

# IS IRRIGATION NECESSARY

IN

## UPPER INDIA ?

BY

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## P R E F A C E .

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A VERY great majority of the residents in Upper India, *i. e.*, the North-Western Provinces, the Punjab and Oude, look on Irrigation as absolutely necessary to cultivation in these Provinces, and will doubt the correctness of the theory I here broach. If however, while doubting, they will give the system a fair trial, I feel assured they will find good reason for altering their opinions.

A. F. C.





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# IS IRRIGATION NECESSARY

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## UPPER INDIA?

At a time when extensive irrigational works are being carried out and more proposed, it may not be out of place to consider to what extent such works are required, and what quantity of water is useful, or otherwise, to crops in general.

It may in the first place be as well to consider the general condition of land and the present system of cultivation of both irrigable and unirrigable lands. I shall here, where not otherwise mentioned, refer more particularly to the rubber crops, and take wheat as an example, it being the most valuable of these crops as a food for man.

The soil of cultivated fields has lying immediately below the cultivated surface soil a hard layer or crust; this is not a natural, but an artificial, formation, caused by the treading of men and cattle, and the pressure of the sole of the plough. This is called by farmers in England the *pan*, and is known to the natives by the word "tawa," which is almost identical in meaning. This pan is much denser in stiff than in sandy soils, and in some clays and



stiff loams, is almost impermeable to water: the roots of cereals can hardly force their way into this pan.

As the irrigable land is prepared in this country for sowing by being ploughed and re-ploughed about three or four inches deep, the cereals are limited to a little more than this depth of soil in which to seek moisture and nourishment, and this too in a soil impoverished by yearly cropping. The moisture quickly evaporates from this loosened upper layer of soil above the pan, and irrigation becomes necessary to keep the plants alive.

I believe indiscriminate irrigation to be the bane of Indian farming, for as long as a cultivator can, by scratching the surface soil and swamping it with water, get a crop of four or five-fold the amount of the seed sown, he lets things follow the old course, and does not trouble himself to look about for a better system.

Below this pan the soil is generally more free and open and contains moisture held there by capillary attraction; the amount of water is small, as most of the rain falling on the land or water supplied by irrigation is evaporated from the surface or taken up by the crops before passing through the pan.

All porous soils have a greater or less power of capillary attraction; the smaller the particles composing the soil the less will be the power of capillary attraction possessed by it. Thus clay soils, which can be rubbed into an almost impalpable power, have a much less power of capillary attraction than gritty sandy soils; but whilst clay or loamy soils have a less power of capillary attraction, they have a greater retentive power for moisture, that is, they will retain moisture longer when once it has

penetrated into them, and will not so soon lose it by evaporation or filtration.

We have a familiar example of capillary attraction in a flower-pot. If we fill a flower-pot with dry loose earth and place it in a shallow pan of water, moisture will rise in the flower-pot by capillary attraction to the surface of the soil, although much higher than the water was in the pan. If however, instead of a flower-pot, we use tubes, we can ascertain what height the water will rise in different descriptions of soils.

Rain falling on the surface requires some time to penetrate the hard pan, and should hot sunshiny weather succeed the falls of rain, the greater part of the water is evaporated. In Upper India it requires a heavy fall of rain, or rather a continuance of wet weather, to produce what the natives call the "*Miluan*," or meeting of the surface water with the water held by capillary attraction in the lower strata of the soil, below or in the lower part of the pan.

As I said before, under the present system irrigation is required to keep the plants alive. This irrigation tends to consolidate the soil, the smaller particles being washed into any fissures there may be in the pan, and the surface soil binds together. The roots of plants, however, require air as well as water, but the air can hardly penetrate the now almost hermetically-sealed surface soil. Weeds grow amongst the crop, and in hoeing these out the soil is loosened. Here we see the use of weeds, in the absence of which the surface soil would not be stirred. When the crops are cut, there is a little grass, which is eaten off by cattle, after which the bare fields are left a smooth hardened surface, almost impervious to air and moisture.

The more water has been supplied to the land by irrigation, the more parched the land becomes when the crops are removed and irrigation ceases. Solar heat is reflected from the hardened surface of the soil and heats the air, causing the hot winds; the direct rays of the sun having very little effect in raising the temperature of the air.

It is difficult to say what amount of water is applied to irrigated lands, but where the fields are irrigated from wells I think we may calculate the amount of water to be about two inches for each irrigation, so by doubling the number of times the lands are irrigated we get a fair approximation of the depth in inches of the water supplied to the land. As the land irrigated from wells is generally watered three or four times during the growth of the crop, we may consider it receives a depth of six or eight inches of water.

I believe where canal water is used, very much more water is applied to the land than where water has to be drawn from wells, and if I am correct in my reading of a tabular statement in a late *Government of India Gazette*, the amount of water supplied by the Ganges Canal during the month of February last was equal to a depth of six inches over the whole of the irrigated area.

There is a Report on Tank Irrigation in Aimore and Mhairwarra, by Lieutenant Home, R. E., in No. 4, Vol. I, second series, "Selections from Records of Government, N.W.P.," and a letter from Major Stewart, R.E., forwarding the said Report, in which he says:—"The average required to irrigate one acre is shewn by Lieutenant Home to be 177,261 cubic feet, whereas in our calculations we have allowed 200,000 to 300,000, and generally the



latter." Now 177,261 cubic feet per acre is equal to a depth of 407 feet, and the 300,000 cubic feet is nearly 7 feet, say 80 inches. This seems excessive, as one inch depth of water over an acre of ground is upwards of 100 tons in weight; so every inch of rain that falls, or water that is applied to the land by irrigation, supplies upwards of 100 tons of water to the acre. By weighing the produce of a few square yards of churree (jowar),\* I calculated the weight per acre of the crop, when at its full growth and full of sap, to be about 100 tons. The amount of water in churree cut green for cattle is about 80 per cent of the total weight of the crop; and an inch of water, being say 100 tons, the crop only contains eight-tenths, i. e., four-fifths of an inch of water.

A good crop of wheat with its straw, at the time of its greatest succulence, just before the formation of the blossom, may weigh about ten tons: this may contain about 75 per cent, or three-fourths of one-tenth of an inch of water, or say one-tenth the amount taken up by churree.

In round numbers, we may say a crop of jowar, bajra, or maize retains one inch, and a rubbero crop only one-tenth of an inch of water when at its full growth.

As plants, however, lose a great quantity of water by evaporation from their leaves, the above-mentioned amount of water would be altogether insufficient for their support.

Mr. Lawes found from experiments carried out in England, that common plants (wheat, barley, beans, peas and clover) exhaled during five months of growth more than 200 times their dry weight of water. A crop of wheat of

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\* *Holcus Sorghum*.

19 bushels of 60 lbs., equal to half a ton of grain, is, I believe, greatly above the average of the wheat crops now grown in Upper India. To grow a crop of half ton per acre with its straw,—which may be put down as double the weight of the grain, or 1 ton—total weight of grain and straw,  $1\frac{1}{2}$  tons,—would require 300 tons or 3 inches of water in England; if we allow the amount of water exhaled or evaporated from the crops to be in India double what it is in England, the crops would require to absorb from the soil 600 tons, or 6 inches depth of water. The water evaporated from the crops would not all be lost to the soil, as a great amount of it would be returned in dew and rain. I do not think there would be any difficulty in retaining double this amount of water in the soil, if the pan were broken up and the soil deeply ploughed; and I believe it would be a simple matter with the aid of manure, which can be had in any quantity, to raise the average of wheat crops in Upper India to one ton, or say 37 bushels per acre. The soil and sub-soil in many parts, for instance Rohileund, is a rich alluvial deposit, and only wants thorough cultivation to make it one of the most productive in the world; and the climate during the time the cereals are growing is all that can be desired to bring them to perfection.

A fair index, however, to the amount of water required by the wheat and other rubbee crops is obtained by observation of unirrigated lands, most of which are light sandy soils called "bhoor."

Under the present system of farming in Upper India,



with an average rainy season and cold-weather rains, crops of wheat and barley are obtained from these lands. Being light soils, they are ploughed deeper than irrigated lands, perhaps six inches deep, and the water that remains in the sub-soil, together with the cold-weather rain, is sufficient to raise the crops; and these bhoor lands have some grass on them throughout the hot weather which the irrigated lands have not. I allow the crops on these bhoor lands are light, but this is from a want of manure and a deficiency of water, which can be remedied.

These unirrigated land crops are in a great measure dependent on the cold-weather rains. If we can retain in them the moisture from the regular monsoon rains, we shall be independent of what may fall in the cold weather. I know of no reason sufficiently valid to deter experiments being made at once on these lands on an extensive scale.

The average rain-fall during the rains may be from 20 to 30 inches, and the cold-weather rain from 1 to 3 inches. I believe, with an improved system, one-half, or even less rain, would be ample.

My reason for this belief is, that a greater part of the water which falls on these soils, either runs off the surface, or is lodged on, or in the soil, so near the surface above the pan, that it is lost by evaporation before it can penetrate into the sub-soil.

Now if these light soils, which are much less retentive of moisture than irrigable lands, can retain sufficient moisture to produce a crop, succeeded by some scanty herbage, during the hot weather, what necessity can there be for irrigating soils of a closer texture, which have a greater power of retaining moisture? I maintain that if we prevent the

rain running off the land, and as much as possible prevent evaporation and use manure, the annual rain-fall even in dry seasons will be found sufficient to produce even better grain crops, than are now obtained by irrigation under the present system. Irrigation applies water to the surface; crops do not want water on the land, but in it.

It is a mistake to suppose that a great amount of water is required for either khureef or rubbee crops. We see every year both descriptions of crops damaged if water lies about their stems: the chilling effect of water evaporating about the stems of the crops is always more or less detrimental. Cotton in particular suffers from this. What plants chiefly require is a deep porous and somewhat moist soil, in which their roots can strike downwards to such a depth as to be unaffected by drought and the heat of the sun. The roots of wheat will penetrate four feet, or even more, in a loose open soil, and as long as there is moisture in the soil within the reach of the roots, there is no fear of the plant dying for want of water.

To obtain a deep moist soil, in the first place the land must be ploughed or stirred up deeply, so that the rain will sink into it to a depth from which it will not readily be evaporated.

The rain-water will pass through the loosened soil by gravitation, leaving the soil moist, and as the upper surface soil is dried by evaporation caused by the heat of the sun, the water lost by evaporation will be replaced by water rising in the loosened soil by capillary attraction, exactly as oil rises in the wick of a lamp.

The loss of water by evaporation would tend to dry the soil; but as solar heat would be absorbed by the

loosened soil during the day, and radiated during the night, and the surface consequently cooled by the radiation, we should have a copious dew deposit, from the vapour in the atmosphere caused by evaporation during the day.

The advantage of allowing as much rain-water as possible to penetrate to the sub-soil before it has time to evaporate will be sufficiently evident when I mention that from experiments carried out in the temperate climate of England, during a period of eight years, it was ascertained that of a mean yearly rain-fall of 26.49 inches, the quantity evaporated was 15.20 inches, and only 11.29 inches filtered into the sub-soil. It is shown in the same experiments, that whilst in the month of February, from an average rain-fall of 1.971 inches only 0.424 inch was lost by evaporation, from a mean fall of 9.556 inches in June, July, August and September, the loss by evaporation was 9.080. What then must be the amount of loss by evaporation in India?

What the required depth may be, to which land should be stirred, will vary with the description of the soil: thus close-grained soils, having a greater retentive power for water, will not require to be stirred so deeply as loose sandy soils, which possess that power in a less degree. In sandy soils we must make up for the want of retentive power by deeper stirring.

