee would undertake to keep both roads in proper repair in future.

115. The plans and sections of the bridges as completed shew the relative heights of the pipes and the positions of the scour and stop-valves.

Baircha village.

116. Most of the peasantry who had to leave Baircha hutted themselves below the dam close to the point where the pipe cutting from the dam joins the road. The old village was dismantled and the soil over the greater part of its area was carted away, any suitable soil having been thrown into the outer slope of the dam.

117. It was ascertained that interments never took place near old Baircha, nor within the lake area, so it may be presumed that the site is fairly clean.

118. Where the road crossed irrigation channels, 3-inch pipes were inserted in the embankment, with masonry troughs at either end, so built that a long bamboo could be passed at any time through the pipes to clear them of silt when required.

Catchment area.

119. An inspection of the plans of the catchment area* with its boundaries will show that His Highness the Maharajah Holkar had, for several years, previous to the commencement of the dam, made over to the Government, for commencement for "Commissariat" and "Tapkhana" grazing purposes, most of the land lying within the catchment area. The comparatively small Bhadurkha Koorun, and part of the Baircha 'Koorun' were not included in the area transferred, until the water-works project was sanctioned. The revenue from these two 'Kooruns' will now also be lost to His Highness. This would be about equivalent to the value of from 400,000 to 500,000 bundles of grass yearly.

* No. 9.

120. There is no doubt, however, that the value of the land below the dam will, for revenue purposes, be considerably enhanced hereafter; as there will be more water available for irrigation for some distance below the dam, owing to percolation, than there ever was before at the season when irrigation is most required.

121. The catchment area and the pipe line and road should, for administrative and judicial purposes, be placed under the jurisdiction of the Cantonment Magistrate, Mhow.

Valves, Pipes, and Fittings.

122. The valves, pipes and fittings fixed in the inlet and outlet wells, and in the Service Reservoir, were supplied through or by Messrs. Richardson and Cruddas of Bombay, who also cast the flanged pipes for the main in the head works cutting and for the delivery and distribution mains and scour valves and stand-pipes in and near the Reservoir.

123. The spigot and socket 10-inch main pipes, and those of smaller diameter for the distribution in Mhow, were supplied through the Secretary of State for India.

124. The first consignment of 3-inch and 10-inch pipes arrived in Mhow at the end of November 1887.

125. The embankment and cutting from the Reservoir, across the British Infantry parade ground, and as far as the circular road, were finished first, and a commencement in laying the 10-inch pipes was made early in December 1887.

126. The distribution pipes as they arrived were carted to the roads along which they would have to be laid, and placed in the side ditch, or where this would have caused danger or inconvenience, they were stacked in groups of 50 or so, about 450 feet apart, at convenient points, close to the pipe lines.

127. On the 24th January 1888, Colonel Gibbs went on furlough and was relieved by Major Conner, and on the 21st February 1888, Mr. Tickell was transferred from the Waterworks to charge of the Civil Works of the Mhow Division owing to serious illness. Major Connor was relieved of the Mhow Division on the 24th May 1888 by Mr. R. H. Tickell, Executive Engineer.

128. On the 25th May 1888, the 10-inch main was completed from Mhow to Baircha and water was let into the Service Reservoir. One tank of the latter was filled in 36 hours. The estimated rate of filling is 63 hours, when the Baircha tank is down to low water level.

129. About 16 per cent. of the pipes of the 10-inch main arrived at Mhow cracked at the spigot ends, but nearly all of these were utilized after cutting. Great delay occurred in completing the main owing to the special pipes at the culverts not having arrived. Only 10-inch pipes had to be replaced on account of leaks or bursting.

130. No air valves were fixed in the 10-inch main, as it was designed without any vertical angle. For this reason the pipe line and road to Baircha are rather more circuitous than they might have been.

There are three stop valves at places where nullahs are crossed, and to each are fitted tees and scour valves.

The Pipe distribution at Mhow.

