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ANNUAL  
PROGRESS REPORT  
OF THE  
IRRIGATION DEPARTMENT, PUNJAB,  
FOR THE YEAR  
1878-79.



LAHORE:  
PUBLIC WORKS DEPARTMENT PRESS,  
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PHYSICS DEPARTMENT

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ANNUAL PROGRESS REPORT  
OF THE  
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FOR THE YEAR 1878-79.

BARI DOAB CIRCLE.

1ST DIVISION BARI DOAB CANAL.

BARI DOAB CANAL.

1. During the year 23 floods were recorded between April and October, varying in height from 11 feet to 18·80 feet on the *Sidhauri* gauge. Several times during July, August and September the floods continued for three and four days together with but small fluctuations. The highest flood ever recorded (18·80 feet) reached its maximum about 8 A. M. on the 24th July; on the following day the level of the water had fallen a few inches, but again rose above 18 feet on the 26th July.

Floods in the River  
Ravi.

2. After the heavy flood of the 24th July, it became apparent that there was something wrong below the outlet, and when the water subsided a little, and soundings could be taken, two holes were detected. One of these was on the left flank near the tail wall; the other was in front of No. 5 bay; both were down-stream of the flooring. Nothing could be done at the time to check the enlarging of these holes, because the river continued high and floods succeeded one another at intervals of two or three days. The destructive action thus went on from day to day and hour to hour until at last the holes met in the centre of the flooring, and the damage extended in width from one flank of the work to the other, in length from the timber baulk (which was 15 feet down-stream of the piers) to the crate bed below the tail wall, and in depth to as much as 13 feet below the level of the outlet flooring.

Damage to Head-  
Works.

3. As soon as it became apparent in August that deep and heavy masonry repairs would have to be undertaken in the cold weather, measures were taken to divert the main stream and keep up the canal-supply during the repairs to the outlet and inlet. The long main bund was broken through on the 2nd October, and by the 26th of the month the outlet was laid dry, the extent of the damage ascertained, and a long drain commenced with the object of leading off the water from the foundations and hole in the flooring. By the 22nd November this drain had been completed, the foundations laid dry, and the silt cleared out to R. L. 1113·5, when a freshet in the

Repairs performed.

## RANI DOAB CANAL.

## Repairs performed.

river filled up the drain, and it was not till the 4th December that the water had again subsided sufficiently to admit of the drain again acting. By the 20th December the foundations were again dry, and the silt cleared out to R. L. 1109.5, and by the 28th December the new foundations were in place, and well beyond danger from subsequent freshets. From this date the work progressed rapidly, and was completed by the 31st March.

## Nature of repairs.

4. The new floorings to the outlet and inlet are cut stone set on end in Portland cement, that for the outlet being 2 feet cut stone-work laid on 2 feet of first class boulder masonry in kunkur cement, which in its turn rests on 2 feet of superior concrete rammed on the top of dry boulder pitching 9 feet in depth. The cut stone flooring is divided into bays transversely by baulks of squared timber, tarred, and bolted down to the lower masonry, it having been found that such timbers are very useful in arresting the cutting back when by any accident a portion of the flooring becomes damaged during a flood season.

## Damage to bunds.

5. The same great flood (that of 24th July) which injured the outlet also scoured out the toe of the boulder pitched defence bund on the right bank of the Ravi, opposite Mádhopur. The damage extended from the angle below the old spill channel to the end of bund No. 5, known as "Jacob's Spur." Every endeavour was made to save this bund by throwing out brush-wood spurs; but, owing to the constant heavy rain and the continued floods, nothing could be put in of sufficient strength to divert the force of the water, and the whole spur disappeared. The long bund above this spur was also gradually carried away, until out of about 4000 feet in length only a few chains remained. By continuous hard work the portion of this bund in front of the spill channel was fortunately saved; had this portion also gone, the main stream, which was setting direct on to the spill channel, would have taken to it, and the canal would have been left dry. Floating spurs made with whole trees bound together with ropes were placed along the face of the bund and helped to deaden the force of the great rush of the water which for several days was within 12 inches of the top of the bund, and was at this point 15 feet in depth.

## Nature of repairs.

6. A new line was selected for this bund, which is now retired further from the main stream than the old one; on the river face it is protected by groynes having crate points put in at a low level; and the Executive Engineer expresses a hope that the system of brush-wood bunds and spurs, which were



## BARI DOAB CANAL.

put in in connection with this work, will tend to push the main stream of the river more towards the left bank, and thereby relieve the long defence bund of some of the rush and scour attendant on high floods.

Nature of repairs.

7. On the right bank of the Ravi the small *Basantpur* canal, under construction for His Highness the Mahárajah of Kashmir, was nearly completed. It was ready for the admission of water on the 31st March, so that the lands in rear of the bunds will no longer be deprived of irrigation.

Kashmir Canal.

8. The floods in the *Chakki* were heavy and frequent, and would have done much damage to cultivated lands had it not been for the new spur which had been made. This spur did its work well, but was topped at the end and lost about 150 feet of its length. This loss has since been repaired and the work strengthened, so that it is now expected to withstand future floods.

Chakki torrent.

9. There was no closure of the canal for repairs during the year, owing to the want of rain in January and February. A hole in the flooring of No. 5 rapid was repaired by lowering the supply for a few hours, during which the damaged bay was bunded-off. The floor was repaired with masonry laid in Portland cement, the water being turned over the work again two days afterwards. It has since stood well.

Closure of canal for repairs.

10. The supply in the canal during the kharíf crop of 1878 was the largest which has been hitherto sent down, the reading on the *Salámpur* gauge having been for a long time 4.7 feet. There was great demand for water during the rabbi, owing both to want of rain and to the extension of irrigation on the new rájbahás of the *Kasúr* Branch.

Supply in the canal.

11. The inlet and outlet of the mill channel of the Punjab Sugar Works Company, Limited, were completed during the year, as was also one of Lieutenant Clibborn's sugar-cane mills at *Zafarwál* fall on the *Talwandi* rájbaha.

Mills.

12. Thirty-nine masonry water-course heads were fixed during the year, 38 of these being on the *Salámpur* rájbaha.

Water-course Heads.

13. The rájbahás of the Main Line and Main Branch Upper were kept in good working order during the year. On the *Kasúr* Branch, the *Jaura*, *Pakhoki* and *Pindori* rájbahás were maintained, and the *Tarn Taran* and *Khem Karn* rájbahás completed. On the *Sobráon* Branch, the *Raya* rájbaha was completed, and the *Patti* rájbaha nearly so.

Rájbahás.

14. On the *Kasúr* Branch one foot-bridge was completed and one in progress; on the *Sobráon* Branch, also, one foot-bridge was completed and one in progress.

Bridges.

## BARI DOAB CANAL.

## Buildings.

15. All the buildings at *Mádhopur* and on the Main Line and Main Branch Upper were repaired and kept in good order, the Executive Engineer's office being converted into an inspection bungalow. On the *Kasúr* Branch the chauki at *Khem Karn* was completed; and on the *Sobráon* Branch the 2nd class chauki at *Naushahra*, on the *Patti rájbaha*, was in progress; all existing buildings on these branches having been kept in good repair.

## Escapes.

16. The old arrangement of working the *Malikpur* escape by means of kurries having been found unsuitable, gates and travelling cranes for lifting them were provided.

## Drainage Works.

17. The flooring of the *Sujánpur* drainage inlet was repaired, and the *Sujánpur* and *Nalloa* drainage cuts kept in thorough repair during the year. A branch of the *Allowála* drainage was surveyed and levelled.

## Plantations.

18. One hundred and twenty young Bombay mango trees were grafted, and 102 were transplanted and tended. Over 33,000 young trees of various kinds were transplanted and tended; 19½ acres of land were ploughed and sown with tree seeds; 23,785 feet of *Phulái* fence were put down; 1959 square feet of land were prepared for seedlings; and all the trees and nurseries in the Division were cared for.

Observations on  
River discharges.

19. The Executive Engineer, Mr. J. Doyle Smithe, reports the following results of observations on the discharge of the Rivers Ravi and Beas:—

RIVER RAVI.		
Date.	Place.	Discharge. C. ft. per sec.
29th April 1878	Kamwál	13,151
15th October "	"	5901
15th Novr. "	Head channel	4929
16th Decr. "	"	4227
15th Jany. 1879	"	3243
15th Feby. "	"	2692
27th March "	Taen	6534
RIVER BEAS.		
19th Decr. 1878	Naushahra	3411
19th Jany. 1879	"	2789

## 2ND DIVISION BARI DOAB CANAL.

Thamman and Turkwind  
Rájbahás.

20. The *Thamman* and *Turkwind* rájbahás have been still further developed during the year under review. Eight more irrigation outlets have been allotted to the villages on the *Thamman* rájbaha, and one on the *Turkwind*. On the former three new villages have been brought under irrigation, and one on the latter. Some bridges remaining incomplete on the *Thamman* rájbaha at the close of the last year have now been completed.

## BARI DOAB CANAL.

21. The permanent parapets of *Valla*, *Rájajang*, *Gilpan* and *Vahn* bridges were completed.

Bridges.

22. Out-houses to the 1st class chauki at *Pambay* were built during the year.

Buildings.

23. Materials were collected for the remaining weirs on the Main Branch Lower ; but, owing to the non-closure of the canal, the work could not be carried out.

Weirs.

24. A large quantity of silt which had been taken from the canal and thrown in irregular heaps on the banks was removed and evenly spread over the spoil-banks. The silt-clearance of the *rájbahás* was nearly completed during the year ; the channels were maintained in a thoroughly satisfactory condition.