The proper depths to ensure crops on the different soils can best be found out by direct experiments on the soils. I am, however, inclined to think, from experiments carried out with tubes filled with soil, and an experiment I am going to describe further on, that 15 to 18 inches



would be sufficient for stiff soils of the "doomat" sort, and  $1\frac{1}{2}$  to 2 feet would be a safe depth to plough light sandy bhoor lands. The depths I here state are what I consider extreme depths, which would be sufficient for the very driest seasons. Every few inches deeper we plough unirrigable lands will tell in increased produce from them. Wherever the culturable soil is of two or more feet in depth, I believe there is no necessity for irrigation. Deep ploughing will be sufficient, provided the soil is brought to a fine tilth, i. e., sufficiently broken up and pulverised. Where, however, kunkur, stone or loose sand, which will not retain moisture, lies within less than two feet from the surface, irrigation *may* be necessary, but I am not certain that it is.

The country plough, although abused by many persons, is perfectly efficient as long as shallow ploughing only is wanted.

The whole of the mechanical operations we see brought into play in England in cultivating the soil, such as ploughing, sub-soil ploughing, the use of the cultivator or grubber, the clod-crusher, the harrow and the farrow pressers, are, after all, only to make a suitable seed-bed for whatever we may wish to sow. Where shallow cultivation only is wanted, the land can be very efficiently prepared with a country plough and a "putola," which is merely a log of wood drawn over the surface; and with a tube tied behind it the country plough makes an efficient drill. Still this country plough will not do for deep cultivation, as any pressure on the stilt depresses the heel of the plough and raises the point. English ploughs and sub-soil ploughs are from their price

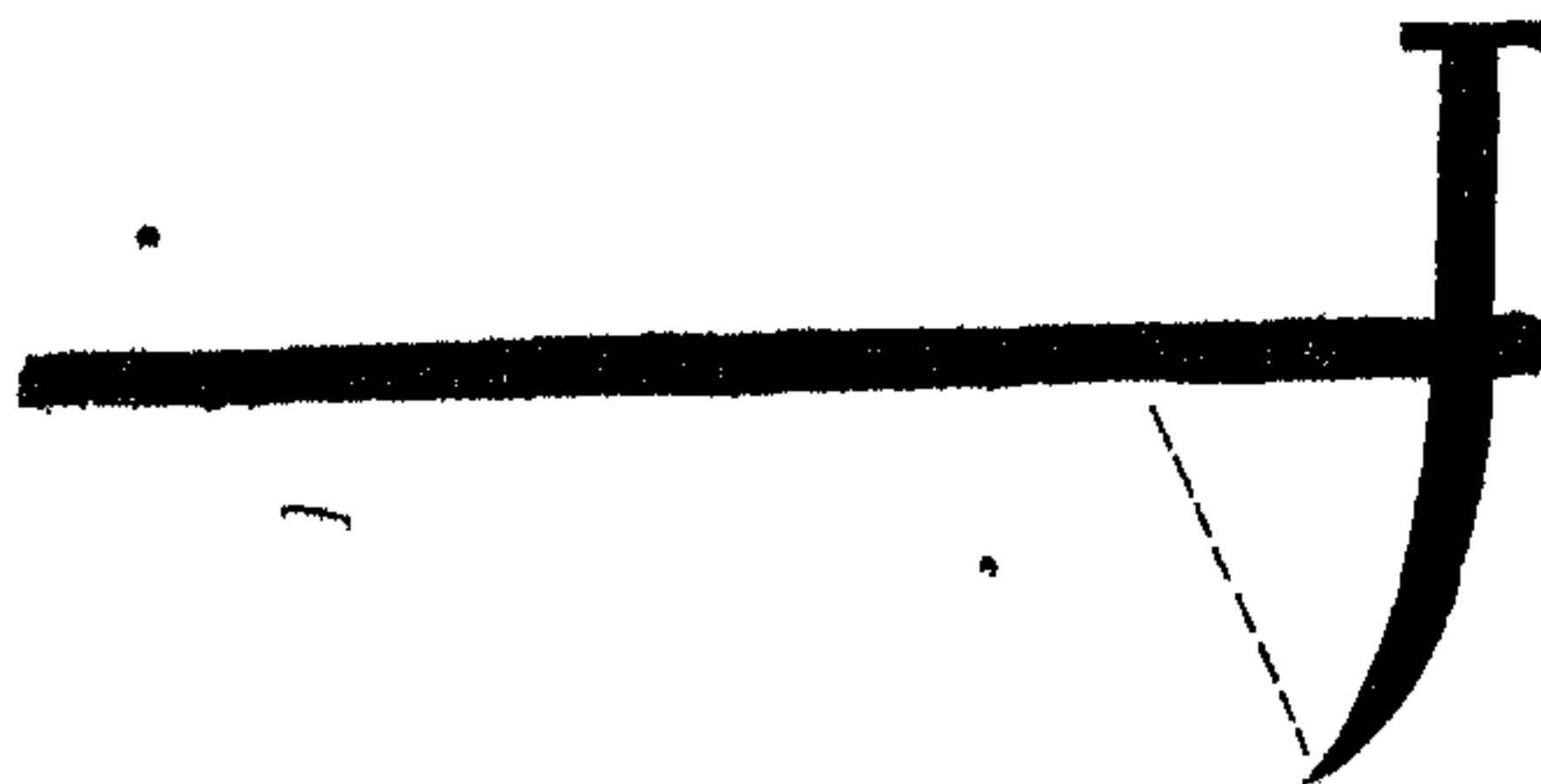
beyond the reach of natives, even if they were inclined to try them. What is wanted is an alteration in the common plough of the country, to enable it to penetrate deeper into the soil, which alteration must be effected so cheaply as to make the improved plough not more expensive than the present one.

I give here a rough sketch of a country plough and a modification I have made of it.

*Fig. 1.*



*Fig. 2.*



The old plough, *Fig. 1*, is made in three principal pieces—the *haras* or draught pole which rests on the yoke, the stilt or handle, and the share in which an iron point is

fixed. The angle at which the share is to the draught pole will not allow of its penetrating deep into the soil; true the share is fitted into a groove in the stilt and fixed there by wedges, by altering which a slight difference in the angle can be made, and a somewhat deeper ploughing effected; still pressure on the stilt depresses the heel and not the point of the plough, which is thus brought to the surface.

My altered plough, No. 2, is made in two pieces, the draught pole and the stilt which is continued, the lower end of it forming the share, which is like, in shape and action, one of the tines of the modern cultivator. Pressure on the stilt forces the point (which is covered with iron) into the ground. This is simpler than the country plough, being in two pieces, and less likely to get out of order, and it is also cheaper. It could be strengthened by having a piece of iron from the point of the share to the pole (where the dotted line is), thus forming a coulter.

The natives have a prejudice against deep ploughing; they say it turns up bad soil. I believe this is merely an excuse for laziness; as although I have asked hundreds of natives whether they have tried it, I have not met one who told me he had. Thirty or forty years ago there was a strong objection on the part of farmers in many parts of England to breaking up the pan, but now it has been done they acknowledge the advantages of deep cultivation. Cereal crops are always better here after cotton or indigo. This is, I believe, because these crops have, with their deeply penetrating roots, loosened the sub-soil, which enables the roots of cereals to penetrate deeper into it.



Another objection made by natives to deep ploughing is that their bullocks cannot draw the plough. If one pair of bullocks cannot draw the plough I have made, two pairs can do so easily. As, however, the deep ploughing would be effected, not by one ploughing, but by several, each going a few inches deeper than the former, there would not be much more power required with my plough than there is at present with the ordinary country plough.

Secondly, banks must be raised round the fields to prevent rain-water running off by surface drainage. Where the land is tolerably level, there will be no difficulty in this; the ordinary ridges will be sufficient when the land is deeply ploughed; but where the land is undulating, long narrow fields should be made with the length of the fields running across the direction of the slope; in fact, the fields will require to be terraced, as they are in the hills. By raising the ridges between the fields, any manure there may be on the surface, droppings of cattle, stubble of old crops, &c., is all retained on the land, and, when the land is also deeply cultivated, sinks into the soil, where it remains available for crops. Now, all this manuring matter is carried down by streams to the Ganges and deposited on the low lands of Bengal, where it is the cause of malaria and disease on the subsidence of the floods which have carried it there in suspension. Not only is manure lying on the land lost by surface drainage, but the rain-water, which is required to moisten the sub-soil, and also contains valuable manurial ingredients, is lost to the land of these provinces, and carried down to Bengal, which does not require it. Bengal, with an ample rainfall, is flooded and manured by the Ganges, as Egypt is by

the Nile; only Egypt has next to no rain-fall and requires it, whereas it is injurious in every way to Bengal.

The water being arrested in the soil of the fields where it fell would slowly filter through the sub-soil to the rivers, which would be kept at a more equal depth throughout the year; and Bengal would not suffer to the extent it now does from floods. Another advantage resulting from deep ploughing would be that solar heat, instead of being reflected and heating the air, would be absorbed and radiated by the loosened surface soil, and the intense heat of the hot weather would be moderated; as also would the steamy atmosphere of the rains, by the rain sinking into the lower soil before it had time to evaporate. The temperature being lowered, the evaporation would be lessened, consequently less rain would be sufficient, and possibly the climate might be so altered as to adapt it to many plants, such as tea, which cannot now be grown in the plains, and also to the culture of the silk-worm.

With modified hot winds there would be less difficulty in growing grasses and forage crops in the hot weather, and the crops that have now to be irrigated almost daily, to keep them alive, might possibly, after a few years, when the sub-soil was more moistened, hardly require irrigation. A reduced temperature would render the climate more adapted to Europeans and lessen the necessity for hill sanatoria for troops. To what extent the temperature might be reduced I have no means of judging, further than some balloon experiments of the British Association gave a decrease of  $1^{\circ}$  Fahrenheit for every 276 feet of altitude. If, therefore, we divide the difference of altitude in feet of hill stations and the plains by 276, we get the

theoretical difference of temperature. Thus 5,520 feet, which is about the difference between the altitude of parts of the Upper Doab and Nynce Tal, should give a temperature in the Upper Doab only  $20^{\circ}$  higher than that of Nynce Tal. A loosened soil of  $1\frac{1}{2}$  or 2 feet in depth would be useful as a sanitary measure for the country generally, porous earth being a great absorbent of malaria and noxious vapours. Troops moved into camp on cholera breaking out in military stations soon improve in health, I believe chiefly from getting away from the sodden consolidated soil of cantonments to the vicinity of more cultivated land. Cantonment lands cannot well be cultivated, but if they were sub-soil drained, I believe we should have less sickness in the stations. I am here straying from my question. I have, however, brought the subject of sub-soil drainage of military stations to the notice of the Sanitary Commissioner with the Government of India.

So convinced was I of the benefits of deep ploughing, that last year, in the rains, I ploughed and re-ploughed a piece of ground, stated to be four *kucha* beegahs, as deeply as I could with the country plough. The land was hard "doomal," which had always been irrigated. I thought I had ploughed this field ten to twelve inches deep, but on testing it, it proved to have only been ploughed eight or nine inches deep. I sowed wheat in this field on the 4th November,  $7\frac{1}{2}$  seers Budaon weight per *kucha* beegah. The last fall of rain there had been on it, previous to sowing, was on the 9th October. Hardly a blade of this was touched by white-ants, and as the crop looked very healthy up to the 12th January, I determined not to irrigate it.