131. The pipe laying in the cantonment was commenced on the 3rd April 1888, but rapid progress could not be made as there was no water available for testing purposes. After the Service Reservoir was filled, the mains were laid and tested rapidly. All the C. I. pipes were tested to pressures varying from 100 to 130 lbs. per square inch, and were caulked till free from all sweating, previous to the filling up of the trenches.

pipe

132. The following shows the progress made :—

	Completed. Running feet.	
10-inch Main	24,497	Up to end of November 1888.
9 „ „	432	
8 „ „	7,600	
7 „ „	774	
6 „ „	396	
5 „ „	4,215	
4 „ „	8,238	
3½ „ „	3,483	
3 „ „	13,706	
2½ „ „	8,456	
Total of C. I. Pipes	71,797	

	Completed. Running feet.	
Carried over	71,797	
W. I. Pipes—		
2 inch „	19,661	Up to end of November 1888.
1½ „ „	26,600	
1 „ „	12,000	
¾ „ „	13,440	
½ „ „	600	
Total of W. I. Pipes	72,305	
Grand Total	1,44,102	

133. The water-supply of the barracks is arranged on the following plan :—

Three-quarter-inch taps direct from mains are laid on to all filters, cisterns of kitchens and bath-rooms, and kitchens and bath-rooms and kitchens of sergeants' quarters.

The barrack lavatories have each a masonry cistern to which the water is carried by ball valves and the water distributed by taps in the bath-rooms.

134. The married men's barracks are each provided with either two or four wrought-iron galvanized cisterns 3 feet 3½ inches or 4 feet square. From these cisterns the water is carried in pipes along the walls and a tap is fixed in each bath-room and an outside tap for each set of four or six kitchens.

135. Followers' lines and followers' bazars have each one or more stand-posts from which to draw water.

136. Native Infantry Barracks have cast-iron or masonry stands with numerous taps supplied direct from the mains.

137. The bazaar is supplied with water by about 140 public taps arranged as shown in the distribution and detail plans No. 6A, 6B, 6C, 6D.

138. All Government buildings have water laid on with one or more taps in each bath-room, kitchen and block of servants' quarters.

139. Only 12 private bungalows have at present had water laid on, but numerous applications have been received.

140. The following is a list of the Government buildings or set of buildings to which water has to be laid on, and the number of taps in each :—

	Barrack S. P.	Bazar S. P.	2 inch.	1½ inch.	1 inch.	¾ inch.	½ inch.
1. European Infantry Barracks supplied from a W. I. tank 20×10×6 on the roof of No. 3 Block, the tank being in direct connection with the 10-inch main.	...	1	1	...	...	40	2
2. Royal Horse Artillery Barrack and Bazaar	...	...	1	...	1	39	...
3. Garrison Cells	...	...	...	...	...	4	...
4. Royal Artillery Barracks	...	...	1	1	...	36	...
5. Station Hospital and Bazaar, &c.	...	1	...	...	...	27	...
6. Auxiliary Hospital	...	...	...	1	...	14	...
7. Staff Hospital	...	...	...	...	...	6	...
8. Commissariat Mule Lines and Bazaar	...	...	...	2	...	12	...
9. Fort and Arsenal	2	...	1	...	1	1	...
10. European Cavalry lines	...	...	1	3	...	104	...
11. Lines of 17th Native Infantry	3	...	...	...	...	14	...
12. Lines of 7th Native Infantry	2	1	...	...	1	17	...
13. Native Infantry Hospital	...	...	...	...	...	11	...
14. Charitable Hospital	...	1	...	...	...	...	...
15. Dâk Bungalow	...	...	...	...	...	5	...
16. Telegraph Office	...	...	...	...	...	3	...
17. Post Office	...	...	...	...	...	1	...
18. Government Slaughtery	...	...	...	...	2	2	...
19. Ditto Bakery and its out-houses	...	...	...	...	...	7	...
20. Protestant Church	...	...	...	...	1	1	1
21. Roman Catholic Church	...	...	...	...	1	3	...
22. Commissariat Store Yard	...	...	...	...	...	8	...
23. Library	...	...	...	...	...	1	2
24. South old Travellers' Bungalow	...	...	...	...	...	...	...
25. North Public Works Store yard	...	...	...	...	1	2	...
26. South ditto ditto	...	...	...	...	...	1	...
27. North Public Works Subordinate's Quarters	...	...	...	...	...	3	...
28. South ditto ditto ditto	...	...	...	...	...	3	...
29. Commissariat Conductor's Quarters	...	...	...	...	...	2	...
30. Ordnance Conductor's Quarters near Staff Hospital	...	...	...	...	...	2	...
31. Barrack Master's House	...	...	...	...	...	3	...
32. Barrack Sergeant's House	...	...	...	...	...	2	...
33. Presbyterian Church	...	...	...	...	...	...	...
34. Old Bomb-proof Building in Ordnance Lines	...	...	...	...	...	2	...
35. Bazaar Public Stand Posts	...	...	...	...	...	150	...