Silt-clearance.

25. About 45,000 maunds of fire-wood were collected and sold at an average rate of ~~Rs.~~ 20 per 100 maunds.

Plantations.

26. The remodelling of the *Gumtála* drainage, as an escape for the *Jaithowál* *rájbaha*, was nearly completed.

Escapes.

27. Materials were collected for the two new syphons on the Meean Meer Cantonment *rájbaha*, rendered necessary by the alterations being made to the Cantonment drainage channels. One was completed during the year, the other was in hand, and has since been finished.

Meean Meer Cantonment *Rájbaha*.

28. The 25 flour-mills worked by canal-water-power earned during the year ~~Rs.~~ 35,738, showing an excess of ~~Rs.~~ 9,034 over the earnings of the previous year.

Mills.

## UPPER SUTLEJ DIVISION INUNDATION CANALS.

UPPER SUTLEJ DN.  
INUNDATION CANALS.

29. As there had been settlement of the ends of the timber-bridge over the *Katora* Canal at *Ganda Singh*, on the Trunk Road between Ferozepore and Lahore, the beams were shored up and strengthened to allow of the passage of the siege guns moving from the Arsenal to Affghánistán. The bridge at *Khudián* was also repaired and tarred.

Katora Canal bridges.

30. Wooden railings were fixed to the timber-bridges over the *Atári* and *Chunián* *rájbahás* ; these bridges were further repaired and put into good order.

Katora *Rájbaha*  
bridges.

31. New heads were dug for the *Khánwah* and *Upper Sohág* canals.

New heads.

32. The silt-clearance of the canals and *rájbahás* was carried out as usual, and the banks kept in repair.

Silt-clearance.



UPPER SUTLEJ DN.  
INUNDATION CANALS.Discharge of River  
Sutlej.

33. The discharge of the Sutlej was measured by Mr. R. D. Bayley with the following results :—

Date.	Place.	Discharge. C. ft. per sec.
19th December 1878	Betu	8027
19th January 1879	Do.	7128

## SWAT RIVER CANAL.

## SWAT RIVER CANAL DIVISION.

34. Major Swinton, R. E., who is Officiating as Executive Engineer during the temporary absence of Captain Jacob, R. E., on Field Service, reports as follows :—

Land.

35. All the land for Main Canal has now been made over to the Canal by the Civil authorities.

Regulators.

36. The regulator at the head has not been commenced. The regulators at head of Rájbaha No. VI. and at the bifurcation have been just commenced, that is, the foundations have been excavated.

River and Hill Torrents.

37. *Lundai Superpassage*.—The foundations have been completed, and the arching nearly completed, and boulder paving has been commenced.

*Nowedand Aqueduct*.—The masonry is up to springing level.

*Jinda Aqueduct*.—The excavation for foundation and drains has been done.

*Ziám Culvert*.—The invert has been commenced.

*Hissára Kanda Culvert*.—The foundation is completed, and the superstructure is nearly up to springing.

*Narrai Culvert*.—The arch-work is completed, and the earth-work is well advanced. The new channel will be cleared, and the old channels blocked up, so that the drainage may pass under this culvert in the rains.

Minor Drainages.

38. The minor drainages were commenced in January, and the foundations have been excavated, but, with the exceptions of Kanáwar No. 1 and No. 2, and the *Narrai* syphons, no masonry has been done. This is owing to the masons having been taken away in March for the works in the Khybar Pass and at Ali Masjid.

Bridges.

39. Nothing done on the bridges; the excavation for two of them was commenced in March.

Nowedand Escape.

40. The escape in connection with the *Nowedand* aqueduct was commenced, and is up to floor level of the aqueduct; it will be completed with the arching of the aqueduct.



## SWAT RIVER CANAL.

41. The progress on earth-work has been better than last year,—16,721,697 cubic feet as against 13,419,954 cubic feet; this also would have been still greater but for the number of men taken away for Military Works.

Earth-work.

42. The first set of roads has been completed, and 15 miles of the cross roads have been made.

Temporary Roads.

43. The crate-work has been put up, and the boulder filling is in progress.

Abazai Spurs.

44. During the year 497,345 cubic feet of masonry, including concrete and arch-work, were executed on the principal masonry works; on these same works, also, 2,236,298 cubic feet of excavation had been got out, besides the 167 lakhs of canal excavation. These figures represent good progress when it is remembered that there were many difficulties to contend with.

General statement of work done.

45. There is also a considerable quantity of fuel collected, as well as stone and lime-stone, besides lime not yet taken over from the contractors. A great deal of soorkhee and lime has been burnt with thorn bushes from the "Maira," and a considerable saving in wood-fuel has thus been obtained.

Collection of materials.

46. The following of the Swát River were observed:—

Discharge of Swát River.

<i>Date.</i>	<i>Place.</i>	<i>Discharge.</i>
		C. ft. per sec.
19th December 1878 .....	Head of Canal .....	3290
18th January 1879 .....	Ditto .....	2779

## WESTERN JUMNA CANAL CIRCLE.

## KARNAL DIVISION WESTERN JUMNA CANAL.

## WESTERN JUMNA CANAL.

47. The bridge connecting the island with the Western Jumna Canal Regulator was completed; seven new sluice gates were obtained and put into position.

Head-works.

48. Materials for *Radaur* bridge continued to be collected. The inspection bungalow was nearly completed, the out-houses and a little finishing up work remaining to be done.

Radaur Bridge and Bungalow.

49. Some slight repairs were executed to the floors of the undersluices at *Tájawála*. The spurs above the Eastern Jumna Canal Regulator were repaired; silt was cleared out and cuts made through islands formed in the leading channel of the Western Jumna Canal; the bunds put up to maintain a temporary supply were removed; and the channel below the Western Jumna Canal undersluices was dug out to an even width and slope so as to induce a good flow.

Repairs and Maintenance, Head-works.

## W. J. CANAL.

## Mandawála Works.

50. These works were improved, silt excavated from some of the channels, and crib-work, and concrete bars placed across others down which it was desirable to regulate the floods.

## Silt-clearance in the Sombe,

51. At *Dádúpur* the silt brought down by the *Sombe* torrent had formed an island in the channel above the dam ; the effect of this was to force the floods over to the left portion of the *Patrála* dam, instead of allowing the water to pass evenly over the whole width of the work ; moreover, a much larger body of silt accumulated above the regulator after each flood and on the re-opening of the gates was scoured into the canal. It was determined to try and reduce the evil by cutting a channel through the newly formed island, supplementing this work by spurs on the left bank of the torrent. It is reported that these measures have been completely successful.

## Meerut Road Bridge.

52. The repair of the *Meerut* road bridge was completed during the year ; it having been found impossible to get sufficiently long beams from the Forest Department, the openings were eventually spanned by trusses.

## Protection of banks of canal from erosion,

53. Bushing and staking was carried on as usual, and an attempt was made to introduce the use of wire for holding the branches ; it was found, however, that the wire was invariably stolen, and consequently its use had to be given up. This is greatly to be regretted, as the ordinary rope fastenings rapidly rot, and the branches thus set free float down the canal, and often do as much harm as good.

## Surveys for alteration of line of Rer Escape.

54. Surveys and levels for the proposed alteration of the tail of the *Rer* Escape were carried out.

## Plantations.

55. The mango gardens at *Dádúpur* and *Karnál* were maintained, and the new *chauki* compound at *Radaur* was planted with young trees. About three miles of fencing were completed, and preparations made for starting new nurseries.

## Discharges.

56. The following discharges of the River *Jumna* and the *Western Jumna Canal* were taken :—

Date.	Place.	Discharge.
		C. ft.
1st August 1878	... Indri ... ..	W. J. Canal ... 3350
18th December "	... Tájawála ... ..	River <i>Jumna</i> ... 2241
" " "	... Ditto ... ..	W. J. Canal ... 1889
19th " "	... Dádúpur ... ..	Ditto ... 1862
18th January 1879	... Tájawála ... ..	River <i>Jumna</i> ... 2296
" " "	... Ditto ... ..	W. J. Canal ... 1801
23rd " "	... Dádúpur ... ..	Ditto ... 1908
17th February "	... Tájawála ... ..	River <i>Jumna</i> ... 2355
3rd March "	... Ditto ... ..	Ditto ... 2121

## Loss in boulder formation.

57. From observations taken in December and January it would appear that between the *Fyzabad* escape and the head of the *Western Jumna Canal* there was a loss of from 250 to 300 cubic feet per second.

58. When the discharge was taken at Indri above the head of the New Main Line Division on 1st August 1878, the gauge at that place stood at 10.5 feet, and the measured discharge was 3350 cubic feet per second, with a velocity of 3.38 feet per second. On the 21st August the highest reading of the gauge during the year was recorded as 11.25 feet, from which the velocity was deduced as 3.57 feet per second, and the discharge as 3856 cubic feet per second.