I did not see it again from 12th January till I returned from camp on 1st March, when it seemed to be in want of water, and I was persuaded to irrigate a few beds (kiarees) (possibly one-twentieth part of the field) on one side of the field, which looked more dried up than the rest: the irrigated part at once became laid and the irrigation did more harm than good. The next field to mine (said to be three beegahs), farmed by a native in the usual way, was ploughed three or four inches deep, and also sown on the 4th November, the same day as mine; he sowed ten seers Budaon weight per *kucha* beegah; a great quantity, I should think three-fourths of his plants, were destroyed by white-ants when the crop was a few inches high, he irrigated his field three times from sowing to harvesting.

As the *kucha* beegah is rather a vague measurement, I had these fields measured, and found the area of mine was 3,213 and the native's field 1,944 square yards. The crop from my field was 9 maunds 6 seers 8 chittacks Budaon weight of 100 tolahs to the seer, and the native's crop was 2 maunds 10 seers, according to his statement. Reducing this to bushels of 60lbs., my crop was at the rate of nearly 23 bushels per acre, and his a little over 9 bushels. I must mention that I manured my land with a dressing of farm-yard manure; on one part of it I applied some broken bones and afterwards gave a dressing of brick kiln ashes over the whole.

It is impossible to say what amount of the crop was due to manure and what to deep-ploughing.

Had I, after the manure was applied, ploughed my land like the native three or four inches deep and watered, I do not think I should have had as good a crop as



I had This is only conjecture. However, had I only ploughed three or four inches deep and not irrigated, I am certain I should have had no crop at all. But, had my land been ploughed even five or six inches deeper than it was, I think I should have had nearly double the crop I had; as a great many of the ears of my crop were altogether empty, and a great quantity of the grain was shrivelled from want of moisture when the grain was forming, which would not have been the case had there been a greater depth of pulverized moist soil under the plants and the roots been able to penetrate deeper. My land being ploughed to a depth of only eight or nine inches, the roots of the plants could not strike down sufficiently deep in the soil to be unaffected by drought and the heat of the sun, and the moisture was dried up out of the depth of soil they could reach, before the grain was perfected.

My field sloped down to one side, and perhaps half the rain which fell on it ran off by surface drainage, it not having been properly banked up: this makes me consider that half the average rainfall would be sufficient if it were retained in the land.

The cultivators about Budaon have been enquiring how it was I obtained a better crop without, than they did with irrigation. Some say they irrigated four and even five times, and only got about half the return I did, and from the same description of soil. I merely tell them to "manure well and plough deeply," and have shewn them my new plough, which they seem to have taken a fancy to; and say they will adopt.

As it is, my crop does not compare badly with the aver-

age crops of European countries, as mine was nearly 23 bushels per acre. In a late number of the *Farmer*, the average of wheat in bushels per acre in different countries is given as follows :—

Ireland, 26 bushels, high farming 30 to 40 ; England and Scotland, 28, high farming 44 ; Belgium, 21 ; France, 14 ; Russia, 17 ; Silesia, 10 ; Austria, 15 to 16 bushels.

The rainfall at Budaon, from the 10th October to within two or three days previous to the time I cut my crop, was 1.3 inches. I do not include rain falling just previous to cutting the crop, as it delayed my harvesting and did it more harm than good.

The natives sow a large quantity of seed per acre, as they expect a great quantity of the young plants will be destroyed by white-ants. White-ants, I believe, will not attack strong healthy plants. It is only when, in the struggle for existence caused by the poverty of, and want of nourishment in, the soil, the weaker plants begin to droop, that they become the prey of white-ants.

After my crop was cut I could easily push a walking stick into my field to the depth it had been ploughed, but could not push it above an inch deep into the native's field. The soil of my field being thus light and porous, I ploughed it to the depth it had been originally ploughed, and left it in the rough, to get the benefit of the ameliorating influences of the air and rain. Had the occupier of the land next to mine attempted to plough his land after removing his crop, he could not have done so above two inches deep.

Under the present revenue system, unirrigable lands are assessed at a much lower rate than lands which are

irrigable: if my theory is correct, there is no reason why the unirrigable lands should not be rated as highly as the irrigable. At present, in general they are of a lighter or more sandy composition, and as such more suited to barley than wheat, but in ploughing deeply the sandy particles now on the surface would fall down into the furrows, and be mixed with the minuter particles of the denser sub-soil, and the texture of the soil would be improved and become more suited for wheat: at the same time the soil of lands now irrigated would, by deep ploughing and ceasing to irrigate them, become more light and porous and better suited for all agricultural crops.

Every year we hear of the cotton crop being damaged in some district or other from either excess or want of rain. Were the land deeply cultivated, so that rain could easily penetrate to the sub-soil, I do not think we should hear of damage from either of these causes, and instead of getting a crop of from 50 to 70lbs. an acre, we should have one of from 200 to 300lbs., or even more.

As it now is, a great amount of the vital energy of the Cotton plant is expended in forcing its roots into the hardened pan, and we have a dwarfed plant.

With reference to lands barren from being covered with "reh," I believe wherever kunkur has been quarried from these lands they have become fertile. This probably is from the *reh* becoming mixed with a mass of soil, instead of being collected on the surface; it might be worth trying whether deep ploughing and thus mixing the *reh* with the sub-soil would have the effect of making these barren soils fertile.

Whether I am right or wrong is a question which could



be settled by a few simple experiments carried on in different parts of the country. If I am right, the money spent in irrigational works, except under certain conditions of the soil and subsoil above explained, is simply money thrown away.

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ON

# THE SOONKÊSALA CANAL

OF THE

MADRAS IRRIGATION AND CANAL COMPANY.

BY

JOHN HERBERT LATHAM, M.A., M. INST. C.E.

WITH AN ABSTRACT OF THE DISCUSSION UPON THE PAPER.

EDITED BY

JAMES FORREST, Assoc. Inst. C.E.

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## THE INSTITUTION OF CIVIL ENGINEERS.

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March 12, 1872.

T. HAWKSLEY, President,  
in the Chair.

No. 1,326.—“On the Soonkêsala Canal of the Madras Irrigation and Canal Company.”<sup>1</sup> By JOHN HERBERT LATHAM, M.A., M. Inst. C.E.

THE object of this Paper is to give a general description of the canal between Soonkêsala and Cuddapah, recently constructed for irrigation and navigation by the Madras Irrigation and Canal Company; and also to direct particular attention to the mode of safely constructing high banks for canals or tanks, illustrated by that work.

It seems not to admit of doubt, that the countries possessing the greatest powers of production are those in which the yearly rainfall is concentrated into a few months; as it is certainly beyond doubt that the innate resources of such countries are up to this time the least developed. Settled warm weather is the safest for crops at every stage of their sprouting, growth, and ripening; and, not only in England but in India, it is found that crops grown during uncertain weather, as all unirrigated crops must be, are nearly as often and as severely injured by rains or floods as by drought. Egypt, as far back as history exists, has been a country of settled weather, and also notorious for its fertility; yet that country, even as far as irrigation has gone, can scarcely be called more than half developed. To fully develop the productive powers of land three things are needed: first, settled weather, which art cannot give nor control, and can only turn to account; secondly, irrigation, which must be controlled by art, though a supply must exist upon which art may operate; and, lastly, manure. When it is considered that good land, under constant cultivation in a settled climate, may utilize a ton of guano an acre a-year, besides more bulky and less potent manures, it is impossible not to think what a population the world is capable of supporting, and how unnecessary it is that so many mouths in the most industrious nations are insufficiently filled.

From time immemorial the native inhabitants of the Madras

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<sup>1</sup> The discussion upon this Paper occupied portions of two evenings—having been resumed on the 9th of April—but an abstract of the whole is given consecutively.

Presidency have spent large sums in the construction and management of undertakings having for their object the application of water to irrigate fields and gardens. The only native engineering buildings in the country consist of works of irrigation, fortification, religious worship, and shelter for travellers; and of these, in magnitude and importance, works of irrigation rank the first. These have been of three chief kinds, viz.:

I. Wells, which are generally large square pits lined with stone, from which water is raised by simple machinery and delivered on to the fields.

II. Tanks or reservoirs, which are filled by rain-water, and from which the water flows through sluices on to the fields.

III. River channels, of which the canal under review is one. These are the most prized of all the methods, and are stated to give 25 per cent. more crop per acre than either wells or tanks. In some few cases tanks were supplied from river channels, as at Nundloor, Nellore, &c.

River channels were constructed for turning the water of rivers on to the fields in such a way that a nearly constant supply should flow down them, whatever floods should come down the river. Unless so constructed they required to be annually closed, near their entrance or offtake from the river, by a bank; for head sluices were rarely made. The first object, viz., an offtake of constant supply, is accomplished in various ways. If the river-bed be a broad ill-defined one of deep sand, channels are cut parallel to the river along its margin, having their bed lower than the summer level of the water in the sandy river-bed, the spoil being thrown towards the river to make a flood bank, and prevent the river floods flowing into the channel. The up-stream end of this flood bank would abut upon any natural sandhill or other eminence. After running down a mile or two, the channel is given a less fall than the river, and is gradually brought out of the river-bed. Such channels flow by filtration, whether the river be quite dry or in full fresh. They are numerous on the rivers Châyér and Chittawutty. On the other hand, if the river-bed be rock, a constant offtake may be secured by carrying a rough weir of loose stones across the rocky bed of the river, and returning it downwards under each bank on the margin of the river-bed, until out of the reach of floods; as at Hoosoor, Darojee, &c. The upper side of each return forms the inside of the channel, and is well lined with earth and vegetation. The weir and returns have their crests all at the same level; and the channel runs with a slight fall from the ends of each return.

Where the formation of the ground is such that a channel of the former sort in a sandy river would be carried away yearly, the side channel is abandoned, and the offtake channel requires to be banked across its mouth yearly to prevent the floods running down it and doing damage. This can be conveniently done at the close of the dry season; and when the rains are over and irrigation is needed, the entrance is cleared and a catch bank of sand is constructed in the river-bed to divert the water of the river into the channel. This catch bank is run farther and farther out upward across the stream as the river falls, and at an angle of about  $30^{\circ}$  with the direction of the stream, so as to keep the supply to the channel constant, until the bank may perhaps extend right across the river. Similarly, where the formation of the ground is such that a weir in a rocky river cannot be returned along the rocky river bank, the channel has been run directly from the end of the weir and at once completely banked off from the river. The case or cases of head sluices being built to such channels before the English rule are so few that it can be hardly called Hindoo practice to build them at all, so far as the Author's personal experience goes. To prevent excessive damage from the river floods, the entrances of such channels are generally cut very narrow, and, if possible, in solid rock; and numerous waste weirs are placed along the channel in the course of the first mile or two in order to get rid of the surplus water poured in by floods through this narrow entrance.

English Engineers soon adopted the rule of placing head sluices across all river channels at or near their entrance. They also extended the use of weirs to sandy rivers as well as to rocky ones, as more effective than the annual bank of sand. Scouring sluices were inserted (not always judiciously) in the weirs, to keep down the silt in the pond above them, and to clear the face of the head sluices of the channels led off from the pond. These scouring sluices are invariably in Madras called "undersluices," whether in the weir or not, though, in the latter case, no water goes over them. Indeed none of the so-called "undersluices" of the Madras Irrigation and Canal Company are strictly undersluices, but they are merely low-level scouring sluices built at the end of the weir, and generally in a line with it.

By great energy some of the engineers of the Madras army induced the Madras Government tentatively to adopt these innovations in situations admirably chosen for the trial; and weirs were constructed at the head of all the considerable dallas—as the Cauvery, Kristna and Godavery—of rivers having a sufficiently



constant flow to irrigate fields for one crop at least of rice each year. The channels from these weirs run along the uniform slope of the delta country, rarely crossing any considerable drainage, and diverge like the rays of a fan from each end of the weir.