141. Along the lines of all C. I. pipes, there are fire plugs fixed at distances varying from 100 to 300 yards. In the bazaar the fire plugs average 1 in every 100 yards.

Five strut watering posts are fixed along the main road, and two fountains are supplied at the Station Hospital and the Mhow Library.

142. The whole of the pipe laying for Government buildings and bazaar with the fitting up of taps, &c., was completed by November 1888.

143. In the bazaar 150 public taps of $\frac{3}{4}$ inch diameter have been fixed to stands shewn in the plans. A supplementary estimate of R5,123 for various masonry works required for the public hydrants and two estimates of R4,824, and R4,727, for taps, pipes and fittings to be procured from Bombay, were sanctioned to complete the pipe distribution scheme out of savings of various sub-heads of the original estimate.

144. The accompanying statement shows the amounts expended on the various sub-heads of the estimate up to the end of January 1889, with the probable cost on completion, from which it will be seen that a saving of R2,282 will be effected on the estimate, or of R31,746 on the allotment:—

Name of Works.	1 Estimated amount.	2 Expenditure to end of January 1889.	3 Probable expenditure to completion.	4 Total probable expenditure.	5 Probable saving.	6 Probable excess.	Remarks.
	R	R	R	R	R	R	
Gambier Bund	1,54,815	1,50,953	...	1,50,953	3,862	...	
Waste Weir	84,532	36,174	...	36,174	48,358	...	
Outlet Works	16,514	20,188	...	20,188	...	3,674	
Service Reservoir	44,064	55,313	...	55,313	...	11,249	
10-inch Main	1,46,676	1,01,362	195	1,01,557	45,119	...	
Pipe distribution	1,20,798	1,35,775	6,805	1,42,580	...	21,782	
Assistant Engineer's Bungalow	1,232	1,718	...	1,718	...	486	
Compensation	1,905	2,025	...	2,025	...	120	
Road to Dam	...	24,643	7,000	31,643	...	31,643	
Establishment	...	6,573	250	6,823	...	6,823	
Light and Fencing	...	235	...	235	...	235	
Furniture	...	272	...	272	...	272	
Tools and Plant	...	1,031	...	1,031	...	1,031	
Medicine	...	440	...	440	...	440	
Interest	...	14,303	3,000	7,303	...	17,303	
Total	5,70,536	5,51,005	17,250	5,68,255	97,339	95,058	

145. It is proposed to construct two filter beds out of the savings on the allotment, and plans, and an estimate amounting to R27,463, have been submitted for sanction.

One of the proposed sites of the filter beds is shown on plan No. 5 and 5 B., they are designed 1 foot below the draw off levels of the collecting tank about 1,000 feet from the outlet works. Designs for filter beds near No. 3 European Infantry Barrack at Mhow are also in hand. This arrangement would utilize the full need of water available in the 10-inch main, but would necessitate separate filtering arrangements for the wrought-iron reservoir on the roof of No. 3 Barrack.

146. From December 1st 1888, to the 15th of March 1889, the following buildings have had water laid on:—

Contagious Disease Hospital near Sarwan Mohah, one tap $\frac{3}{4}$ inch.
Surplus Porter Godown No. 20 in Cavalry line, one tap $\frac{3}{4}$ inch.
Sergeant's quarters near Cavalry stable, five taps $\frac{1}{2}$ inch.
Indore Durbar Vakeel's Bungalow, one tap $\frac{3}{4}$ inch.
Bungalow No. 57, two taps 1 inch, and one tap 1 inch.
Railway Police Office, one tap 1 inch.
Bungalow No. 6, three taps $\frac{3}{4}$ inch.
" No. 67, three taps $\frac{3}{4}$ inch.
Station Master's Quarters, one tap $\frac{3}{4}$ inch.
Bungalow No. 64, one tap $\frac{1}{2}$ inch.
Bungalow No. 28, one tap $\frac{1}{2}$ inch.
" " 30, one tap $\frac{1}{2}$ inch.
" " 7, four taps $\frac{1}{2}$ inch.
" " 11, one tap $\frac{1}{2}$ inch.
" " 14, five taps $\frac{1}{2}$ inch.
" " 63, one tap 1 inch.
" " 122, two taps $\frac{1}{2}$ inch.
" " 83, four taps $\frac{1}{2}$ inch.
" " 20, one tap $\frac{1}{2}$ inch.