## DELHI DIVISION WESTERN JUMNA CANAL.

59. The *Saragthal* chauki was completed. Saragthal Chauki.
60. The *Gaumri* minor was completed, but the land has still to be settled and paid for. No. IX. Rájbaha.
61. The land of Main Line was all paid for, and masonry and earth-work completed, and 36 kolabas fixed in the two main branches. Of the minors, the *Guhna*, *Mohána*, *Jaoli* and *Saragthal* were completed in all respects; the *Bhainswál* minor was completed except kolabas, and the land only of the *Rubrah* minor remained to be paid for,—in all other respects it was completed. No. XII. Rájbaha.
62. Rájbahás Nos. 11, 14, 21 and 22 were surveyed and levelled during the year, and their designs and estimates put in hand. Other Rájbahás.
63. The arch of *Bhatgáon* bridge, which was very low and interfered with barging, was altered. *Juah*, *Machri*, *Jáji* and *Jharaothi* bridges were repaired, and *Jharauth* bridge put in hand. The *Negambode* aqueduct and the tail of the *Bowána* escape head were also repaired. Masonry works.
64. The verandah of the *Negambode* mills, which was in a very dilapidated state, was renewed, and the mill rooms and escape channel of *Tamáncha* mills were put in order. The *Naultha* chauki was thoroughly repaired, and the other buildings maintained in fair order. Mills and Buildings.
65. The mango gardens at *Naultha*, *Sirdhana*, *Palri*, *Chota Thána* and *Gangatoli* were kept in order. The new rájbaha chauki compounds were planted out and looked after. Plantations.
66. Some cuts were made across the old abandoned *Bhainswál* Rájbaha to liberate the drainage. Silt-clearance to a small extent was carried out on the *Najafgarh* jhíl drain; some fallen trees were removed from the bed, and the banks of the channel were repaired. Drainages.

## W. J. CANAL.

Transfer of portion of  
Rohtak Branch.

67. A portion of the *Rohtak Branch* and 34 villages at the tail were transferred from the Hânsi Division to the Delhi Division on the opening of No. XII. Râjbaha, which now supplies water for their irrigation.

Discharges.

68. The discharge of the River Jumna, taken at *Wazirabad Ghât* near Delhi, was as follows :—

			C. ft. per second.
19th Decr. 1878.	Wazirabad Ghât.	River Jumna.	1122
20th Jany. 1879.	ditto	ditto	1014

## HANSI DIVISION WESTERN JUMNA CANAL.

Jind Râjbahâs,

69. Owing to the illness of both of the subordinates and to the death of Mr. H. C. Cotton, the work of plotting the surveys and levels was thrown back ; it will, however, be pushed on as soon as a suitable officer can be deputed to take it up.

Silt-clearance.

70. Nearly five lakhs of cubic feet of silt were taken out of the *Rohtak Canal*, and about  $3\frac{1}{2}$  lakhs from the *Bahâdra Branch*, which was also cleared of weeds. The season, however, was not suitable for closing and clearing the *Hânsi Branch*, which is very badly silted. It is hoped that it may be found possible to close this canal for clearance during the cold season of 1879-80.

Masonry Works.

71. Petty repairs were executed to the bridges, regulators, &c.

Plantations.

72. The mango garden at *Butâna* was tended, and the plantations near *Hissâr* were watered and looked after, but the principal work was in collecting and stacking fuel and timber. The Executive Engineer has brought to notice that it is useless attempting to plant young trees along the canal in place of the numbers of old ones that are dying off, as the depredations of the swarms of monkeys utterly preclude the chance of any young trees growing. It has been found, however, that the thorny "Kîkar" is a tree which these animals do not destroy, and orders have therefore been issued by the Superintending Engineer to sow the seed of this species as much as possible.

## NEW MAIN LINE DIVISION WESTERN JUMNA CANAL.

Earth-work.

73. The works in this Division were vigorously pushed on : 40,175,029 cubic feet of earth-work were got out as follows :—

Main Line	...	...	Cubic feet.
Hânsi Branch	...	...	26,656,019
Indri Escape	...	...	10,659,110
			2,859,900
			<hr/>
			40,175,029
			<hr/>



The Hási Branch and Indri Escape only require to be cut at points of junction with the canal ; and of the Main Line 98 per cent. has been completed, so that it may be said to be practically finished. The work has also been cheaply done, Rs. 2-8-6 per 1000 cubic feet on the Main Line and Rs. 2-0-5 on the Hási Branch, against Rs. 3 in the estimate, so there will be a large saving effected under this head.

Earth-work.

74. 1,250,897 cubic feet of masonry were done during the 12 months, or at the rate of over 100,000 cubic feet per mensem. The state of the works at the close of the year was as follows :—

Masonry.

*D.—Regulators.*

Indri—Complete, except gates and kurries.  
Hási—Centrings fixed.  
Delhi—Two-thirds done.

*E.—Falls and Weirs.*

Grand Trunk Road—  
Karnál. } Complete, except parapets and  
Ghogripur. } plastering.  
Jáni. }  
Mor Májra—Half done.  
Safidon—Curtain and cistern in progress.

*F.—Cross Drainages.*

Phusgarh Inlet—Complete.  
Barota Syphon—Complete, except a little earth-work of drain.  
Gagsina Syphon— Ditto ditto.  
Nye Naddi Syphon—Up to springing of arches.

*G.—Bridges.*

Gorgarh. } Complete.  
Kheri. }  
Ramba—Plastering and metalling wanting.  
Karáli. } Plastering remaining.  
Kaithal Road. }  
Barota. } Completed, except approaches, which  
Gagsina. } are nearly done.  
Bála. }  
Bhuslána, } Complete, except parapets, approaches  
Anta, } and plastering.

*H.—Escapes.*

Indri—Complete, except gates and gearing.

*I.—Locks.*

Grand Trunk Road—  
Karnál. } Gates and quoins wanting and the  
Ghogripur. } masonry adjoining where the  
Jáni. } latter have to be built in.  
Hási Head. }  
New Delhi Head. } Cistern in progress ; abutments 5'  
Mor Májra. } high.  
Safidon—Up-stream floor complete ; main walls 8' high ; concrete of cistern laid.

*K.—Buildings.*

Temporary buildings all completed.  
1st class chauki, Ramba. } Complete.  
Ditto Jáni. }  
Ditto Múnak—Almost finished.

## W. J. CANAL.

## Surveys and Estimates.

75. Surveys, designs and estimates for distributaries were pushed on; those of No. IV. have since been received and sent on to Chief Engineer, and III. and V. will shortly follow. The estimate for No. I. kharíf rájbaha was sent up for sanction, but orders were received to hold them in abeyance. Nos. II., III. and IV. were also in a forward state when temporarily laid aside.

## NEW DELHI BRANCH DIVISION WESTERN JUMNA CANAL.

## Land.

76. No land was taken up during the year, but payments, amounting to Rs 2,948, had to be made for trees, houses, &c., which were under reference to the Civil Officers, and some further sums will have to be disbursed for about five acres more required near Delhi.

## Cross Drainages.

77. Surveys have been made of the Juah and Koali drainage basins and materials collected at sites. 425,275 cubic feet of excavation has been got out at sites of Bowána and Pulhádar aqueducts, and 2475 cubic feet of masonry put in foundations of the former. Plans and working estimates have been sanctioned by Chief Engineer for the latter.

## Bridges.

78. Ten were put in hand out of 27. 202,278 cubic feet of masonry and 1,073,144 cubic feet of earth-work were done :—

Mithái	} Are nearly completed, and are open for traffic.
Bangash	
Andha Mogal	} Approaches not complete, but open to foot and cattle traffic.
Khatra	
Paembári—Complete, except approaches.	
Háidarpur—Arched.	
Badli—Up to springing.	
Sirispur—Abutments up to skew-backs.	
Bowána—Concrete laid.	
Kabri—Abutments up to skew-backs.	

## Escapes.

79. At Rer and Daryápur escape heads materials have been collected. The Daryália escape and aqueduct combined is complete, with exception of caps to pillars and sluice gates and gear. The work done during the year was—earth-work 191,668 cubic feet; masonry 71,475 cubic feet.

## Locks and Falls.

80. There are seven locks and falls on New Delhi Branch, and of these one has been commenced at *Gangatoli*, on which 796,431 cubic feet earth-work and 74,786 cubic feet masonry have been done. The side walls of lock are 8 feet high; materials are being collected at the other sites.

## Buildings.

81. Four sets of temporary quarters and Assistant Engineer's quarters at *Binjaol* have been completed. *Naraina* 1st class chauki was ready for roofing. Part of the materials for the one at *Kakroi* were collected, and the chauki at *Háidarpur*, with out-houses, &c., was completed.

82. Out of a total of 140 millions cubic feet of earth-work, 104½ millions have been completed—half during the year under report. The Division is 71·3 miles long, and of this 37·8 miles were completed; 23·5 miles more than half out, and 10 miles not opened at points crossing old canal, sites of works, &c. Part of the work was kept in hand in case of being wanted for famine laborers. The ordinary earth-work has cost under Rs. 2-8-0 per 1000 cubic feet, including price of 121,300 cubic feet of masonry in revetment walls, the estimate rate being Rs. 3·125 per 1000. The rock-cutting, amounting to 3,801,820 cubic feet, has cost Rs. 5-8-10 per 100 cubic feet, and there is a considerable balance left to credit in the estimate.

Earth-work.

83. In digging through *Shálámár* and other gardens, the young trees that came in the line of the canal were taken up and transplanted to outside of the spoil-banks between *Sirisipur* and *Haidarpur* bridges.

Plantations.

84. To make *rājbahás* through the gardens in the neighbourhood of *Delhi* would have been enormously expensive; it was therefore determined to take up the old irrigation by putting in outlets in the banks of the canal, so that water might be sent down the old water-course channels. These outlets have been put 4½ feet above level of canal-bed, so as not to interfere with the minimum depth for navigation; the work done amounted to 7400 cubic feet masonry and 33,000 cubic feet of earth-work.

Miscellaneous.