The first result of the great success of these innovations was the extended use of similar permanent weirs at the heads of channels, for rivers of very short and uncertain flow, which, instead of running to the fields, run into a series of ordinary village tanks. Of such a kind is the Nellore Anicut across the Pennâr. By its means the floods of the Pennâr are distributed; but, as in London, each householder, so in Nellore, each village, irrigated by the weir, has to provide and keep in repair its own tank to receive and store the intermittent supply, as well as an escape weir for the passage of surplus water to the next tank below. These tanks rarely exceed 1 mile in breadth and 9 feet in depth of water. Other rivers have received, as the Palâr, &c., or deserve, as the Soonamooky, &c., similar treatment.

While the rebuilding of the Nellore Anicut, since it was last carried away, was making progress the "Toombuddra project," for using the inland rivers for irrigation, was adopted by the Secretary of State, so far that interest was guaranteed on £1,000,000 to be raised by the Madras Irrigation and Canal Company, towards carrying out a definite portion of that project for irrigation and navigation combined. The objects of the Toombuddra project, of which the Soonkêsala canal is a portion, were two: the first, continuous irrigation throughout the year of three large areas, of which the largest lies in the Bellâry District, the next in the Koondêr Valley, and the other in the Nellore District. The second object, apparently necessary to the success of the first, was a means of communication by canals, by which the produce of these areas could be sent to a market more cheaply than by cart or railway, more expeditiously than by cart and more securely than by railway. In order to maintain irrigation, the autumn and winter supply of the river Toombuddra itself was to be directly distributed to the fields over these areas, and the surplus autumn rainfall was to be stored in large tanks near the sources of the Toonga and Budra in the western hills, in sufficient quantity to maintain the irrigation when the river Toombuddra (Toonga-Budra) itself failed. Navigation could thus be maintained along the line of irrigated country, either in the channel used for the distribution of water or in separate canals. Navigation is particularly suited to India, both on account of its cheapness and security. Two arrangements seem necessary for security, viz., that the goods should not be transferred



from one vehicle to another during the whole journey, especially where other similar goods are being similarly transferred; and that the owner or his agents should be allowed to accompany the goods in whatever vehicle they be placed, and that he should be able to do so in comfort. It is not petty pilfering, but wholesale change of large consignments of grain or cotton, of which the Indian merchants express fears and relate their experience.

This Toombuddra project is one of great importance, not only for India but generally, on account of the hitherto insurmountable difficulties it is intended to meet. These are three in number. In the first place, it proposes, by the mere offer of water, to induce a vast population of ill-educated and poor ryots or cultivators to forsake in great measure the cultivation of dry grain—the only cultivation they know either by experience or tradition—and to undertake a more expensive and intelligent system of agriculture. No doubt, wherever water has already been used from time immemorial, as in the delta countries or in Scinde, it is highly prized; and additional security or extension of the supply is there immediately taken advantage of by the ryots, if the terms suit them. But in the parts of Bellâry, Kurnool, and Cuddapah proposed to be supplied with water by this project, it is not so much the extension, as the introduction of wet cultivation that is aimed at; not the irrigation of dry crops of corn, as on the Ganges and Jumna canals, but the superseding of dry crops by wet, and that without any of the compulsion inseparable from Government works.

A second difficulty is the necessity for the provision of a constant supply of water, by storing it in sufficient quantity for all the work, for use in the dry months. For this purpose it will be necessary to construct tanks or reservoirs, having banks as high as, and longer than, any constructed in historic times, and to provide these reservoirs with surplus weirs or sluices, which on account of the great uncertainty of rain in India, and the great range through which the yearly discharge varies, will need to be of extraordinary discharging power.

The third difficulty lies in the adverse character of the country. Throughout its whole length the Toombuddra valley is crossed by ridges of hills, which render it difficult to carry off channels from the river. Hence the canals executed or projected by the Company, have some very heavy cutting and banking before they can be led away from the river so as to command a large area of country. The ridge of hills which crosses the Kristna valley just below the

confluence of the Toombuddra and Kristna, is about 25 miles wide, and its summits are nearly 3,000 feet high. The river passes through this ridge in a narrow and sinuous course, between high and often precipitous banks, for a distance of upwards of 60 miles. Neither navigation nor irrigation could be carried through such an obstruction. Instead of being surmounted, the flank of the ridge is turned by a canal on the level of the watershed dividing the Toombuddra basin from that of the Pennêr, which flows into the sea at Nellore. The canal already completed has its off-take from the Toombuddra, at Soonkêsala, 17 miles above Kurnool, and after a tortuous course of 75 miles, in which it passes over the river Hindry and three other considerable tributaries of the Toombuddra, at an average cost of £8,000 a mile, arrives near Metacondâl, at the watershed between the river Bôanâssey, a tributary of the Kristna, and the Kâlî or Caulee, a branch of the Koondêr, a tributary of the independent river Pennêr. There can hardly exist a valley more favourable for irrigation than the Koondêr. The soil is good, the valley broad and flat, and the disposition of the levels, or slope of the ground, excellent. Indeed, when once the Metacondâl watershed is passed, irrigation becomes almost as easy as it is from the weir at the head of a delta country, and the cost of the canal was, for the rest of its course, only £2,900 a mile.

To pass on to a description of the canal itself. (Plâte 14.) The Toombuddra project was first brought forward by Colonel Haviland, but it was not till 1858 that the Madras Government, on the report of General Sir Arthur Cotton and other Engineers, selected it as the first work to be undertaken by the Madras Irrigation and Canal Company. In 1861 that Government limited the work of construction under the guarantee to the canal between Soonkêsala and Cuddapah, and the weir at Somêshwaram; and in 1866 made terms with the Company for completing the canal between Kurnool and Cuddapah by the 1st July, 1871.

The character of the canal may be sketched as follows: the first 75 miles is calculated to carry 400,000 cubic yards of water per hour at the head at Soonkêsala, and, after gradually parting with about 100,000 cubic yards for irrigation, to convey at least 300,000 cubic yards an hour through the Metacondâl cutting at its other extremity. There 255,000 cubic yards an hour may be discharged into the Kâlî, and 45,000 cubic yards carried down the continuation of the canal. Of the 255,000 cubic yards an hour poured into the Kâlî, the canal is calculated to take up 100,000 cubic yards at Jutoor and 50,000 cubic yards at Râjoli, leaving above 100,000



cubic yards of water per hour for the insignificant irrigation below Cuddapah and for Nellore.

The canal begins at Soonkêsala with a weir, Figs. 3 and 4, Plate 15, across the river Toombuddra, 1,500 yards in total length of clear over-fall, which is broken into two lengths by an intervening island. The weir stands upon the rocky river bed, and is formed of three patterns, viz.: 1. Of solid rubble masonry of gneiss, trap and quartzite boulders, of the form Fig. 3. 2. Of gravel concrete, with gneiss rubble facing in front and rear, of the same section. 3. All recent portions are of solid gneiss rubble masonry, with a facing on the lower side of Kurnool limestone ashlar, which averages  $\frac{3}{4}$  yard thick where exposed to concussion. Fig. 4. Patterns Nos. 1 and 2 have a front and rear batter of 1 in 8; while No. 3 has an upper batter of 1 in 4, and a rear face vertical. All are 8 feet broad at the top, and coped with dressed limestones 1 foot thick, of which every alternate one is a through stone 8 feet long, weighing about  $1\frac{1}{2}$  ton. The mortar throughout is of Kurnool kunkur, except the joints of the coping, which are of Portland cement. The coping is joggled wherever the anicut (which is not straight, but follows the line of highest solid rock) is concave in plan on the up-stream side. No part of the anicut formed on any of the above patterns, either with or without the coping, has ever failed. The height varies from 6 feet to 26 feet, and averages about 18 feet; and the highest registered flood rose  $7\frac{1}{2}$  feet over the crest.

From the pond above the Soonkêsala weir the water is admitted into the canal by a head sluice without any lock. The face of the head sluice is kept clear by the scour of ten under-sluices at a lower level in the weir, the stream to which is forced against the front of the head sluices by a long curvilinear groin. The minimum cross section of the canal for the first 75 miles has a 90-foot bottom, with 2 to 1 side slopes. For the first 45 miles the fall per mile is adapted to secure a discharge of 400,000 cubic yards of water an hour, if requisite, without increasing the depth of the water to more than 8 feet. Below the 45th mile, the canal being in good soil, and lying on easy slopes with limestone or shale subsoil, a depth of 9 feet of water is allowed. At the 75th mile the canal passes through the watershed between the Toombuddra and the Pennêr rivers; and thence the natural water-course becomes the main supply channel, under the successive names of the Kâlî, the Koondêr, and the Pennêr. From this natural main supply channel the water is taken at four points, viz., Lockinsula, Jutoor, Râjêli, and Adanimayapilly, by the simple process of throwing

weirs across it, with under-sluices in the weirs to keep down the silt, and head sluices across the channel to control the supply and entrance locks.

The first branch irrigating channel forms the main canal from the 75th to the 95th mile. Its head is formed at Lockinsula by blocking up the water-course (there so rudimentary as to have been used for a village road) by a bank with scouring sluices, and turning the main supply over a natural weir of rock, whence it joins the old water-course below. The head sluice and lock are adapted for working this branch with a depth of 6 feet of water, when the irrigation becomes sufficiently extended to require it in the Nundi-cotacoor and Nundial Talooks, and at this depth the flow will be 45,000 cubic yards an hour. This canal is an irrigating channel for the first 6 miles only. Below that it is a still-water canal, with a fall of 180 feet 5 inches, overcome by seven double-chambered locks and five single-chambered locks. The greatest drop in any one double lock is 21 feet 8 inches, and in a single lock 13 feet. The chambers are 120 feet long, by 20 feet broad. The canal is 45 feet wide at the bottom, and the minimum depth is 5 feet.

The second branch irrigating channel takes its supply from the main stream in the Kālī at Jutoor, and forms the main canal from the 95th to the 146th mile. It has a very wide area of distribution in the Nundial, Seriwell, and Koṣcoontla Talooks of the Kurnool district. It is intended to distribute 180,000 cubic yards of water an hour, if required; but to do this 2 feet height must be added to the banks over the first 20 miles of its course. In its present form it is adapted for carrying about 100,000 cubic yards an hour; and this is probably enough to supply rice for all the local demand for food, leaving the cultivation of cotton and indigo, for which the valley is celebrated, more room than is available while dry grain has to be grown for food. Already the Company has irrigated a greater area of dry than wet crop in this valley. A good indigo crop is of more value as an article of commerce than a good rice crop, but hitherto indigo cultivation has been so precarious that a really good crop might not be obtained once in six years. No crop more needs and repays irrigation. The head works consist of a weir (Fig. 5) of solid limestone in rubble masonry founded on soft shale, and of head sluices, the face of which are scoured by under-sluices in the weir by help of a training wall and of an entrance lock. The weir is 6 feet broad below the coping, and has a batter on the upper side of 1 in 4; the rear face, which is ashlar, descends vertically into a trench or

water cushion, hollowed out of the shale and lined with limestone masonry. This water-cushion is narrower than it should be. The coping is protected from floating timber by a foreshore of rubbish from the shale excavation. This branch is adapted for a depth of 6 feet of water down to the first drop lock in the 118th mile. Below that lock, water is passed, for a limited extent of irrigation, round ten locks, and at the eleventh lock (130th mile) all irrigation ceases. The canal between the 118th and the 146th mile consists of level reaches adapted for a depth of 5 feet of water, and contains seventeen locks, with a total fall of 187 feet 6 inches, and a maximum fall in any one of 14 feet. The bottom breadth throughout is 50 feet.