Private Houses.

House No. 2546, one tap $\frac{1}{2}$ inch.
" " 1024, one tap $\frac{1}{2}$ inch.
" " 377, one tap 1 inch.
" " 1040, one tap $\frac{1}{2}$ inch.
" " 342, two taps $\frac{1}{2}$ inch.
" " 736, one tap $\frac{1}{2}$ inch.
" " 339, two taps $\frac{1}{2}$ inch.
" " 2449, two taps $\frac{1}{2}$ inch.
" " 1005, one tap $\frac{1}{2}$ inch.
Railway Quarters, one tap $\frac{1}{2}$ inch.
Charitable Dispensary, three taps $\frac{1}{2}$ inch.
House No. 16, one tap $\frac{1}{2}$ inch.
House No. 415, two taps $\frac{1}{2}$ inch.
" " 137, three taps $\frac{1}{2}$ inch.
" " 313, two taps $\frac{1}{2}$ inch.
" " 302, one tap $\frac{1}{2}$ inch.
" " 309, one tap $\frac{1}{2}$ inch.
" " 168, one tap $\frac{1}{2}$ inch.
" " 1016, one tap $\frac{1}{2}$ inch.
" " 820, one tap $\frac{1}{2}$ inch.
" " 197, one tap $\frac{1}{2}$ inch.
" " 201, one tap $\frac{1}{2}$ inch.
" " 198, one tap $\frac{1}{2}$ inch.
" " 414, one tap $\frac{1}{2}$ inch.
" " 452, two taps $\frac{1}{2}$ inch.
House No. 2542, one tap $\frac{1}{2}$ inch.
" " 2547, one tap $\frac{1}{2}$ inch.
" " 320, one tap $\frac{1}{2}$ inch.
" " 1670, one tap $\frac{1}{2}$ inch.
" " 682, one tap $\frac{1}{2}$ inch.
" " 72, one tap $\frac{1}{2}$ inch.
" " 2548, two taps $\frac{1}{2}$ inch.
" " 308, one tap $\frac{1}{2}$ inch.
" " 36, one tap $\frac{1}{2}$ inch.
" " 397, one tap $\frac{1}{2}$ inch.
" " 77, one tap $\frac{1}{2}$ inch.
" " 36, one tap $\frac{1}{2}$ inch.

147. The population of Mhow has increased in the last 12 years from 26,000 to about 38,000. However, from the 1st of January 1889 the water mains have supplied all demands. The registered daily consumption of water from the 1st January has averaged 216,900 gallons. The estimated amount available when the Baircha tank is at low level is 415,000 gallons per day, so that there is no danger of the water-supply falling short of demands.

148. A sheet of photographs of the works after completion taken by the Executive Engineer accompany the drawings.

R. H. TICKELL,
Executive Engineer, Mhow Division.

Mhow;
27th March 1889.

Statement showing the expenditure on Mhow Water-works up to end of January 1889, and probable expenditure to completion of work.