85. The total work done in the Division was 52,690,834 cubic feet earth-work, and 460,635 cubic feet of masonry.

Earth-work and  
Masonry executed  
during the year.

## DERAJAT CIRCLE.

86. The Superintending Engineer, Mr. Garbett, reports as follows :—

INDUS INUNDATION  
CANALS.

## DERA GHAZI KHAN DIVISION INDUS CANALS.

87. The culvert for passing the *Kála Khand* drainage under the *Mánka* Canal near its tail was completed, with the exception of the boulder pitching. This exception was owing to the impossibility of obtaining camels to carry the boulders.

Kála Khand culvert.

88. Lifting gear for the gates of the *Shoria* Regulator No. I. was supplied during the year. *Shoria* Regulator No. V. was begun and completed, with the exception of the regulating kurries and the earth-work in the approaches. As a bridge was greatly needed on the *Choti* and *Kot Chota* road, half the cost of the work was contributed by the District Funds.

Regulators, Shoria  
Canal.



## INDUS INDN. CANALS.

- Gámánwála Canal Regulator. 89. An estimate was sanctioned for replacing the old stakes and wattling (with which the regulation of the supply in the *Gámánwála* Canal has been hitherto attempted with very indifferent results) by a masonry regulator. The foundations and flooring were got in during the year, but progress was hampered by the want of lime. No carriage was procurable, as nearly all the camels in the district were engaged with the troops or carrying supplies for them.
- Fazalpur Chauki and Out-offices. 90. The *Fazalpur* chauki, its well and out-offices were commenced and completed during the year, with the exception of the chauki roof, which was not quite finished.
- Shoria Canal new channel. 91. The excavation of the new channel for the *Shoria* Canal was completed last year, and the payments this year.
- Maintenance and Repairs. 92. The maintenance and repairs to the canals and embankments were unusually heavy and expensive in consequence of the damages caused by the very exceptional floods in the Indus, which were higher and lasted longer than had ever been known before.
- Chaukis and Buildings. 93. The chaukis and buildings were repaired. The *Kharakwála* first class chauki was carried away by the river in September, and the small kacha third class building at *Bahár Shah* was destroyed by the flood.
- Maintenance of Embankments. 94. Large watch and ward parties were kept up to repair and maintain the embankments during the floods, but breaches occurred in the *Kálah*, *Káliwála*, *Bahár Shah*, *Cantonment* and *Shah Jamál* embankments.
- Repairs to Embankments. 95. Two-thirds of the repairs, or about 18 lakhs cubic feet of earth-work to embankments and canal-banks above the *Shoria* Regulator, were completed by end of the year, and about half the amount of work on the protective embankments below it.
- General repairs to Canals heavy. 96. The repairs to the canals and their banks have been unusually heavy, not only were they damaged by the river-floods, and the high volumes entering them, but they were cut across by the river torrents, which were swollen by the heavy rain in the neighbouring hills.
- Brief notice of particular Canals. 97. The river erosion has necessitated a new and costly head to the *Mánka* Canal, and the repairs to the banks at the tail (*Kála Khand*) have also been heavy. The repairs to the upper part of the *Shoria* Canal were very heavy, as the banks had to be strengthened to resist the inundation, as were also those to the supply-channel of the *Kastúri*. The *Dhingána*, lying in the centre of the inundated tract, was much damaged.



The expenditure on the group of canals near *Shah Jamál*, viz., the *Gámánwála*, the *Sohan* and *Núr*, was chiefly on the clearance of their supply-channels. On the *Dhundi*, the outlay on silt-clearance and repairs to banks has been below the average. On the *Kádra*, expenditure was limited to the clearance at the head and repairs of the *Ghuka* breach.

98. Erosion having set in above the *Murád* and *Jahánwála* heads of the *Mánka* Canal, protective spurs were put in hand in the cold season of 1877-78, and their maintenance continued in April and May, but the works were not successful, and were carried away in June. In August the *Mánka* regulator was carried away, and in September the *Kharakwála* chauki. Nearly 1600 acres of land were thus lost; the greatest length on a measured line being 6150 feet; the mean on 19 lines (one thousand feet apart) 3860 feet. Work was resumed on the subsidence of the river in October, and nine short tree-spurs run out. These have arrested the erosion and caused a very large deposit of silt above them, and now at the end of May are still doing well.

River Protective  
works.

99. The plantations were maintained during the year, but the losses from severe frost and inundation have been great.

Plantations.

#### LOWER SUTLEJ AND CHENAB DIVISION INUNDATION CANALS.

100. The chauki at *Shujabad* was completed, and that at *Lodhrán* very nearly so. All the other buildings were kept in repair.

Buildings.

101. The Chenab embankment was repaired, and sustained but little damage from the heavy floods of the year.

Chenab Embankment.

102. The plantations were kept up throughout the year.

Plantations.

103. The improvements of the main channels forming portion of the *Shekhwah*, *Baháwalwah*, *Mubárawah* and *Khánwah* were completed in time to allow of the canals being opened. The banks have still to be cut down, but there will be a considerable saving on the estimate. New heads were dug for the *Sikandarábád* and *Jámwah Khurd* Canals. The latter was not quite completed during the official year.

Improvements of  
Channels—  
Sutlej Series.

104. The excavation and the construction of the bridges on the *Khairpur* cut was completed during the year, but the compensation for land taken up remains unpaid.

Khairpur cut.

105. Considerable progress was made during the year in making up the canal maps, and the work was done at a cheaper rate.

Making up Canal  
Maps.

## INDUS INDN. CANALS.

Maintenance and  
Repairs from "Zar-  
nágha."

106. The *chers* or laborers supplied by the cultivators were paid on several canals for working beyond the prescribed time of 90 days.

Silt-clearances.

107. The *cher* labor was supplemented by paid work on the *Gajjuhatta* and *Dhundi* Canals of the Chenab series; and on the *Jámwah*, both *Khurd* and *Kalín*, the *Muhammadwah* and *Khánwah*.

New Head—  
Díwánwah Mailsi.

108. The *Díwánwah*, owing to changes in the course of the *Sutlej*, required a new head,—about three-quarters of the work, and a length of about 8000 feet, was completed by paid labor during the year, leaving about 3000 feet to be finished in April.

The Muhammad and  
Sirdárwah.

109. The *chers* did not work on the *Muhammadwah* as satisfactorily as was desired. The *Sirdárwah*, the most important canal in the *Lodhrán* Tahsíl, has been looked on for some years as in a bad state, and arrangements were made which it was hoped would secure much larger parties of *chers*, who were to have been aided considerably by paid labor, but the men would not turn out on either work, though the Executive Engineer, Mr. O'Brien, himself took charge of the work; the progress has been disappointing, and it is to be feared that the fines on this canal will be unusually high.

## SIRHIND CANAL.

SIRHIND CANAL.

MAIN LINE DIVISION, SIRHIND CANAL.

Weir at Rúpar.

110. The state of the weir at the beginning of the official year 1878-79 was as follows:—

Measuring from the left flank 238 lineal feet had been completed to within 5 feet of full height, and 462 lineal feet had been carried 3 feet higher than the first section. The foundations for a further length of 600 feet had been excavated, and the masonry work of the core walls commenced. Between the commencement of the official year and before the setting in of the rains of 1878, the section of 600 lineal feet above mentioned had been completed to the level of the adjacent section. Since the rains a further length of 200 lineal feet has been added on the right flank, and measuring from the left flank a length of 310 feet of weir has been constructed to an average height of 3.5 feet below the level of finished crest. Of the entire length of the weir which measures 2400 feet, 1810 feet had been built to an average level of 3 feet below crest by the end of the official year 1878-79. The bed of the river for the remaining length of 590 feet had been carefully strengthened and brought to an even surface by

depositing rubble stone and shingle from barges, and as the river will have been diverted through the undersluices before the setting in of the monsoon, no serious erosion of the bed in the gap is apprehended. Attention has also been paid to the removal of the large masses of spoil on the island through which the right half of the weir has been constructed. Part of this spoil has been utilised in filling up the bed of the right branch of the river which used to flow immediately below the right flank revetment, and the weir has been raised at that point to the level of 3 feet below crest, so as to assist in diverting the flood-water through gaps which have been purposely left in the remaining spoil, and it is expected that if the floods are numerous, and of average height, a great part of the spoil will be removed by the action of the water. The arches of the weir sluices have been turned. Half the apron below the weir sluices remains to be constructed, as also the pitching above the weir. The stones used for this work average 4 tons each.

111. Since the submission of last year's report, the arching of the regulator bridge has been finished, and the entire work completed to the top of the wheel-guards.

Regulator at Rápar.

112. Consequent on the commencement of this work a great deal of earth-work has been executed in widening out the channel. A siding from the railway has been put down, the excavation of foundations has been completed, and the masonry foundations built in.

Rápar Bridge.

113. The excavation for this work was commenced in May 1878, and a well was sunk for unwatering the foundations. In September one of the down-stream water-wings was begun, but a heavy spring breaking out near the pumping well, the site of the work was moved 50 feet up-stream. The concrete in foundations was commenced in December 1878, but progress has been at times retarded owing to the caution which has to be exercised in excavating the foundations. The original disposition of the tramways for the delivery of materials on the work having proved faulty, the lines have been altered to suit requirements. In the year under review the whole of the down-stream and part of the up-stream curtain were finished, and 250 lineal feet of the lower portion of the foundations were put in. Materials are received at site in ample quantities. Three large continuous lime-kilns were finished in November 1878, several small lime-kilns have been built, and arrangements have been made for erecting workshops for petty repairs to the Tools and Plant employed on the work.