The third branch irrigating channel takes its supply from the main stream in the Koondêr at Râjôli. The 146th mile of the navigable canal falls into this branch about  $\frac{1}{4}$  mile below its head, and is continued to the 180th mile. The Râjôli weir is of solid limestone in coursed rubble masonry, 5 feet thick at the top, with a batter of 1 in 2 on the upper face and plumb on the lower face. (Fig. 6.) It stands on thick beds of solid limestone. With a depth of 5 feet of water in it, the canal will discharge 50,000 cubic yards of water an hour, the bottom breadth being 50 feet. The irrigating channel ceases at the first lock in the 172nd mile, and thence to the river Pennêr is a still-water canal, which falls 90 feet 6 inches, by means of nine locks, of which the greatest drop is 13 feet.

The fourth branch is a length of 8 miles of canal at nearly a level, supplying a small area of irrigation. It is, in fact, the first 8 miles of the projected continuation of the canal into Nollero. It is adapted to distribute for irrigation about 5,000 cubic yards an hour of water, and has a bottom breadth of 50 feet. The headworks consist of a weir<sup>1</sup> across the main supply in the Pennêr, with head and under sluices, and entrance lock. The river gates of the entrance lock are 25 feet high, and are the heaviest on the canal. The weir for a short portion of its length is of solid limestone in rubble masonry founded on rock; but the greater proportion of it is founded on sand, and consists of a masonry slope supported on the upper edge by a double row of wells and on the lower edge by a single row of deep wells. There is a longitudinal row of wells along the middle also. The slope is 1 in 11.75; and below the

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<sup>1</sup> Mr. H. P. Higginson, M. Inst. C.E., has presented to the Institution a description of this weir. It was not possible to read this communication during the Session 1871-72.



slope is a dry rubble apron 105 feet broad. The canal terminates at a distance of  $1\frac{1}{2}$  mile from the Madras railway, and 163 miles from Madras.

Besides the weirs, some of the masonry works on the canal deserve notice. The Hindry aqueduct carries the canal 90 feet broad and 8 feet deep over the Hindry, at an elevation of 32 feet, by fourteen 40-foot arches, the length between the abutments being 651 feet. The lowest headway, at full water, under any bridge over the canal, is 15 feet; the smallest width, in locks is 20 feet. The under bridges have a width of 30 feet, except in two cases, where it is 25 feet. The lock chambers are 20 feet by 120 feet in the clear, and are adapted for working with a depth of 5 feet 6 inches of water, though they will work with less. The filling and emptying sluices are a pair to each pair of lock gates, *i. e.*, four to each single lock. Each sluice has an opening 4 feet square, and the ratio of the inlet ports to the sluice and to the outlet ports is as 5, 4, and 8 respectively.

The grade or fall of the canal where it is taken down the irrigating channel varies between 18 inches a mile in one or two deep cuttings, and a level in the tanks formed where the canal is carried over an open valley, by damming it across. In other places it is usually from 4 to 6 inches a mile. The last seems to be the most suitable fall where the cuttings and banks are of cotton soil unprotected by revetment of any sort; but it is impossible, without further experience, to say whether a more rapid fall would not be better. The more rapid the fall, the less silt will be deposited, but the more current there will be against ascending boats. Hitherto the silt has given but little trouble, and it seems likely that an annual outlay of £1,000 will suffice to remove all deposits of silt.

The lock sluices are simple cast-iron shutters running on wheels 8 inches in diameter. When quite closed, however, the shutter bears on the cast-iron frame or seat. They readily are raised by a rack by two men in a few seconds, or by one man where balance weights are attached.

No measuring sluices are needed. Two sizes of sluices for irrigation are used, besides some small ones, closed by hand, in the first three sections. The smaller size is 18 inches wide and 1 foot-lift, worked by turning round a vertical screw lifting a cross-head, to which the cast-iron shutter hangs. The larger has a lift of 3 feet 9 inches, and is 5 feet broad, the shutter being made of wood; and it is raised in the same way as the smaller ones. Each turn of the screw raises the shutter 1 inch, and one man can easily



work it against an average head of water of 6 feet. The raising gear and cast-iron grooves of the larger size cost £11 4s., delivered in London on board ship, and the smaller size, including iron shutter, £5 7s. The lock valves with crab, shutter, and frame complete, cost £36 each; while the gates complete in place cost about £2 11s. per foot drop.

Though the masonry works, and especially the weirs, contain a great variety of work, the chief interest and novelty in the construction of the canal is, undoubtedly, the mode of forming the banks. These range up to a height of 50 feet from the ground surface of their site to the water line. They are upwards of 35 feet in total height in the 13th, 18th, 22nd, 23rd, for nearly half the 24th, 29th, 32nd, 33rd, 34th (in these last 2 miles  $\frac{1}{2}$  mile of bank is 40 feet high), 48th, 54th, 58th, and 63rd miles; while in the 26th and 27th miles the bank exceeds 40 feet high. These banks are always on sloping ground, so that the height above the outer toe is more than the nominal height. Their formation in the above cases is as follows (in all cases the single bank is reveted or shingled on the inner slopes):—

|                                |                                                    |
|--------------------------------|----------------------------------------------------|
| Simple filling only in miles   | 5, 13, 22, 23, and part of 24, 32, 40, 54, 58, 63. |
| Masonry wall, Fig. 7, in miles | 24, 26, 28.                                        |
| „ face wall, Fig. 8, in miles  | 26, 27.                                            |
| „ revetment, Fig. 9 „          | 18.                                                |
| Puddled bank, Fig. 10 „        | 24, 33, 34.                                        |
| Puddle core bank, Fig. 11 „    | 26, 29.                                            |

The banks of the sections Figs. 7, 9, and 11 came into the Author's hands in 1865, as finished works, but have since been strengthened or raised. In Fig. 7, the rear wall is almost superseded by the backing of dry rubble added behind, so that the front wall acts as a face-wall to the mass of rubble behind. This is found a very efficient kind of wall; but it is right to mention that a portion of wall of this section was carried away during an extraordinary flood in August, 1870, which rose over the wall and, probably, cut down the ordinary bank at its junction with the end of the wall. The bank represented in Fig. 11 was originally constructed—as shown by the dotted lines—without the foreshore of puddle, and with merely a vertical central core of puddle 9 feet thick, extending from top to bottom, between two slopes of hand-packed rubble. The objection to this proved to be that the vertical core, being held by the packed rubble walls, could not settle. Hence if, on first filling the canal after a dry season, the water penetrated through some crack in the core, it would extend the crack, by wearing it wider

and deeper; while the puddle above would stand in an arch. No breach ever occurred from this cause, but excessive leaks took place in two cases, before the cracks could be reached through the hard puddle above them. A puddle foreshore was therefore added, in a position more easy of access than the puddle core.

The strongest and best sections are those shown in Figs. 8 and 10; sections adopted after the experience of two seasons in the working of banks of all kinds. The Author estimates the efficiency of these as so nearly equal, that the choice between them may be a question of cost. The only objection to the face-wall is that the bank cannot be raised, when once the wall is built, without carrying up the wall to a narrower width than 2 feet, or at least increasing the weight on the original wall by the addition of the material required to raise the bank. Hence, if enlargement of the canal be anticipated, the wall has to be built of a stouter section from the first. No portion of this face-wall has cracked or shown any signs of weakness; nor, though unprotected in front by either plaster or puddle, is the leakage more than just sensible. The puddled slopes are even tighter than the face-wall, and have proved efficient even when the bank is of the worst kind of white and grey clay, mixed with salts of lime and soda, and such as to absorb water readily. It may be thought more liable than a wall to injury from vermin, but no difficulty nor accident has yet occurred, and any defect is more readily repaired, and is less dangerous than in a wall; and this remark applies to defect from bad workmanship as well as from external violence. The total length of masonry walls in the banks is but a few chains short of 5 miles, and the puddled banks are nearly of the same extent.

In estimating the probable stability of a bank composed of soil thrown up, without either selection or puddling, when first exposed to water, a few first principles require to be borne in mind. Failure will take place either from the soil taking a flatter slope, when acted on by the water, than it originally stood at in the bank, or from leaks forming holes through the bank and ultimately destroying it. The Author has successfully stopped leaks 2 feet 6 inches in diameter, occurring at a height of 12 feet above the ground; and, on the other hand, has had the rear of a bank slipping down to a slope of about 1 in 10 also readily repaired. A little consideration will show how such casualties may be best treated; and lastly, how, by a careful construction of the bank, they may be avoided altogether.

It is necessary, in treating failures of banks, to get rid of the notion that, in practice, soil acted on by water becomes really



viscous, *i. e.*, chemically semi-fluid. The action of water for all practical purposes is mechanical. It is true that the presence of salts causes dry earth rapidly to absorb water to which it may be exposed; and the subsequent deliquescence of the contained salts may leave the soil in a thoroughly boggy state. But such soil only requires mechanically draining (perhaps no easy matter) to restore it to firmness; and it will then be freed from the salt, which will have been carried away in solution. The flattest slope taken by dry material is probably that of ground quick-lime, as it runs dry from the grindstones, when it will run nearly flat; and generally the natural slope at which dry material, deposited at hap-hazard, will stand is steeper in proportion as the particles are angular and rough, and flatter in proportion as they approximate to polished spheres; in the former case hardness of each particle or piece secures a maximum steepness of slope, in the latter case a minimum. The effect of a little moisture is virtually to increase the roughness of the particles, supposing no chemical action; the cohesion of small surfaces in contact being increased so much, that if the particles are small the material may stand vertically when damp, or at an overhanging slope. Excess of water may have, however, a very different effect, which will depend on the nature of the material. Thus a mass of rubble or gravel consists of materials of such a size as to be unaffected by the presence of water, as far as regards the relative position the particles are disposed to take; except only when the flood of water is so violent as to displace them by mere force of impact. Again, clean sand may be defined as a collection of insoluble particles, so small that, though after being thoroughly wet much of the water, if allowed, will drain out of it, yet enough will remain to increase cohesion, and so much as to equal or exceed the force of gravity on any particle. But clayey earth has its particles so fine as to retain by cohesion a sufficient quantity of water to separate, or nearly separate them, and to render the mass apparently viscid; and so it will remain until the water be squeezed out by pressure or dried up by heat. It may require intense pressure or heat to render such a material really dry; but a moderate amount of either may render it very hard. When really dry, the material will have become stone, or so like stone that the particles will not separate if again exposed to water; but if only moderately dry, as it is found in banks, it is possible that, when water is admitted into the crevices or pores of the material, it may so loosen the particles as to make them easy to separate, and unable to resist the slightest action of running water. This may happen even while the

cohesion remains so strong as to check and practically resist the passage of water through the body of the material.

The two dangers of slips and leaks to which a bank is exposed, and the mode of meeting them, are the following. In the first place water may be forced by pressure into the accidental interstices or fissures in sand or clay faster than it can drain or dry out of it; as where the outer slope of a leaky bank is made of sand, or where a bank is thrown up entirely of moist clay, and the greater weight on the centre squeezes out water contained in the central portion and forces it into the slopes. In both these cases slips of the slopes are likely; and they take a flatter slope than that at which they first stood. The danger from leaks is when water obtains a free passage, either through a crack or a burrow, without meeting any resistance sufficient to hold it back against the head under which it advances. The action of such a stream may enlarge the opening until the bank is destroyed. To stop a slip, either the water must be tapped by a drain before it enters the slope, or the slope must be artificially supported by a weight sufficient to prevent its movement. In the case of water flowing through a crack or burrow, no danger will result unless the material be tough clayey soil. A sandy soil soon falls in, as

Fig. A.