Name of Works.	1 Estimated amount.	2 Expenditure to end of January 1889.	3 Probable expenditure to completion.	4 Total probable expenditure.	5 Probable saving.	6 Probable excess.	Remarks.
	R	R	R	R	R	R	
Gambier Bund.							
Excavation of puddle trench	5,034	4,587	...	4,587	447	...	
Roughing surface soil	1,045	785	...	785	260	...	Earthwork instead of Puddle was done in the centre.
Earthwork in bank	57,516	78,989	...	78,989	...	21,473	
Puddle wall	46,209	20,587	...	20,587	25,622	...	Puddle wall was only done under ground.
Pitching face with rough dressed trap stone laid dry	34,919	35,796	...	35,796	...	877	
Sowing grass on land slope	560	364	...	364	196	...	
Metalling foundation of bund 6 inch in depth of metal	2,160	2,142	...	2,142	18	...	
Contingencies	7,372	5,331	...	5,331	2,041	...	
Temporary establishment	...	855	...	855	...	855	
Earthwork in slope of bund	...	3,361	...	3,361	...	3,361	
Excavation and cleaning nullah	...	39	...	39	...	39	
Earthwork refilling nullah	...	730	...	730	...	730	
Excavation moorum drain	...	194	...	194	...	194	
Dry stone filling in drain	...	103	...	103	...	103	
Excavation moorum rock in slope of east bank	...	36	...	36	...	36	
Deduct percentage recovered from contractor	...	—2,943	...	—2,943	2,943	...	
Amount due to labourers	...	3	...	3	3	...	
Total Gambier Bund	1,54,815	1,53,902	...	1,53,902	31,530	27,668	
Waste Weir.							
Excavation in moorum and rock	28,355	34,422	...	34,422	...	6,067	Retaining wall on west side of Waste Weir was not built.
Random rubble	19,328	2,233	...	2,233	17,095	...	
Hammer dressed stone	255	...	...	...	255	...	
Chisel dressed stone	678	160	...	160	518	...	
Dry stone pitching	280	...	...	...	280	...	
Concrete	3,039	34	...	34	3,005	...	
Contingencies	2,597	62	...	62	2,535	...	
Deduct percentage recovered from contractor	...	—737	...	—737	737	...	
Add for Weir 100 feet chord for every additional 10 feet	30,000	...	...	...	30,000	...	
Total Waste Weir	84,532	36,174	...	36,174	54,425	6,067	
Outlet Works.							
Excavation in moorum and rock	3,383	6,578	...	6,578	...	3,195	
Tunnelling in rock	1,300	244	...	244	1,056	...	
Puddle concrete backing	84	...	...	...	84	...	
Coursed rubble	450	7,602	...	7,602	...	7,152	
Coursed rubble arching	15	46	...	46	...	31	
Coursed rubble tunnelling	656	333	...	333	323	...	
Coursed rubble tunnel arched	552	85	...	85	467	...	
Random rubble	5,943	...	...	...	5,943	...	
Hammer dressed stone	5	...	...	...	5	...	
Chisel dressed stone	67	114	...	114	...	47	
Concrete	44	34	...	34	10	...	
Flat tiles in roof 12 × 12 × 2	22	13	...	13	9	...	
Lime plaster	17	...	...	...	17	...	

Statement showing the expenditure on Mhow Water-works up to end of January 1889, and probable expenditure to completion of work—continued.