Budki Superpassage.

114. An attempt was originally made to unwater the foundations of this site by excavating a trench on all four

Siswán Superpassage.

sides to below the foundation level, and by erecting two pumps on the right and left up-stream sides to convey the water out of the trench. The excavation of a part of the site was carried down to 4 feet above bed, when the sub-springs burst through the excavation, throwing up large quantities of blue silt and covering the entire site with a considerable depth of water. This method of unwatering the site was now definitely abandoned, and it was determined to allow the sub-springs a free discharge through caissons upon which the curtain walls and water-wings could be founded, the lines of caissons being connected by tapping wells placed behind the abutments of the superpassage and undersunk into the sub-springs. As the springs when uncontrolled rise to 14 feet above the level of the canal bed, experiments were first made to find out to what level the springs could be reduced without throwing up silt, and it was found that at a level of five feet above bed the water discharged was practically clear, and the water on the site was kept to this level by pumping whilst the caissons and round tapping wells were being undersunk. The caissons are made of sheet-iron, and are strengthened with angle irons; whilst undersinking is in progress they are further stiffened by a braced wooden frame, which is removed when the undersinking is completed. The caissons measure  $9' \times 4'$ ; 63 of them have been sunk. The tapping wells are five feet in diameter; they are made of deodár staves, and are hooped with iron; 11 of them had been sunk. It has been found by experiments on several isolated springs that if the silt is dredged out and replaced by a certain depth of coarse grained sand, the coarse sand acts as a filter, and the discharge from the spring is quite clear. The wells and caissons, when fully sunk and dredged out, will be treated in this way, and it is expected that the required lowering of the spring level to six feet below canal bed will be attained by the continuous action of powerful steam-pumps. Materials of all kinds have been collected, and arrangements are well advanced for a continuous supply of everything necessary for the vigorous prosecution of the work as soon as the water has been sufficiently lowered. A steam-pump has been erected at the site of the *Kamálpur* inlet, which is situated about half a mile above the superpassage, and it is expected that its action in drying the canal bed will sensibly affect the work to be done at the superpassage site.

115. The excavation of the foundations of this work was commenced in September 1878. The site had been chosen with great care, but it was known to be a very wet one. The foundation level of the masonry was  $14.75'$  below canal bed, and the excavation was carried out in sections, in order to



minimise the danger of an irruption of the sub-springs. The excavation of one of the sections was carried down to 12·5' below bed when a heavy irruption of the springs occurred, and the site was flooded with water and blue silt. After inspection of the site by the Chief Engineer, it was determined to change the site and to modify the design. With this object the width and height of the openings were decreased, and their number increased, so that the syphon could be founded at 10·4' below canal bed. The site was moved 89 feet down-stream, and work was again begun. A large quantity of spoil which had been thrown on the new site was utilized in refilling that which had been abandoned, and, as in the former case, the excavation was taken out in sections. The centre section was excavated to nine feet below bed, when signs of heavy springs were observed, but the extra thickness of the overlying clay stratum gained by the change in design prevented the bed breaking up, and the springs threw up only water which was run off by surface drains to a sumph from which it was pumped out, and the foundations were thus excavated to their full depth. Curved drains of dry brick were then constructed, into which a system of iron pipes delivered the water from the springs. Over these the whole of the concrete in foundations was successfully laid and rammed. A spring which broke out near the down-stream right bank water-wing gave some trouble; the wall was eventually built, and by the close of the year under review the masonry in superstructure was commenced. It is expected that the *Dohar* syphon will be completed in October 1879.

116. These works have been almost completed during the official year 1878-79. In the regulator, part of the concrete bed of the flooring has been completed, and the whole of the superstructure built; the iron girders to carry the traveller for the regulator gates have been built in, and some work in the approaches is all that remains to be done. In the escape head all the work from five feet above bed has been completed during the year. The parapet walls and some pitching below the escape head remain to be done.

Chankar Regulator  
and Escape Head.

117. This work was commenced in January 1879. It was much delayed by the influx of surface springs, and in order to build the cistern, it was necessary to use piles and boarding for excluding the water. The bridge abutments have been founded on piles, and it is hoped that the work will be completed before the rains of 1879.

Katlaur Inlet.

118. This work was begun and completed during the year under review.

Kubeh Inlet.

119. This inlet has been almost entirely constructed during the year.

Bampur Inlet.

SIRHIND CANAL.  
Doráha Regulator.

120. The work remaining to be done on 1st April 1878 has been completed. A large quantity of earth-work in the approaches has been executed, and the canal has been widened out.

Excavation of Channel.

121. During the year 13,735,182 cubic feet of earth-work in the canal channel have been excavated, of which 9,217,867 cubic feet have been taken out in the second and third miles. No earth-work has been carried on in the 1st mile, which, with the exception of the last 900 feet, had already been excavated to bed level. In the 2nd mile the canal has been excavated to seven feet above bed; the work in this and the 3rd mile has been much delayed by the breaking down of one of the direct acting pumps, by the great amount of sickness prevalent among the prisoners, and by the want of sufficient wagons, and for the latter reason, the second locomotive incline could not be continuously used. No. 1 locomotive incline has been regraded, and it is expected that the wear and tear of the rolling-stock will be sensibly diminished. The number of prisoners employed in the excavation of the channel has greatly decreased, not only on account of the sickness which has prevailed, but likewise by the necessity which existed for employing a great number at the head-works for the diversion of the river. Several new earth wagons have been made; the pumping arrangements have received careful attention; and good progress will be made during the next official year.

Siswán Outfall Channel.

122. The alignment of this channel was effected during the early part of the cold weather. The land was given over in January, and by the close of the official year 8,179,442 cubic feet earth-work had been excavated.

Miscellaneous.

123. The necessary repairs to permanent and temporary buildings, to the channel slopes and to diversion cuts have been carried out. The drainage of *Rámpur* has been completed, the drains being now connected with the *Rámpur* inlet, and discharging their flood water into the canal.

Discharges.

124. The usual observations have been made on the flood and cold weather discharges of the Sutlej at *Rápar*, and the courses of the river and of the various torrents crossing the canal have been surveyed.

Date.	Place.	Discharge.
19th Augt. 1878	Rápar	133,000 c. ft. per sec.
19th Decr. 1878	"	4,246 "
22nd Jany. 1879	"	4,208 "
15th Feby. 1879	"	4,495 "
21st Apl. 1879	"	6,668 "

125. The table appended to the report shows the progress made during the year in the collection and manufacture of materials, &c.

Collection of materials.

#### RAILWAY AND WORKSHOPS DIVISION.

126. The following report by Mr. T. Higham, Executive Engineer, on the work performed by the Railway and Workshops Division, is inserted as received from that officer :—

127. The operations and progress of the year may be most conveniently considered under the following heads :—

Heads of report.

- Railway.
- Workshops and New Plant.
- Maintenance and Repairs.
- Railway Traffic.
- Manufacture Operations.

#### *Railway.*

128. The principal works in progress in connection with the Railway were the protections of some of the nallah crossings, and the construction of additional sidings at sites of works and of drainage culvert on *Nálagarh* Line. The rails across the *Sirsa* nallah were anchored down to large blocks of stone from the quarries before the commencement of the rains with perfectly satisfactory results, as the line stood well through all floods. The *Sugh* nallah crossing was made equally secure by piles driven into the bed up-stream of the line, which was tied to them by wrought-iron link-rods, and no difficulty was experienced in maintaining traffic across this nallah throughout the rainy season. Later on the *Budki* nallah was treated in a similar way ; the piles were nearly all driven before the end of the year, and the line will be connected with them before the monsoons of 1879 set in.

Railway Nallah Crossings.

129. Additional work sidings were put down at the *Nálagarh* quarries, at the *Budki* superpassage, *Dohar* syphon, *Rápar* bridge and *Kubeh* inlet. The last of these has been since taken up on completion of the work. A temporary line of about 2500 feet long was also made for delivery of stone for the bars across the *Siswán* outfall channel, but has also since been taken up.

New Sidings.

130. On the *Nálagarh* Line seven new culverts have been built during the year for passing the drainage, and one more only remains to be built. A careful survey was also made of the land occupied by the Railway in the *Nálagarh* State with the view of showing the extent of the erosions caused by the former interception of drainages which the above works are intended to remedy.

Culverts on *Nálagarh* Line.

## SIRHIND CANAL.

*Workshops and New Plant.*Workshop Build-  
ings.

131. The new smith's shop was practically completed during the year, and fitted up with new forges. The increased accommodation has been no more than is required, and the whole of the forges are, as a rule, kept regularly at work. Towards the close of the year the prospect of increase of work in the foundry led to the commencement of a second and larger cupola, and of other improvements in this shop, the cost of which will be met from the profits that have been actually realized on manufacture.

Increase to Rolling-  
Stock.

132. The Railway plant has been increased by the purchase of 25 new 6-ton wagons, which were supplied by the Bombay Saw-Mill Company. This increase was found to be absolutely necessary to meet running requirements. Thirteen tons of State Railway fish-plates and bolts were also purchased, as there were not sufficient in store to utilize to the full the length of rail available.

Increase to Work-  
shops Plant.

133. The following additions have been made to the Workshops plant :—

- One 12" lathe from Mádhopur Workshops.
- One small lathe ditto.
- One drill ditto.
- One plate-bending machine ditto.
- One set of tin worker's machine ditto.
- One Root blower from Roorkee.
- A second head to 10" lathe from Roorkee.