Fig. A will show, for the bed of the cavity will absorb the water, and the material will run to so flat a slope, and the sides, right and left, will be undermined so fast, that the top will fall in from the surface of the bank before it can attain any magnitude. In a tough loamy clay a crack is much more dangerous,

for the soil is nearly impervious, and the stream will simply soften and carry away the bottom and sides of the burrow with which it comes into actual contact. (Fig. B), and may cut its

Fig. B.



way down without widening the cavity sufficiently for it to fall in, even though it meander about and cut caverns 5 or 6 feet in diameter. The quicker the stream the more vertically the sides will stand; so that a leak of long standing is generally found to have cut a steep, narrow way nearly down to the level of the ground near the centre of the bank, and then to have made a series of wide chambers on its less rapid passage to the rear. Such leaks are best stopped by filling

the caverns in the rear with gravel or rubble, and at once cutting

down to the leak on the water side of the bank, and puddling it up on that side.

But the real problem is to make a bank which can neither slip nor be cut up by leaks; and may be safely filled after being dried for a couple of months by a mean daily temperature of 98° Fahr. in the shade, that of evaporation being 70°.

The consideration of this problem is the more necessary owing to the wholesale condemnation of earthen dams of above 65 feet in height, by M. Graeff, Engineer in Chief of the Ponts et Chaussées, in 1866.<sup>1</sup> This condemnation is disproved by the long existence and security of the dam of Cumbum, 102 feet high, under 94 feet depth of water. It may however be interesting to show, that a scientific and practicable theory exists for the construction of earthen dams; and it only remains to bear in mind, that a given quality may be secured, with less risk of defective work, in earth-work, with at least as much certainty as in masonry.

Before a bank can be safely exposed to water as above, the following conditions must be satisfied:—

1. The greatest possible leakage must not carry any material out of the bank.

2. It must be impossible for any burrow or crack to be made right through the bank.

3. The impervious part of the bank must be secured in its place, so that neither settlement can breach it, nor leaks through cracks which will occur in it carry the material out of place.

4. The impervious part must be encouraged to settle or shrink so as to close any cracks which may occur in it.

5. It must be easy to detect and overhaul any bad puddle.

It will be found, in practice, that when a bank fulfils these conditions, the entrance of water into any part of the bank is more difficult than its exit, and that in consequence the head of water upon the bank tends to press upon and tighten up every layer of material in the bank—a result that tends very much to increase the stability of every part.

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<sup>1</sup> "It is not necessary to consider the plan of constructing dams of earth, which are things of chance when they attain a height of 20 mètres (65·6 feet), and it is out of the question to use this construction for a height of 50 mètres (164 feet), which we have now under consideration."—Fife's translation of Graeff's Report\* on the Dam of Furens, &c., in "Selections from the Records of the Bombay Government—Irrigation Series.—No. ix." 8vo., Bombay, 1869.

\* This Report appeared in the "Annales des Ponts et Chaussées" 4<sup>e</sup> Série. Tome xii pp. 184-211. 8vo., Paris, 1866



It may be well to consider first how a bank should be theoretically constructed without any puddle at all; and, for this purpose, as round numbers are convenient, a bank 200 feet high will be taken merely as an illustration. It may be observed, to start with, that though the theoretical conditions of quality and arrangement of soil may not be absolutely attainable in practice, yet the margin of safety is so large, and the modifications permissible so ample, that any condition of security can, in fact, be attained in practice. Again, it is well to premise, that not only clean sharp sand and small gravel, but also these materials, after having their interstices silted up with a tough matrix of clay or puddle, present an insurmountable obstacle to the burrowing of vermin and to cracking by heat.

Let Fig. 13, Plate 16, represent a vertical cross section of a perfect filter in a prismoidal or wedge-shaped trough, whose sides contain an angle of  $60^\circ$ . By its being perfect, let it be understood that, whatever depth of water be placed upon it, the water alone moves as it passes through the filter; and that the material of the filter is arranged in horizontal layers, beginning with fine sand at the top, and then becoming successively coarser until the lower angle contains large rubble blocks, in such accurate proportion that the water flows through freely enough not to resist that behind it, but not so freely as to leave any apertures.

If the upper layer of fine sand be as deep as the water placed upon it, and be clean, the quantity of water flowing through the filter, or, in other words, the leakage, would be usually calculated at 700 gallons per day for each square yard of surface; which, for the filter in the figure 200 feet high, would give  $18\frac{1}{2}$  cubic yards of leakage an hour per lineal yard of filter; an amount so small that it would flow away in a stream an inch deep, with a velocity of little over a quarter of a mile an hour. And this leakage would represent the work done by 200-feet head of water, in forcing a passage for such a stream through the obstruction presented by the filter, and imparting to it the velocity with which it issues from the lower edge.

If this prismoidal filter be supposed to be laid on its side upon an impervious soil, and the casing containing it be removed and replaced by slopes of fine sand in front and of filling in rear, care being taken to keep open a drain of dry stone, or of masonry arches, from what was previously the lowest edge of the filter (Fig. 14), the result is a bank so constructed as to fulfil the five conditions already stated for a safe bank, but without any puddle. The higher the bank for a given coarseness of sand, and



the thinner the layer of sand forming the front slope, the more water would flow through the bank; but even if the leakage increased a thousand times, and the water poured from the rear of the bank like the back lash of an Atlantic storm wave, there is no engineering difficulty in securing the rear so that the water should pass out without disturbing the outer too of dry rubble blocks; and if these do not move, no particle in front of them can be displaced, by hypothesis, except by actual crushing of the material. It will be observed that no crack nor burrow can be made in the material of this bank, either by sun or vermin; and that it only needs its surface protecting from the action of rains and waves to form a durable bank.

In the Author's opinion, there is no other sound and safe principle on which earthen banks of tanks or reservoirs can be constructed except that described. In practice, puddle is added to stop the leakage, and the durability of the bank is thereby also increased. But a reservoir bank can hardly be considered safe if, owing to the mode of its construction, a crack, burrow, or other leak through the puddle, would be dangerous to it. In practice, the best position for the puddle is on the flattest slope in front of the bank (Fig. 10), where it should be protected by rubble, the larger and smoother the better, laid on sharp loose gravel impervious to vermin. The thickness of this protection must be so great that it cannot be wholly removed as the bank settles. Rubble packed, or very rough stone, as kunkur, is best avoided; since it will not follow the bank during settlement: hence the dry rubble facing must be thicker as the bank is higher. Unless there be liability to a scour along the inner toe, there is no occasion to make it thicker at the bottom than at the top, but rather the reverse, since the waves will be heaviest when the tank is full. The puddle will be the most dense part of the bank. Where used by the Author, the surface of puddle under construction is kept always flooded, like a rice field; and gangs of men, with their arms linked together, walk backwards and forwards on short lengths of it all day, treading it stiff to a song, as layer after layer is added by the workmen. The thickness of puddle used for banks under 40 feet high is just 1 foot thinner than that used in the bank of the Sheffield Waterworks Company, which did so much damage by bursting on the 11th of March, 1864; *i. e.*, it is 3 feet thick at the water-line, and increases at the rate of 1 foot in thickness for every 8 feet vertical depth below the water-line. The puddle must, if necessary, be carried down in a trench—sheet piling also being added if necessary—so far as to prevent any flow of water below



it being so violent as to displace material, or so copious as to be wasteful.

In order to insure the puddle remaining watertight under all circumstances of original settlement, and of alternate wet and drought, it is desirable that it should rest on a substance rather more compressible than itself. To lay it at once on ordinary rammed filling would be too violent a change; and it has always been laid by the Author on a cushion of earth moistened and rammed; each layer, of 6 inches or so, being well wetted and then sprinkled with enough dry earth to prevent it sticking to the rammer, when punned with a rammer of 40 lbs. weight. The rest of the front slope, if not already existing, has been made of earth rammed dry in the usual way; since it was found safest, indeed almost necessary, to establish the broad rule, that nothing but earth should be brought to the front of the centre line of the bank. The bank was then completed with any gravel or bad soil available, the gravel being kept at the bottom as much as possible, and the finest soil to the centre. Though such banks are not theoretically perfect, they have never failed nor given trouble upon letting the water against them. The lengths entirely constructed on these rules are insignificant, but about 5 miles of old bank have been faced with puddle laid on earth rammed moist.

The form recommended by the Author for higher banks is shown in Figs. 15, 16, and 17, which only needs a remark, that where the bank runs out on a hill-side, or the ground along the centre line of the bank rises or falls, the water which leaks through and under the puddle will be liable to run along inside the bank, instead of escaping out of the rear toe at once. Hence, at the deeper parts of the bank, larger stone is desirable at the outer toe, whatever other artifices the nature of the ground may admit of.

The greatest average monthly progress in any year made on the Soonkésala and Cuddapah canal was 273,000 cubic yards of earthwork and 11,572 cubic yards of masonry, in the working season, April to March, 1869-1870; but this could be exceeded were labour concentrated in one spot and assisted by machinery.

The cost of earthwork varied from 2d. to 6d. per cubic yard; of rock cutting, from 6d. to 2s.; and of rubble masonry, from 6s. to 10s., the latter including a little cut stone.

Much rubble masonry, including arch work, was done in aqueducts and bridges, as in the whole of the 9th section of the canal, at the rate of 8s. a cubic yard over all, with centerings found. Earthwork in black cotton soil 6 feet deep, or thrown



into banks, was done rapidly during the year 1870, at  $2\frac{1}{2}d.$  a cubic yard.

The actual cost of the first 75 miles of canal—the length whose main office is to carry water for distribution below—has been £8,710 per mile, including headworks. The next 115 miles, including locks and all works, has cost £2,900 per mile; and the whole canal, including the expensive weir across the Pennâr, has cost £5,260 per mile. These rates include all English stores and plant, used for the work; but to cover the cost of engineering, management, and stores in stock never issued for use, 50 per cent. requires to be added to the above figures.

The powers of irrigation possessed by the canal, as it at present exists, admit of a clear but not very precise definition, owing to the number of contingencies for which it is adapted, but which are not yet determined by experience. If rice alone be considered, the irrigating power possessed by the canal, estimated at 2 cubic yards of water an hour per acre where the waste water is lost, and  $1\frac{1}{2}$  cubic yard where it is again taken up by the canal below, is—

|                                   |               |
|-----------------------------------|---------------|
| In the Toombuâdra Basin . . . . . | 50,000 acres. |
| „ „ Câulee „ . . . . .            | 30,000 „      |
| „ „ Koondêr proper . . . . .      | 100,000 „     |
| „ „ Pennâr „ . . . . .            | 3,300 „       |
| Total . . . . .                   | 183,300 „     |

To which can be added, at an expenditure of 2s. an acre—

|                               |               |
|-------------------------------|---------------|
| In the Câulee Basin . . . . . | 17,000 acres. |
| „ „ Koondêr proper . . . . .  | 50,000 „      |
| Grand total . . . . .         | 250,300 „     |

Since the supply amply suffices for growing a second crop of wheat for every acre of rice, and it is already found that this cultivation is commencing, during the first season of the canal being opened throughout, the revenue possible at the present water rate of Rs. 6 an acre, and assuming no first crop irrigated except rice, is £300,000; and the yield, at the average yield of five years under tank irrigation in the Kurnool district, would be above 300,000 tons of rice grain, and about 500,000 tons of rice straw, and about a third of that weight of wheat and wheat straw; quantities which could be increased by the importation and use of manure. But in order to grow so much rice, the irrigation of dry

crops, such as indigo, cotton, &c., would have to be neglected; though the demand for irrigating such crops is, so far, as extensive as that for rice.