Name of Works.	1 Estimated amount.	2 Expenditure to end of January 1889.	3 Probable expenditure to completion.	4 Total probable expenditure.	5 Probable saving.	6 Probable excess.	Remarks.
	R	R	R	R	R	R	
OUTLET WORKS—*contd.*							
Teak timber work	5	...	...	...	5	...	
Iron work	670	480	...	480	190	...	
Cast iron pipes	1,551	1,573	...	1,573	...	22	
Special bend and casting	234	274	...	274	...	40	
Strain girders and netting	68	498	...	498	...	430	
Valve to 10 inch main	180	348	...	348	...	168	
12 inch plug to inlet pipe	100	1,232	...	1,232	...	1,132	
Single purchase crab winch	140	143	...	143	...	3	
Wrought iron pulley block 9 inch	54	22	...	22	32	...	
Hoisting and fixing strainer girder	1	...	...	...	1	...	
Hoisting and fixing cantilevers	6	...	...	...	6	...	
Hoisting and fixing crab winch	3	...	...	...	3	...	
Laying and pointing 10 inch main	80	86	...	86	...	6	
Laying and pointing 10 inch valve	1	...	...	...	1	...	
Laying and pointing 12 inch inlet and outlet bend	4	...	...	...	4	...	
Laying and pointing 9 inch pulley block	3	...	...	...	3	...	
Tar coating	8	9	...	9	...	1	
Portland cement pointing	82	124	...	124	...	42	
Contingencies	786	390	...	390	396	...	
	...	20,228	...	20,228	...	...	
Deduct percentage recovered from contractors	...	—296	...	296	296	...	
	...	19,932	...	19,932	...	...	
Materials at site of work	...	256	...	256	...	256	
Total Outlet Works	16,514	20,188	...	20,188	8,851	12,525	
SERVICE RESERVOIR.							
Excavation moorum and rock	5,883	4,520	...	4,520	1,363	...	
Random rubble trap masonry	29,372	...	...	...	29,372	...	Executed in concrete.
Coursed rubble trap	6,128	11,399	...	11,399	...	5,271	
Chisel dressed stone in coping	629	1,657	...	1,657	...	1,028	
Chisel dressed stone in steps	76	...	...	...	76	...	
Concrete Hydraulic lime	170	17,404	...	17,404	...	17,234	Done in concrete instead of masonry.
1st class brick in lime	255	...	...	...	255	...	
„ brick-in-lime arching	4,555	...	...	...	4,555	...	
Lime pointing	28	...	...	...	28	...	Roof was not made.
Roof terracing	3,330	...	...	...	3,330	...	
Iron girders 25½ feet long	39,590	...	...	...	39,590	...	
Iron girders templates (18 × 12 inch)	900	...	...	...	900	...	
Iron work (brackets, ladders, &c.)	697	532	...	532	165	...	
Cast iron pipes (flanged on the straight)	1,774	792	...	792	982	...	
Cast iron pipes (spigot and faucet)	353	...	...	...	353	...	
Cast iron pipes, bend and casting	442	...	...	...	442	...	
10 inch diameter valve	620	...	...	...	620	...	
9 inch „ „	260	189	...	189	71	...	
Cast iron valve standard with rod	625	17	...	17	608	...	
Cast iron lifting wheel	180	...	...	...	180	...	
„ plug 9 inch diameter	120	...	...	...	120	...	
Filling cock to syphon	6	...	...	...	6	...	
Wrought iron chain ⅝ inch	14	...	...	...	14	...	
Teak timber work	465	...	...	...	465	...	
Tar coating	43	...	...	...	43	...	
Girders 25½ feet long	214	...	...	...	214	...	
Rim of cast iron pipes	141	...	...	...	141	...	