As the engine now used for working the machinery is not up to the work, an estimate was sanctioned for a new 18 horse-power engine with boiler, &c. The engine was designed by Mr. Hughes, and adapted to a spare locomotive cylinder, and has been under construction in the shops during the latter portion of the year, and a new boiler has been procured from Bombay.

*Maintenance and Repairs.*

## Permanent-way.

134. The usual maintenance gangs were kept up on the permanent-way, but the expenditure in keeping open the road was unusually heavy, owing to the amount of running that was done during the rains; 7000 sleepers were renewed during the year, against 11,500 in the previous year, and as the road was in very good order at the end of the year, this decrease is satisfactory.

Repairs to Locomo-  
tives, Rolling-Stock  
and Plant.

135. The expenditure on Locomotive repairs was very heavy during the year, and amounted to Rs. 21,195. This included special repairs to two Locomotives,—“Thunderer” and “Vulcan,”—besides the ordinary annual and running



## SIRHIND CANAL.

Repairs to Locomotives, Rolling-Stock and Plant.

repairs. As running was very constant, repairs were often carried out during the night, which tended to enhance their cost considerably. The expenditure on repairing wagons amounted to Rs. 12,457, as against Rs. 12,590 during the previous year, but this was exclusive of the cost of renewing six wagons destroyed in an accident on the Nálagarh Line, upon which Rs. 1,000 was spent during the year. The usual repairs of Railway and Workshop Tools were also carried out at a cost of Rs. 3,000, and call for no special remark. The repairs to Workshop buildings amounted only to Rs. 139.

*Railway Traffic.*

136. The following is a comparative statement of the traffic for the last three years :—

Traffic of the year.

Class of Traffic.	1876-77.	1877-78.	1878-79.
	<i>Wagons.</i>	<i>Wagons.</i>	<i>Wagons.</i>
Nálagarh stone.....	9,646	10,298	14,794
Patarheri kunkur.....	4,166	2,073	1,900
Miscellaneous .....	3,071	2,817	6,590
Total.....	16,883	15,188	23,284

From this it will be seen that the number of wagons run out has increased by about 50 per cent. during the last year—a result which, while in itself satisfactory, will fully explain the heavy expenditure on repairs and maintenance, and will sufficiently indicate how the shops have been worked to the utmost extent of their capacity and resources.

137. In addition to the traffic noted above, locomotives have worked on one or both of the earth-work inclines at different periods of the year. Forty-five lakhs cubic feet earth-work were run out to spoil from the 1st and 2nd miles, but working was stopped between the months of July and February to permit of the road being lowered to the bottom lift and regraded, and on account of unwatering difficulties.

Earth-work on Locomotive Inclines.

*Manufacture Operations.*

138. The out-turn from the cast-iron foundry was again nearly double that of the preceding year, as shown by following statement :—

Cast-iron Manufacture.

Out-turn in 1876-77	...	...	1,818 mds.
„ 1877-78	...	...	3,460 „
„ 1878-79	...	...	6,868 „

## SIRHIND CANAL.

## Cast-iron Manufacture.

The quality of the castings has steadily improved, and the manufacture is carried on at a profit with an all-round rate of Rs. 7 a maund. The principal castings have been wagon-wheels for the earth-work inclines (for the renewal of which a foundry at hand is a necessity), and the heavy double grooves for the under-slucies. It has lately been decided to cast at Rúpár all the iron-work required for the locks on Western Jumna Canal, so that a further increase in the out-turn may be expected, and towards the close of the year arrangements were made for an extension of operations; the construction of a new cupola and travelling crane was commenced, the cost being borne entirely by the manufacture.

## Brass Castings.

139. The out-turn from the brass foundry amounted to 143 maunds, and consisted principally of wagon and engine brasses.

## Minor Manufacture Accounts.

140. The out-turn in the following minor manufacture operations may be noted :—

Making phowrahs ...	...	...	237 mds.
Sawing timber ...	...	...	2,585 c. ft. sawn timber.
Belting ...	...	...	12½ mds.

## Other Workshop operations.

141. In addition to the above stock manufactures, and work on repairs and renewal of rolling-stock, the plate iron caissons required for the *Siswán* superpassage were made in the shops. The whole of the 75 caissons required, aggregating about 3582 maunds in weight, were out-turned in about three months, at an all-round rate of Rs. 9-8 per maund. The Workshop operations further included the necessary repairs of all the portable engines and pumps in the Main Line Division, and a great deal of other miscellaneous works incidental to the considerable progress on works that was accomplished in that Division.

## 3RD DIVISION SIRHIND CANAL.

## Channel Excavation.

142. On the *Abohar Branch* the channel at the junction of the *Sutlej* navigation channel has been excavated and dressed since the submission of last year's report. The rest of the channel of the *Abohar Branch*, in this Division, had previously been completed. The grassing of the slopes between the 18th and 50th miles has been attempted during the year under review, but owing to the dryness of the season the result was not good. In the *Bhatinda Branch*, the first 14 miles have been excavated and dressed, but 12 of these miles were reported as nearly finished in last annual report.

## SIRHIND CANAL.

MASONRY WORKS.  
Regulators.

143. The regulators at Head of Abohar and Bhatinda Branches have been completed, with the exception of the breast walls and notches for the overfalls, which are now in hand, and the masonry for securing the anchorage of the gates of the Abohar Branch lock chamber. The roadways over the bridges have been metalled, the approaches are dressed, and the bridges will shortly be opened for traffic.

144. The bridges in miles 5, 10, 14, 21, 26, 32, 36 and 43 of the Abohar Branch are completed, and open for traffic. Of the bridges on the Bhatinda Branch that at mile 7 has been arched, and the foundations of the bridges in miles 12 and 18 have been built. Bridges.

145. The locks in miles 5, 10, 14, 21, 26, 32, 36 and 43 of the Abohar Branch were reported as almost completed in last report: their completion is in abeyance until stone can be procured for the gate quoins, and the iron-work for the quoins has been delivered. The lock in the 49th mile, Abohar Branch, at the head of the Sutlej navigation channel, was commenced in November last. The foundations, except those for the abutment wings of the bridge, have been completed. The flooring of the lock chamber and the walls of the sluice culverts are well in hand. The bricks required for this work have all been made and carried to site, and charcoal and kunkur are being delivered as required. Locks.

146. The falls in miles 5, 10, 14, 21, 26, 32, 36 and 43 of the Abohar Branch were reported as nearly completed in last report. The breast walls and notches will be completed on the designs and dimensions which have been approved by the Chief Engineer as soon as stone can be procured for the work. On the Bhatinda Branch the fall in mile 7 was commenced in October last, and is approaching completion. That in mile 12 was begun at the same time as the above; the masonry is now built up to the level of upper canal-bed, the cistern, drop-wall and down-stream curtain and wing-walls being completed; the progress of this work received a check from want of bricks caused by the difficulty of procuring fuel in sufficient quantities. The fall in mile 18 was commenced in December, and by the end of the year under review the foundations had been nearly completed, and the superstructure was well in hand; the basin below the fall had been nearly finished, and the drop and curtain walls built up 3 feet and 7 feet respectively above foundation level. Falls.

147. The 1st class chauki at 51st mile, Abohar Branch, has been completed and furnished. The chaukis at miles 1, 8, 21, 32 and 43 have previously been reported complete. Of Permanent Buildings.

## SIRHIND CANAL.

**Permanent Buildings.** the chaukis on the *Bhatinda Branch* those at miles 12, 22 and 32 have been practically completed during the year under review.

**Brick Manufacture.** 148. This is being carried on only in the *Bhatinda Branch*, where much difficulty has been experienced in procuring wood-fuel. One of Bull's kiln has been abandoned on this account. Contractors refuse to burn bricks on this Branch, and it will probably be necessary to resort to upla clamps. Seventeen lakhs of bricks were out-turned during the year.

**Plantations.** 149. This work has been limited to sowing spoil-banks broad-cast with Sissu and Kikar seed, and to tending and planting out trees on the approaches to bridges and in chauki compounds. The area of spoil-banks sown during the year amounted to 102 acres.

**Collection of Materials, &c.** 150. The progress under this head is shown in the tabulated form attached to the report.

**Surveying operations.** 151. A large establishment was employed in the cold weather on contour surveys for the extension of the *Bhatinda Branch*, which has now been aligned as far as the 51st mile, and also in fixing the alignment of the distributaries on the *Abohar Branch*. The contour levels for these distributaries have been plotted, and a comprehensive project for their final alignment is now being elaborated.

## 4TH DIVISION SIRHIND CANAL.

*Sutlej Navigation Channel.*

**Channel Excavation.** 152. Since the submission of last report 358 lakhs of earth-work in the *Sutlej Navigation Channel* have been excavated. The total quantity done up to date is 732 lakhs, and only 79 lakhs remain to be done; this consists of temporary crossings which have been left unexcavated at the sites of existing village roads, and of spaces left at sites of masonry works.

**Boundary Roads.** 153. The boundary roads on each side of the canal have been completed throughout the whole length of the *Sutlej Navigation Channel*, viz., 47 miles, 1500 feet.

**Bridges.** 154. The bridge at the crossing of the *Ludhiana and Ferozepore Grand Trunk Road* was commenced in January, and by the end of the official year had been built up to the level of springing of the arch. The bridge to carry the *Zira road* at the 40th mile of the *Sutlej Navigation Channel* was begun in December and completed in March.