In reference to navigation, the capability of the canal seems ample; and it may be necessary to explain the reasons for this. The Board of Directors were desirous of commencing with locks of a smaller size—more like the inland locks on English canals—but at the desire of the Madras Government, expressed in 1866, this was given up. Supposing the accommodation for traffic on the canal to offer no greater attractions to the native public than that of a railway, the weekly traffic may be estimated as equal to that on the N.W. line of the Madras railway when open to Muttonpully—or say £5 per mile a week. If to this be added the immense traffic created by the canal itself, more than equal to the whole then traffic of the N.W. part of the Madras railway, the result will be as follows:—

The total population of the districts through which the canal passes is about 700,000; a population capable of consuming annually 127½ million measures of rice if they ate nothing else. The possible yield of grain is 250 million measures of rice, and 83½ million measures of wheat. Supposing that 250 million measures of grain are not eaten by the local population, the only means of getting rid of them freely is by the canal, and this gives, at 3 lbs. a measure, above 300,000 tons. If this quantity be carried annually over half the length of canal, it gives a daily traffic of 500 tons a mile every working day; to this must be added straw, manure, and the commodities purchased by the sale of the product, besides all the traffic which a railway would have, as above estimated.

But a brief comparative sketch of the Madras Irrigation and Canal Company's canal between Soonkêsala and Cuddapah, and of the Grand Junction canal between Brentford on the Thames and Braunston, will give as good an impression of the work as any technical description can do.

The Grand Junction main canal is 90½ miles long, 4½ feet deep, 36 feet broad at the top, and 24 feet broad at the bottom. The Soonkêsala canal is 190 miles long, of which 75 miles are never less than 100 feet in average breadth, nor 8 feet in depth, and average about 253 feet breadth at the top, and 9 feet in depth. The locks in the English canal are 86 feet long by 15 feet wide; in the Soonkêsala canal 120 feet by 20 feet, or nearly twice the size. The navigable branches of the Grand Junction are 28 feet, and even 20 feet broad at the water level; while the narrowest por-



tions of the Soonkêsala canal are 70 feet, or, for a few miles, 65 feet. The former has one hundred and two locks, averaging  $7\frac{1}{2}$  feet rise; the latter has only forty-seven locks (reckoning double ones as two, and besides three level floored locks), averaging  $9\frac{3}{4}$  feet rise. The former was commenced about 1795, and was completed as follows: 15 miles were opened up to November, 1797;  $28\frac{1}{2}$  miles more were opened in June, 1798;  $20\frac{1}{2}$  in 1799;  $25\frac{3}{4}$  in 1800;  $6\frac{1}{2}$  in October, 1800, and 3 more, including the Blisworth tunnel, in March, 1805; making, with the Paddington branch opened in 1801, a total of  $102\frac{1}{4}$  miles completed in ten years, at a cost which ultimately reached about £2,000,000. The Soonkêsala canal, 190 miles long, was commenced in October, 1861, and was all brought to completion, as required by the Company's engagement with the Government, in June, 1871, or in about ten years, at a cost which, when it includes wharves and floating stock, will reach about £1,750,000. It would probably have been better had the Grand Junction canal been originally constructed of the size of the Soonkêsala canal; for, though it worked profitably to itself—so much so that its £100 shares rose to above £200—yet it proved too small to accommodate the traffic it developed, and has therefore sunk for the present under the competition of the railways. It is interesting to compare the size of the towns affected by the two canals at the time of their opening. London had then 864,845 inhabitants; Madras has about 760,000. Northampton had 7,020; Derby, 10,832; Dudley, 10,107; Walsall, 10,400; and Birmingham, 73,670. Kurnool has about 12,000; Cuddapah, 25,000; Nundial, probably 7,000 or 8,000. Again, the producing and manufacturing powers of the two districts are strikingly similar, though in contrast. The Grand Junction canal promoted the production of coal, iron, and lime from below the earth's surface, and the industrious manufacture of exotics by machinery; the Soonkêsala canal cannot but promote the production of material for food, clothing, and luxury upon the earth's surface, and the manufacture of food, cloths, colours, paper, &c., for which the Madras Presidency was formerly celebrated over the whole of Europe and Asia; and for this work the population is likely soon to be adequate.

Not only corn-fields, but also gold-fields, are far better off in a climate of prolonged settled weather and short heavy rains than in one of comparative uncertainty. It is far better for the gold-digger to have a store of water with which he can work during dry healthy weather, than to have to work in an uncertain climate where he is liable at any time to be flooded out or left dry.

It is satisfactory to find that, while the Governments in India

are becoming alive to the value of irrigation in the centre of India, those of Australia are seriously considering the same subject; and it may be hoped that the English nation will not long be behind the Hindoo, the Italian, and the Spaniard in irrigation, as they at present are.

The communication is accompanied by a series of diagrams, from which Plates 14, 15, and 16 have been compiled.

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[GENERAL STRACHEY,



GENERAL STRACHEY, R.E., thought the Paper was exceedingly valuable, and explained extremely well the great work on which the Author had been engaged in Southern India. His experience had been confined almost entirely to Northern India, and there was very little he could usefully say on the engineering questions which were at issue. If, in the course of the discussion, reference was made to matters not of a specially engineering nature, but touching the general subject of irrigation in India, he would make such remarks as occurred to him.

Sir A. CORRIE said he had had fifty years of Indian experience, and could speak with some authority on this subject. The Soonkêśala canal was a grand work on these grounds: First, it was a large work in the upper country. Irrigation works had been executed by the Government in the deltas of the rivers and in the interior plains, but they were very different in their nature from this, which was carried through a vast, rocky, undulating country with a great fall. In the next place, it was the first instance in India of a thoroughly well-projected and well-constructed system of steamboat canal 190 miles in length. Other navigable canals of considerable extent had been constructed, and the canals of the Godavery could be navigated by steam-vessels, but these were not so complete as they ought to be. Even in America there was no steamboat canal to this day. With respect to the projection and execution of this work, he had examined all the papers that had passed between the Government and the company. It was a matter of notoriety that there was a strong prejudice on the part of officials in India against enterprises of this kind, and the papers he had seen all bore the stamp of that feeling. It was therefore quite safe to consider that in those papers any mistake in projection or execution would be brought forward, and the tone of the papers could not be mistaken. Going through them, he never was more satisfied that there was no considerable mistake either in the projection or in the execution of these works, and that they were thoroughly effective. Numerous errors were pointed out, but they were mere trifles, not affecting in the slightest degree the real, fundamental points of the work. It was a great satisfaction to him to find that it was so. The feeling was, and had always been, exceedingly strong against private enterprise in India, and every effort had been made to suppress the present company. As a rule such works got entirely into the hands of the Government; but he considered it was extremely important that these works should be entrusted to private companies, for, if any questions arose, there was no

appeal in the case of Government works. If the people thought themselves aggrieved in respect of the arrangements about water or the price, they appealed from the power which they considered treated them injuriously to that same power. They had no redress. This had been forced upon his attention repeatedly in India, because several times when he had tried to defend native rights, he had found it impossible to do so, for the authorities were the very persons they had to complain against; and he had been baffled again and again in that way. Now if a company sold the water, and the native considered himself aggrieved, of course he could appeal to the Government, and, what was more, the bias of the Government was always on the side of the native. The natives themselves were extremely sensible of this. He could not conceive what the feeling was against these works being in the hands of a company. This work now consisted of a canal 190 miles long, leading the water of the Toongabudra into the valley of the Pennêr, and by that river to the district of Nellore, where there was a vast extent of native works which had been improved by the Government, and which would receive any water that was not used on the line of the canal. The project was complete in itself in a certain sense. It would irrigate 250,000 acres of rice during the monsoon, and 750,000 acres of what was called dry-grains after the monsoon. Moreover, there were 190 miles of navigation to bring the produce down to a certain point. But two things were required in addition; first, the navigation should be completed from the end of the canal to the beginning of the Government canal at Nellore, a length of 80 miles. When that was done there would be water carriage from the head of the canal to Madras, about 400 miles. Without this the work would be in a certain sense imperfect; that was to say, at the end of the canal the produce would have to be delivered over to the railway, to be carried, at an expense it would not bear, to Madras. If, however, the water transit were completed, it would open the whole of this highly-irrigated country, not only to Madras with its 500,000 inhabitants, but also to all the markets of the world. Therefore he considered the first thing necessary to be done to complete the project was that line of water communication. The other requirement was to store water to keep the canal supplied for the five months during which the natural supply failed. Water could be stored economically all over the valleys of the Toonga and Budra, in quantities sufficient for an additional million of acres during the dry season. These two works could be executed at prices which

would greatly increase the general return of the whole project, though the works as they now stood were, in his opinion, abundantly secure of getting a large percentage upon the outlay.

A minor point he would allude to was the cost of making these canals navigable. In this case there was a gradient of 450 feet in 190 miles, or  $2\frac{1}{2}$  feet per mile, and the outlay had been £150 per foot of fall; therefore with  $2\frac{1}{2}$  feet fall per mile it was £375 per mile. In considering the expense of transit works in India he would refer to the grand standard, viz., the cost of the railways in that empire. This had amounted on the average to £20,000 a mile, while the cost for lockage on this interior canal was, as he had stated, about £375 per mile—an insignificant item in comparison.

There was now open in India an unbounded field of enterprise and employment for the Civil Engineers of England, and the Madras Irrigation and Canal Company had done sensible benefit to the country in thus opening their works, and he hoped they would be permitted to complete the whole project which he had sketched out.

Even in England, where the distances were comparatively insignificant, the cost of transit was an important question; but in India it was of vital importance, where materials or produce had to be conveyed 500 or 1,000 miles to reach markets and ports. As yet almost the whole of India was shut up from the want of cheap water carriage. The railways could not properly open up India. They were carrying goods at 2*d.* per ton per mile on an average, and this only by being backed up by a heavy annual subsidy from the Government, and that charge of 2*d.* a mile was, in fact, a complete failure. India could not be developed under such a system; it must have cheap transit. He wished generally to express his opinion on this subject as an officer of long experience and a Government official. In many respects he stood in a peculiar position with regard to these works. He neither projected them, nor had he anything to do with their execution; nor was he in any way connected with the Madras Irrigation and Canal Company. He spoke as an unbiassed individual; but he could not refrain from expressing his satisfaction at seeing this extensive work completed and brought into active operation.

Irrigation works in India were now projected, and all but two or three of them were in process of execution, which would be completed at a cost of 35 millions sterling in irrigation and navigation, so that there was really an extensive work going on in this essential point.



Mr. BATEMAN said there could be no question as to the great importance of this work, both as a work itself, and with respect to the advantages it must confer upon India; but he confessed to being somewhat surprised at the sections of the embankments. He was himself rather an old hand at making reservoir embankments; but he must say that he dare not construct reservoir banks in the way these canal banks appeared to have been constructed. Fig. 8, Plate 15, represented an embankment 30 feet in height with a wall 2 feet thick at the top, and not more than 6 feet thick at the bottom. He could not comprehend how that bank, even with the water in the canal, could stand at all. If it did, it was a new plan of engineering, and was something from which engineers might learn, and possibly copy, for the future. He was quite sure no railway engineer, much less an hydraulic engineer, would venture to build a wall 30 feet high, 2 feet or 2 feet 6 inches thick at the top, and 6 feet or so at the bottom, and expect it to stand.