Statement showing the expenditure on Mhow Water-works up to end of January 1889, and probable expenditure to completion of work—continued.

Name of Works.	1 Estimated amount.	2 Expenditure to end of January 1889.	3 Probable expenditure to completion.	4 Total probable expenditure.	5 Probable saving.	6 Probable excess.	Remarks.
	R	R	R	R	R	R	
SERVICE RESERVOIR—*contd.*							
Valve with rods and brackets	5	...	...	...	5	...	
Valve without rods and brackets	1	...	...	...	1	...	
Hoisting wheels and standards	2	...	...	...	2	...	
Contingencies	4,844	4,787	...	4,787	57	...	
	1,01,722						
Deduct cost of roof	57,658	...	...	...	...	57,658	
Neemuch stone flooring	...	6,516	...	6,516	...	6,516	
Temporary bund	...	819	...	819	...	819	
Temporary establishment	...	797	...	797	...	797	
Cement pointing wall	...	630	...	630	...	630	
„ „ floor	...	453	...	453	...	453	
		50,512		50,512			
Deduct percentage recovered from contractor	...	1,014	...	1,014	1,014	...	
		49,498		49,498			
Materials at site of work	...	5,832	...	5,832	...	5,832	
		55,330		55,330			
Due to labourers	...	17	...	17	17	...	
Total Service Reservoir	44,064	55,313	...	55,313	84,989	96,238	
10 INCH MAIN PIPE.							
Excavation in moorum	2,284	2,483	...	2,483	...	199	
10 inch Pipes	1,28,633	83,946	...	83,946	44,687	...	
10 inch Stop valve on main	1,350	852	...	852	498	...	
10 inch Pipe laying main	7,296	5,164	...	5,164	2,132	...	
Iron trussing	128	...	...	...	128	...	
Contingencies	6,985	605	...	605	6,380	...	
Excavation of earth in pipe lime	...	1,182	...	1,182	...	1,182	
Rock excavation	...	1,154	...	1,154	...	1,154	
Air valve	...	...	195	195	...	195	
Excavation of foundation	...	7	...	7	...	7	
Coursed rubble masonry	...	563	...	563	...	563	
Stone masonry for arch	...	57	...	57	...	57	
		96,013		96,268			
Deduct percentage recovered from contractor	...	—189	...	189	189	...	
		95,824		96,019			
Materials at site of work	...	5,551	...	5,551	...	5,551	
		1,01,375		1,01,570		...	
Amount due to labourers	...	13	...	13	13	...	
Total 10 inch main pipe	1,46,676	1,01,362	195	1,01,557	54,027	8,908	
PIPE DISTRIBUTION.							
Pipes from 9 inch to 4 inch	56,805	41,777	...	41,777	15,028	...	
„ 3½ inch to ⅜ inch	44,126	55,095	...	55,095	...	10,969	
9 inch Stop valve cocks	125	552	...	552	...	427	
8 „ „	660	424	...	424	236	...	
7 „ „	90	...	...	...	90	...	
5 „ „	360	215	...	215	145	...	
4 „ „	405	334	...	334	71	...	
3½ „ „	135	140	...	140	...	5	
3 „ „	275	339	...	339	...	64	
2½ „ „	120	540	...	540	...	420	
2 „ „	320	315	...	315	5	...	
1½ „ „	312	162	...	162	150	...	
1 „ „	72	32	...	32	40	...	
¾ „ „	20	12	...	12	8	...	
Laying 9 inch pipes	29	108	...	108	...	79	
„ 8 „	2,009	1,909	...	1,909	100	...	
„ 7 „	196	202	...	202	...	6	
„ 6 „	79	113	...	113	...	34	
„ 5 „	700	835	...	835	...	135	
„ 4 „	946	1,303	...	1,303	...	357	
„ 3½ „	244	446	...	446	...	202	
„ 3 „	1,125	1,688	...	1,688	...	563	
„ 2½ „	586	1,161	...	1,161	...	575	
„ 2 „	1,143	1,568	...	1,568	...	425	
„ 1½ „	750	1,593	...	1,593	...	843	
„ 1 „	141	718	...	718	...	577	
„ ¾ „	30	814	...	814	...	784*	
„ ½ „	...	...	...	...	...	...	
Iron cistern on E. I. barracks	3,000	1,836	...	1,836	1,164	...	