155. All the locks on the Sutlej Navigation Channel are still in abeyance.

Locks.

156. The fall at 19th mile, 3000 feet, was commenced during March, the excavation of foundations was completed, and the concrete foundations begun. The fall at 31st mile, 2500 feet, was also started at the end of the year; the foundations have been excavated, and lime-burning and soorkhec-pounding are proceeding.

Falls.

157. The 2nd class chauki at 47th mile was commenced and almost finished during the year. The chaukis at miles 10, 22, 34 and 40 were previously reported as completed.

Permanent Buildings.

#### *Abohar Branch.*

158. An Assistant Engineer with a competent staff of subordinates was engaged during the cold weather in the final alignment of the *Abohar Branch* beyond the 50th mile. Surveys have been made as far as the 106th mile, and the canal has been finally aligned as far as mile 76. A survey, one mile wide, of the whole length of the *Abohar Branch* in this Division, has been made and plotted to a scale of 4 inches to 1 mile. Small quantities of bricks have been burnt at various places along this branch, that there may be no delay in constructing the permanent buildings as soon as the land has been acquired.

Survey operations.

159. This is shown in the statement appended to the report.

Collection of Materials.

#### 5TH DIVISION SIRHIND CANAL.

160. During the year 450 lakhs of earth-work were executed, of which  $15\frac{1}{2}$  lakhs belong to the Feeder Lines, and the remainder to the Kotla Branch. The Feeder Lines are completed with the exception of two spaces left for the Lissára and Sirhind nallah syphons. The first 29 miles of the Kotla Branch are also ready, except spaces left for six bridges and falls and for temporary road crossings.

Channel Excavation.

#### FEEDER LINES.

161. During the year the Bhoray and Khok bridges were commenced; the former was completed, and the latter built up to level of skew-backs. The bridges at *Rámnagar*, *Dhamont*, *Jargari* and *Bhagwánpur* were also completed during the year. The Sirhind nallah syphon was commenced in May, and the work has proceeded without interruption almost to completion. All the large arches are finished, as are also several of the roadway arches; the superstructure also is well

Masonry Works.

## SIRHIND CANAL.

## Masonry Works.

advanced. The excavation of the drainage diversion in connection with this work has been vigorously pushed on. The Lissára syphon is the only considerable work remaining on the Feeder Lines in this Division, and a design and estimate for it are nearly ready for sanction.

## Permanent Buildings.

162. The buildings on the Feeder Lines have already been reported as complete. On the Kotla Branch the 2nd class chauki at *Mohorána* was completed, and that at *Babbanpur* commenced during the year. The latter has been built up to cornice level, and the out-houses have been roofed.

## Collection of Materials.

163. The actual progress is shown on the statement appended to the report. In this, as well as in the 3rd Division, the greatest difficulty has been experienced in procuring fuel; the country is fairly wooded, but the villagers will not sell their wood without pressure.

## 6TH DIVISION SIRHIND CANAL.

## Earth-work.

164. The quantity of earth-work executed during the year on the *Gaggar Branch* amounted to 17,890,197 cubic feet. The excavation of the whole of the *Gaggar Branch*, with the exception of bunds and temporary road crossings, is now completed. On the *Choa Branch* 505,251 cubic feet earth-work were done. The whole of the first 20 miles of this branch is now completed, with the exception of the removal of road crossings. The earth-work executed on the *Patidla Escape Channel* during the year was 1,561,254 cubic feet, and the work is now nearly completed.

## Masonry Works.

165. The state of the masonry works at the end of the year was as follows :—

## GAGGAR BRANCH.

*Regulator at Head*.—Practically completed.

*Fall at 4th mile, 3000 feet*.—Completed in December 1877.

*Do. 11th mile*.—Completed in 1877-78.

*Do. 23rd mile, 2000 feet*.—Completed in 1877-78.

*Do. 27th mile*.—Completed during the year.

*Do. 34th mile*.— Ditto in 1877-78.

*Do. 49th mile, 3000 feet*.—Completed during the year.

*Bridge at 16th mile*.—Completed in 1877-78.

*Do. 19th mile*.— Ditto ditto.

*Do. 30th mile*.— Ditto ditto.

*Do. 38th mile*.— Ditto ditto.

*Do. 44th mile*.— Ditto ditto.

## CHOA BRANCH.

*Regulator at Head.*—Completed in 1877-78.

*Fall at 4th mile.*—Completed in 1877-78.

*Do. 9th mile.*— Ditto during the year.

*Do. 16th mile.*— Ditto in 1877-78.

## PATIALA NAVIGATION CHANNEL.

166. The works on this branch have all been previously reported as complete. Patiala Navigation Channel.

167. The usual annual repairs to buildings have been carried out. Buildings.

168. The avenue trees on the 2nd and 3rd Feeders and Patiala Navigation Channel for a length of 15½ miles, which had been planted out from nurseries, were maintained during the year, and 85 miles of the spoil-banks of the several branches of the canal were sown with Kikar seed. Plantations.

169. Surveys and levels for trial lines of the rájbahás on the Gaggar and Choa Branches were carried on during the cold weather. The length of country levelled and surveyed was 746 miles. Distributaries.

170. This is shown in the statement appended to the report. Collection of Materials.

171. Twenty square miles of country were surveyed, and a line levelled for the extension of the Choa Branch to its escape into the Gaggar nallah. Surveys.

## CONTRIBUTION WORKS.

172. The excavation of the *Bárdari Rájba Channel* was commenced and finished during the year, the amount of earth-work being 3,436,716 cubic feet. The work of *filling in the Patiala city ditch*, amounting to 3,720,154 cubic feet, was completed during the year. Earth-work.

173. A bridge of 30 feet span at 17th mile, 1800 feet, of Choa Branch, was commenced and finished during the year at the expense of the Patiala State. Thirteen small bridges of 8 feet span over the *Bárdari Rájba* were begun and finished during the year. A *culvert* near the *Shehranwála gate*, in connection with the City Improvement Works, was commenced and finished during the year. Masonry Works.

174. 15,185 cubic feet of fencing were erected along both sides of the new bund road and outside the Syfabádi, Sanáwri, and Kalauri gates. Fencing.

SIRHIND CANAL,  
Roads.

175. The Patiála and Nábha metalled road, 16 miles in length, was maintained during the year.

*Statement showing the quantities of Materials collected in the several Divisions of the Sirhind Canal Circle during the year 1878-79.*

MATERIALS.	Main Line Division.	3rd Division.	4th Division.	5th Division.	6th Division.
Bricks ... ..	2,268,632	1,700,000	6,387,774	3,102,070	1,880,632
Soorkhee ... .. C. ft.	314,675	...	...	...	...
Lime ... .. "	111,578	92,306	...	...	...
Nálagarh stone ... "	1,153,488	...	...	...	...
Boulders ... ..	...	...	...	...	...
Rora ... ..	...	...	...	...	...
Concrete metal ... C. ft.	137,916	...	43,393	213,000	...
Wood ... .. "	400,451	...	...	56,348	...
Block kunkur ... .. "	100,000	...	...	...	...
Kunkur ... .. "	112,190	148,203	116,000	119,649	957
Charcoal ... ..	...	...	Mds. 1,797	C. ft. 12,210	...
Spawls ... .. C. ft.	220,900	...	...	...	...
Upla ... ..	...	...	...	...	...
Kúra ... ..	...	...	...	...	...

NOTE.—At Nálagarh the proportion of stone quarried to earth and spoil removed is still small; this is caused by the necessity of opening out a greater length of face. A new quarry has been opened on the south side of the hill.

A Bull's trench kiln has been made at Rámpur, which, with the other Bull's kiln previously built, amply suffices to supply the wants of the whole Division. The rate for 1st and 2nd class bricks is Re 12, and a credit of Re 5,000 to the manufacture account has accrued.

Wood-fuel is rising in price.

SUPPLEMENT.

SUPPLEMENT.

MUZAFFARGARH CANALS.

Muzaffargarh Canals.

176. These canals are not under the Irrigation Department, but an Executive Engineer (Mr. Sibold) was employed during part of the year in assisting the Deputy Commissioner of the District in the management of them. He was paid from the Fine Fund (Zarnágha). His duty was to give such professional advice as might be wanted, and to make himself thoroughly acquainted with the canals, the people and the system.

Muzaffargarh Embankment.

177. The Muzaffargarh embankment constructed in 1874 resisted the high and prolonged floods of July and August most successfully, and was of the greatest service to the district. Though the flood waters rose on the right bank of the Indus a foot higher than on the 10th of August 1874, yet on the left bank they were a foot lower.

Chenab and Indus Canals.

178. Of the Chenab series of canals, the Ganaish and Talairi Canals were put in thorough order; their clearances were supervised; the beds were brought to an uniform slope;



bench-marks and pegs put in, and the widths brought to uniformity. Of the Indus series of canals, the same was done for the following : Gharku, Mogassan, Chuán and Sirdár Canals. The work on the Mogassan, however, was confined to the three first miles, as the irrigators for long refused to furnish the necessary working parties, and even when they did, the number was inadequate to the task of putting the whole canal into decent order. As this canal supplies some 15 large and important branches, it is most desirable that it should be put in better order. Its irrigation amounts to more than 30,000 acres—an area which could be almost indefinitely extended if its waters were led further into the desert.