Rg. ft. in Estimate.	Rg. ft. executed up to the end of January 1889.	
	Private Houses.	Main Government Buildings.
103	The cost of house connections is paid for by house owners, and expenditure of these pipes is excluded from the Water Works Project.	432
8,037		7,600
895		774
423		396
4,479		4,215
7,564		8,365
2,228		3,433
12,003		14,206
7,506		8,665
18,287		22,661
15,999	260	29,482
4,517	340	15,121
960	687	18,153
...	1,808	2,070

*The cost of laying these pipes is shewn below in item (*a*).

Statement showing the expenditure on Mhow Water-works up to end of January 1889, and probable expenditure to completion of work—continued.

Name of Works.	1 Estimated amount.	2 Expenditure to end of January 1889.	3 Probable expenditure to completion.	4 Total probable expenditure.	5 Probable saving.	6 Probable excess.	Remarks.
	R	R	R	R	R	R	
Pipe Distribution—*contd.*							
¾ inch Rivets	24	...	...	...	24	...	
1¼inch Wrought iron tie rods	99	...	...	...	99	...	
Fixing in position, staying and riveting cistern	120	481	...	481	...	361	
Contingencies	5,752	2,793	4,031	6,824	...	1,072	
Small cistern tanks	...	2,220	...	2,220	...	2,220	
Laying ¾ inch pipes	...	26	...	26	...	26	
Earthwork	...	43	15	58	...	58	(a) *Vide* remark as above.
Brick in lime	...	641	74	715	...	715	
Stone masonry	...	638	77	715	...	715	
Concrete	...	424	115	539	...	539	
Stone pavement	...	1,944	676	2,620	...	2,620	
Cement plaster	...	81	1	82	...	82	
Moorum	...	38	...	38	...	38	
Dressed stone masonry	...	345	74	419	...	419	
Coursed rubble masonry	...	8	...	8	...	8	
Cavalry trough	...	25	606	631	...	631	
Masonry drain of 17th Native Infantry Lines	...	...	777	777	...	777	
Masonry drain for drivers line, Royal Artillery Lines	...	...	186	186	...	186	
Cut stones on top of fountains	...	...	150	150	...	150	
		1,23,988		1,30,748			
Deduct percentage recovered from contractor	...	686	...	686	686	...	
		1,23,252		1,30,057	...		
Materials at site of work	...	13,894	...	13,894	...	13,894	Materials should be brought on to stock if possible.
		1,37,146		1,43,951			
Amount due to labourers	...	67	...	67	67	...	
„ „ contractor	...	1,304	...	1,304	1,304	...	
		—1,371		—1,311			
Total Pipe Distribution	1,20,798	1,35,775	6,805	1,42,580	19,217	40,999	
Assistant Engineer's Bungalow.							
Bungalow	961	1,500	...	1,500	...	539	
Servants' houses and stables	183	184	...	184	...	1	
Cook house	88	67	...	67	21	...	
Deduct percentage recovered from contractor	...	33	...	33	33	...	
Total Assistant Engineer's Bungalow	1,232	1,718	...	1,718	54	540	
Compensation	1,905	2,025	...	2,025	...	120	
Establishment	...	6,573	250	6,823	...	6,823	
Light and Fencing	...	235	...	235	...	235	
Furniture	...	272	...	272	...	272	
Tools and Plant	...	1,031	...	1,031	...	1,031	
Medicine	...	440	...	440	...	440	
Interest	...	14,303	3,000	17,303	...	17,303	It is believed that from the 1st of January 1889 the Municipality will pay all interest charges from funds at their disposal. The payment of all interest charges previous to that date is also under consideration, and that the R17,303 may be available for further improvements, not originally provided for in the Water-Works Project.
	5,70,536	5,26,362	10,250	5,36,612	2,53,093	2,19,169	
Road to Dam.							
Earthwork	...	8,315	...	8,315	...	8,315	
Boulder soling	...	2,171	...	2,171	...	2,171	
Moorum blinding	...	124	..	124	...	124	
1st metal coat	...	2,466	...	2,466	...	2,466	
2nd „ „	...	...	3,970	3,970	...	3,970	
Sand blinding 1st coat	...	124	...	124	...	124	
„ „ 2nd „	...	...	124	124	...	124	
Earthwork for banking side	...	...	457	457	...	457	
Mile stone	...	10	...	10	...	10	
Furlong stone	...	12	...	12	...	12	
Spreading and consolidating of boulder soling	...	1,020	...	1,020	...	1,020	
Spreading and consolidating of stone metal	...	1,040	1,877	2,917	...	2,917	

Statement showing the expenditure on Mhow Water-works up to end of January 1889, and probable expenditure to completion of work—continued.

Name of Works.	1 Estimated amount.	2 Expenditure to end of January 1889.	3 Probable expenditure to completion.	4 Total probable expenditure.	5 Probable saving.	6 Probable excess.	Remarks.
	R	R	R	R	R	R	
Culvert for Pipe.							
Coursed rubble masonry	...	50	...	50	...	50	
Culvert No. 2.							
Excavation of foundation	...	9	...	9	...	9	
Coursed rubble masonry	...	664	...	664	...	664	
Cut stone masonry	...	28	...	28	...	28	
Stone archwork	...	48	...	48	...	48	
Culvert No. 3.							
Excavation of foundation	...	17	...	17	...	17	
Coursed rubble masonry	...	1,406	...	1,406	...	1,406	
Cut stone masonry	...	61	...	61	...	61	
Stone archwork	...	320	...	320	...	320	
Culvert No. 4.							
Excavation of foundation	...	17	...	17	...	17	
Coursed rubble masonry	...	1,210	...	1,210	...	1,210	
Cut stone work	...	38	...	38	...	38	
Stone archwork	...	132	...	132	...	132	
Culvert No. 5.							
Excavation of foundation	...	9	...	9	...	9	
Coursed rubble masonry	...	703	...	703	...	703	
Cut stone work	...	30	...	30	...	30	
Stone archwork	...	48	...	48	...	48	
Culvert No. 6.							
Excavation of foundation	...	...	...	...	...	...	
Coursed rubble masonry	...	1,690	...	1,690	...	1,690	
Cut stone masonry	...	63	...	63	...	63	
Stone archwork	...	565	...	565	...	565	
Rock excavation	...	840	...	840	...	840	
Irrigation Syphon.							
Excavation of foundation	...	2	...	2	...	2	
Coursed rubble masonry	...	52	...	52	...	52	
Iron pipes	...	72	...	72	...	72	
Contingencies	...	1,399	572	1,971	...	1,971	
		24,755	...	31,755	...	...	
to labourers	...	112	...	112	112	...	
AD TO DAM	...	24,643	7,000	31,643	112	31,755	
ND TOTAL	570,536	5,51,005	17,250	5,68,255	2,53,205	2,50,924	

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