J. W. OTTLEY, CAPTAIN, R. E.,  
*Offg. Asst. Secy. to Govt. Punjab, P. W. D.,*  
*Irrigation Branch.*



## PUNJAB PROVINCE.

## PART I.

## APPROPRIATION ACCOUNT OF IRRIGATION WORKS FOR THE YEAR 1878-79.

*Extraordinary and Ordinary.*

SERVICE HEADS.	Grant as per Budget Orders.	Final Grant at end of year.	Outlay.
<b>CAPITAL.</b>			
<b>EXTRAORDINARY.</b>			
	Rs.	Rs.	Rs.
Works ... ..	19,83,800	21,78,882	21,46,184
Establishment ... ..	5,70,230	5,09,350	4,99,100
Plant ... ..	99,636	95,869	1,59,744
Suspense Balance ... ..	1,01,000	- 29,435	- 1,05,428
Total ...	27,54,666	27,54,666	26,99,600
Less—Receipts*on Capital Account ... ..	4,666	4,666	10,052
Net Outlay ...	27,50,000	27,50,000	26,89,548
Less—Expenditure in England ... ..	...	...	...
Net Expenditure in India ...	27,50,000	27,50,000	26,89,548
<b>ORDINARY.</b>			
Works ... ..	54,830	3,130	- 7,466
Establishment ... ..	13,140	2,808	1,859
Plant ... ..	...	...	...
Profit and Loss ... ..	...	...	...
Suspense Balance ... ..	...	...	2,450
Total ...	67,970	5,938	- 3,157
Less—Receipts on Capital Account ... ..	...	8,200	10,568
Net Outlay ...	67,970	- 2,262	- 13,725
Less—Expenditure in England ... ..	...	...	6
Reduction in Grant ... ..	70,232	...	...
Net Expenditure in India ...	- 2,262	- 2,262	- 13,731
TOTAL CAPITAL (IMPERIAL) ...	27,47,738	27,47,738	26,75,817
<b>ORDINARY AGRICULTURAL WORKS.</b>			
Works ... ..	5,000	2,000	1,114
Establishment ... ..	34,250	5,100	4,776
Total ...	39,250	7,100	5,890
Reduction in Grant ...	32,150	...	...
Net Outlay ...	7,100	7,100	5,890
Carried over ...	27,54,838	27,54,838	26,81,707

## PART I.—concluded.

## APPROPRIATION ACCOUNT OF IRRIGATION WORKS FOR THE YEAR 1878-79.

SERVICE HEADS.	Grant as per Budget Orders.	Final Grant at end of year.	Outlay.
	Rs.	Rs.	Rs.
Brought forward ...	27,54,838	27,54,838	26,81,707
<b>REVENUE.</b>			
Extensions and Improvements ... ..	82,740	48,418	57,105
Maintenance and Repairs... ..	5,41,850	6,35,945	5,94,080
Establishment ... ..	7,48,890	7,10,828	7,39,216
Tools and Plant ... ..	14,300	25,450	25,725
Profit and Loss ... ..	...	1,550	311
Refund of Revenue ... ..	...	5,614	5,077
Total ...	13,87,780	14,27,805	14,21,514
Less—Expenditure in England... ..	...	...	...
Additional Grant ... ..	40,025	...	...
Net Expenditure in India ...	14,27,805	14,27,805	14,21,514
<b>TOTAL CAPITAL, REVENUE AND AGRICULTURAL (IMPERIAL)</b>	<b>41,82,643</b>	<b>41,82,643</b>	<b>41,03,221</b>
<b>CONTRIBUTIONS.</b>			
<b>CAPITAL.</b>			
Works ... ..	7,23,800	6,76,600	6,40,105
Establishment ... ..	2,06,540	1,81,812	1,71,426
Plant ... ..	41,994	1,64,300	69,154
Suspense Balance ... ..	80,000	29,622	— 46,192
Total ...	10,52,334	10,52,334	8,34,493
Less—Receipts on Capital Account ... ..	2,334	2,334	5,662
Net Outlay ...	10,50,000	10,50,000	8,28,831
Less—Expenditure in England ... ..	...	...	...
Net Expenditure in India ...	10,50,000	10,50,000	8,28,831
<b>REVENUE.</b>			
Works ... ..	...	59,674	33,681
Maintenance and Repairs... ..	...	36,056	12,793
Establishment ... ..	...	...	395
Tools and Plant ... ..	...	...	24
Total ...	...	95,730	46,893
Additional Grant ... ..	95,730	...	...
Net Expenditure in India ...	95,730	95,730	46,893
<b>TOTAL CONTRIBUTIONS</b>	<b>11,45,730</b>	<b>11,45,730</b>	<b>8,75,724</b>
<b>GRAND TOTAL</b>	<b>53,28,373</b>	<b>53,28,373</b>	<b>49,78,945</b>





PART II.—concluded.

APPROPRIATION ACCOUNT OF IRRIGATION WORKS FOR THE YEAR 1878-79.

Distribution of Extraordinary and Ordinary Outlay.

	New Works.	Maintenance.	Establishment.	Tools and Plant.	Profit and Loss.	Refund of Revenue.	Suspense Balances.	Total.	Less Receipts on Capital Account.	Net Expenditure of the year.	Less Expenditure in England.	Net Outlay in India.	Grant as per Budget Orders.	Final Grant at end of year.
	Rs	Rs	Rs	Rs	Rs	Rs	Rs	Rs	Rs	Rs	Rs	Rs	Rs	Rs
Brought forward ...	21,39,832	...	5,05,735	1,59,744	...	...	-1,02,978	27,02,333	20,620	26,81,713	6	26,81,707	27,54,838	27,54,838
<b>REVENUE.</b>														
Western Jumna Canal ...	12,974	1,33,916	2,62,932	5,263	311	39	...	4,15,435	...	4,15,435	...	4,15,435	4,93,651	4,12,341
Najafgarh Jhil Drainage Works ...	...	182	452	...	...	...	...	634	...	634	...	634	...	300
Bari Doab Canal ...	20,732	2,19,308	2,53,305	15,985	...	5,028	...	5,14,358	...	5,14,358	...	5,14,358	4,57,830	5,24,581
Lower Sutlej and Chenab Division Inundn. Canals	1,593	10,499	59,207	241	...	...	...	71,540	...	71,540	...	71,540	70,600	50,795
Upper Sutlej Inundation Canals ...	483	51,663	42,816	1,281	...	10	...	96,253	...	96,253	...	96,253	98,925	1,00,471
Indus Inundation Canals ...	21,323	1,71,130	1,04,867	1,171	...	...	...	2,98,491	...	2,98,491	...	2,98,491	2,24,060	3,13,297
Shahpur Canals ...	...	7,300	1,091	...	...	...	...	8,391	...	8,391	...	8,391	8,150	8,420
Madhopur Workshops ...	...	82	14,546	1,784	...	...	...	16,412	...	16,412	...	16,412	...	16,222
Reserve ...	...	...	...	...	...	...	...	...	...	...	...	...	34,564	1,468
Additional Grant ...	...	...	...	...	...	...	...	...	...	...	...	...	40,025	...
Less Expenditure in England ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
<b>TOTAL D.</b> ...	<b>57,105</b>	<b>5,94,080</b>	<b>7,39,216</b>	<b>25,725</b>	<b>311</b>	<b>5,077</b>	<b>...</b>	<b>14,21,514</b>	<b>...</b>	<b>14,21,514</b>	<b>...</b>	<b>14,21,514</b>	<b>14,27,805</b>	<b>14,27,805</b>
<b>TOTAL IMPERIAL, A., B., C. AND D.</b> ...	<b>21,96,937</b>	<b>5,94,080</b>	<b>12,44,951</b>	<b>1,85,469</b>	<b>311</b>	<b>5,077</b>	<b>-1,02,978</b>	<b>41,23,847</b>	<b>20,620</b>	<b>41,03,227</b>	<b>6</b>	<b>41,03,221</b>	<b>41,82,643</b>	<b>41,82,643</b>
<b>CONTRIBUTIONS.</b>														
<b>CAPITAL.</b>														
Sirhind Canal ...	6,40,105	...	1,71,426	69,154	...	...	-46,192	8,34,493	5,662	8,28,831	...	8,28,831	10,50,000	10,50,000
<b>REVENUE.</b>														
Lower Sutlej and Chenab Inundation Canals ...	31,600	12,793	...	...	...	...	...	44,393	...	44,393	...	44,393	...	95,730
Indus Inundation Canals ...	2,081	...	395	24	...	...	...	2,500	...	2,500	...	2,500	...	...
Additional Grant ...	...	...	...	...	...	...	...	...	...	...	...	...	95,730	...
	33,681	12,793	395	24	...	...	...	46,893	...	46,893	...	46,893	95,730	95,730
<b>TOTAL CONTRIBUTIONS</b> ...	<b>6,73,786</b>	<b>12,793</b>	<b>1,71,821</b>	<b>69,178</b>	<b>...</b>	<b>...</b>	<b>-46,192</b>	<b>8,81,386</b>	<b>5,662</b>	<b>8,75,724</b>	<b>...</b>	<b>8,75,724</b>	<b>11,45,730</b>	<b>11,45,730</b>
<b>GRAND TOTAL</b> ...	<b>28,70,723</b>	<b>6,06,873</b>	<b>14,16,772</b>	<b>2,54,647</b>	<b>311</b>	<b>5,077</b>	<b>-1,49,170</b>	<b>50,05,233</b>	<b>26,282</b>	<b>49,78,951</b>	<b>6</b>	<b>49,78,945</b>	<b>53,28,373</b>	<b>53,28,373</b>

D. H. TRAIL, MAJOR, R. E.,

Examiner Public Works Accounts, Punjab.