Then, as to the masonry revetment (Fig. 9), founded on sand, with no protection or provision to prevent the water from the canal passing through into the bank; that wall, judging from the scale, could not be more than about 2 feet 6 inches thick, and again he could not understand how that stood. If it did, it was a valuable piece of experience in engineering. He would like to ask the Author what was the character of the sand on which that wall stood. If it were pure sand, a depth of water upon it of 30 feet would cause it to act simply as a filter, and the water would escape. If it were argillaceous matter, mixed with sand, it might be so made as to be impermeable to water, particularly if it were made by basket labour and padded over, as on the Corrigent. If so made then he could suppose an embankment might be formed without puddle but impervious to water. Still the material of a bank had a particular slope at which it would stand without thrust; all above that slope would exercise a pushing force or pressure from behind, and such a revetment wall supported as shown he should scarcely expect to stand.

Again, three sections (Figs. 15, 16, and 17, Plate 16) were recommended for adoption, as the mode in which every embankment should be formed, by puddle walling on the face or slope of the embankment, without this face puddle being tied into any material at the bottom or foot of the slope. The great difficulty in constructing water-tight banks in this country was the character of the ground on which the embankment had to be formed. With the right material, and with the materials properly put together, a water-tight embankment might readily be made; but there was



great difficulty in preventing the escape of water below the embankment, through the natural ground on which it rested. If it were, though sandy, a water-tight and somewhat argillaceous mass of alluvial deposit, such as he could imagine would be found over a great portion of India, then there was not only a good material, but a material which could not, except by unskilful management, make a bad bank. If it were put together in thin layers, well trodden, it must inevitably make a water-tight mass, which would be safe. In this country where there were not such good materials, there was danger in putting puddle on the face of an embankment. The embankment, except it were made of sand, gravel, or stone, would gradually settle, the facing of puddle would crack, and the water would escape. These were his experiences; and he should be afraid to trust to less precaution than practice had taught him to adopt.

By way of illustrating how an embankment might be made perfectly safe, the Author had suggested an embankment 200 feet in height, through which the water should leak, but so as not to destroy it. Engineers usually endeavoured to construct banks water-tight in themselves, without any leakage. It was a new doctrine that embankments to be safe should be leaky, though he had known several cases of reservoirs so leaky that they were never filled, and consequently never washed away. But it did not answer to make leaky embankments. The ordinary filtering medium in this country was about 4 feet in thickness. The quantity which he understood the Author to say would filter through this embankment was 500 gallons per square yard: that would be little short of 60 gallons per square foot. He did not know in what time that would take place; but a good filter would allow 75 gallons per square foot to pass in twenty-four hours. The water to be filtered rested on fine sand, which was supported by a coarser medium of sand, and that again was supported by a coarser still, till it got to round boulders as large as turnips and potatoes. That filtration was carried on under only 1 foot or 2 feet of water pressure; or, in the case of the London Waterworks, 3 feet or 4 feet. Where the water was 200 feet deep, he should be sorry to contemplate the result in a work for which he was responsible. In making these remarks he did so only to elicit further information, as to the character of the material on which these banks were constructed, and of which they were made.

With regard to the masonry of the weirs, one of them appeared to have been placed upon red shale (Fig. 5, Plate 15). Now shale



was not a durable material with water falling vertically upon it; and unless the masonry floor was very firmly fixed, the drop of the water from a height of 14 feet 6 inches would suck out that masonry sooner than it would in that weir which was of greater height, but was placed upon the much harder gneiss rock (Fig. 3). The safety of such a work depended entirely upon the character of the rock over which the water fell. As a rule, his experience was that a perpendicular face was not a judicious form for constructing a weir, and that unless the work was built on substantial rock, the foundation was liable to be injured. A sloping weir, which allowed the water to fall gradually to the foot, was a safer mode of construction. He should be glad to hear how the sand and gravel in these banks were put together. In some valleys in Spain in which he had constructed weirs, the material consisted of sand or gravel of such an argillaceous description that it was hardly possible to make a bad bank. But if the embankment was to be formed on ground not itself water-tight, and if it had to be raised 40 or 60 feet high, it required a large amount of skill and caution to secure a good foundation.

Mr. ROBERT C. REID contended that an embankment wholly of earthwork and puddled clay would make a safer and more lasting structure than a composite one of masonry and earthwork. The method proposed by the Author for constructing embankments which could leak without detriment to their stability might be theoretically correct, as far as the bank above the natural surface was concerned, but it was difficult to see how such a structure could be tied into the ground on which it stood so as to be safe. The site for such a bank must be prepared, either by excavating the whole material under the base down to an impervious stratum, and rearranging it according to the plan adopted for the portion above the surface, or a puddle trench would have to be dug and filled with clay all round the inside toe of the bank, where the finest material was placed. In order that the embankment might act as a filter-bed, the different materials must shade into each other, from fine sand to rubble, by minute gradations, or else the sand would be blown by the water through the rubble; and the process of selecting the available materials, by riddling or otherwise, and placing them in their proper positions, would be very costly. Provided the gradations were perfect, the finer the particles at the inside, the less would be the leakage, and if they were very fine, as in clay, there would be no leakage at all. There would therefore be great varieties in the retentiveness of different embankments built in this manner, and indeed in different portions of the same

embankment. It would be almost impossible to predetermine how much a given embankment would leak, and there would be no certainty of having sufficient command over the water in the reservoir, so as to regulate the supply from it.

As regarded the construction of water-tight embankments, the plan of placing the puddle wall along the inside slope was not so good, in Mr. Reid's opinion, as the vertical wall in the centre of the bank. More puddle would be required, since the area of the slope was greater than the vertical area, while the puddle trench having to be carried round the toe was longer than if it were in the centre line, and, in the event of settlement, the puddle if at the face, being inclined to the direction of subsidence, was more liable to crack than if it were in the line of subsidence, as it would be if vertical.

The proper function of the puddle wall in an embankment was to stop the 'creep' of water, which was inevitable in all earthwork unless wholly constructed of clay or other impervious material. Whenever water acted upon clay in any volume, with the slightest motion it disintegrated the particles. Now this was the condition in which the puddle would be in, if at the inner surface, with nothing but rubble and gravel between it and the water; for every wave in the reservoir would have its corresponding undulation in the water lying against the puddle wall, and would eventually in this manner eat into the clay. But, by placing the puddle wall in the centre, there was a great thickness of earth between it and the water, and the minute tubes which carried the water through the earthwork effectually retarded the action of waves in the centre, as well as prevented the direct pressure of the water on the puddle. If, however, the earthwork of the inner slope was of open, stony material, tipped in layers of 5 feet or 6 feet thick, and the stones were allowed to roll down to the bottom of each tip, it would not have the desired effect in protecting the puddle wall. Hence it was, that experienced engineers specified banks to be built in thin layers, with the most clayey portion of the material inside and next the puddle wall. On the outside slope the material next the wall should also be clayey, so that it might bear with the same effect as the inner slope on the wall, and keep it in equilibrium. The layers should also be sloped inwards to the centre, so that the beating and consolidating would tend to press the earth against the puddle wall with as great force as the water of the reservoir would when full. If the outside slope was not capable of exerting such a pressure through an infinitely small space, it could not sustain that pressure; and whenever the water rose, it would yield, the

puddle wall would bend, and, having no elasticity, would crack and cause the destruction of the bank.

There was hardly any limit to the height an embankment might be raised, as far as its power of resisting the pressure of the water was concerned; but the site on which it was built might not be able to carry the extra weight, and might bulge out above and below the bank. The slopes, which were sufficient for ordinary heights, would hardly be safe when the mass of artificial earth was increased to such an extent as was proposed.

Mr. A. J. Dobson, who had been engaged for eight years on this canal, said that, except the addition of a puddled foreshore, and the alteration of the outline of the bank in the rear of the masonry, the wall (Fig. 7), and the masonry revetment (Fig. 9), and all others of which they were types, were completed in the spring of 1865, and the puddle-core walls in the autumn of the same year. The length of canal in which the loftiest specimens of each kind occurred was opened for trial in 1866, without accident. The face walls (Fig. 8), 10,518 feet in total length, and the puddled banks (Fig. 10), were completed by Midsummer, 1868; water was passed down in July, and the canal navigated for 65 miles in August of that year, without doing them the slightest injury. A portion of ordinary bank, thrown up without selection, did, however, give way in that month.

Again, the walls represented in Fig. 7 were completed in 1865; no failure or accident occurred to these except during the extraordinary storm of August, 1870.<sup>1</sup> One wall in the 24th mile was then overtopped, and, as there was no protection to the bank overlying the ends of the wall, a breach occurred at the junction, carrying away about 100 feet of the bank, and something less of the wall. Another wall, in the 28th mile, of narrower section than that shown in Fig. 7, also gave way, for the length of a chain or two; and consequently all the length of the narrow section of wall—a few chains only, and no great height—had been since specially protected in the front and rear. Fig. 9 represented a masonry revetment completed in 1865, above 1 mile in length. No failure had occurred to this revetment beyond cracks, except during the storm of 1870, when it was overtopped by the water, and the bank washed away from behind, so that a breach followed 220 feet long in one place. The scour of the water towards the breach set against the toe of the revetment in another part, where

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<sup>1</sup> *Vide* Minutes of Proceedings Inst. C.E., vol. xxxiii., p. 403.



a length of about 4 chains slipped into the canal, but no breach occurred there.

Puddle-core banks, Fig. 11, were liable to leak. One in the 30th mile, only 10 feet high, on fissured rock and gravel, had the lower part of its core washed out on the 29th of July, 1868. A puddle foreshore was then added, and no failure had since taken place. They were the least satisfactory, perhaps, of any of the sections, though they had never been breached. The banks shown in Figs. 8 and 10 had given no trouble, and they survived the storm of August, 1870.

The above mishaps were spread over a period of six years, and a distance of 65 miles. The first section was exposed to the action of river and land floods; the second, third, and fourth, to large waves on tanks, especially at Tongaduncha tank; in the fifth section land floods spread 5 miles against the upper banks 10 or 15 feet deep. It was to be remarked that the puddle was not of the best nature. It consisted of black cotton soil, which contained little clay. No thought the wonder was that with these difficulties there had not been even more accidents.

Mr. Latham had stated that 2 cubic yards per hour per acre was the datum on which his calculation of the amount of water for irrigation had been made. Colonel Cotton insisted on 1 cubic yard on the Cauvery and Colleroon irrigation works which he constructed; and Sir Arthur Cotton said that in the Tanjore and Godavery works  $1\frac{1}{3}$ rd cubic yard was sufficient, or 4,000 yards for the one hundred and twenty days of wet cultivation, and 1,500 cubic yards for dry crops. If that were the case the capabilities of this canal were far greater than those named in the Paper.

With regard to the navigation of the canal, the Author had stated what he imagined would be the amount of goods conveyed. That, however, would be only limited by the carrying power of the railway from Cuddapah to Madras, into which this canal now worked; but he was sure there would soon be a large amount of traffic in passengers. He had been up and down the Godavery canal, and he was astonished to see the amount of native passenger traffic from one place to another, in districts much less inhabited than those served by this canal. He confidently believed that both in an engineering and in a commercial point of view the Soonkésala canal would prove to be a success.

Mr. G. H. Purrs observed that the particular point which interested him was, as to whether canals in India could be made to contribute largely to the means of intercommunication in that country. From the observations of Sir Arthur Cotton he appeared



to be under the impression that railways, which he assumed had cost £20,000 a mile, could not do much more for intercommunication in India than irrigation canals. Mr. Phipps thought it might be well worth while, where such a canal as the present one, costing £8,000 or £9,000 per mile, had to be constructed, to render such a canal navigable, if it could be done, as stated in the Paper, at such a moderate additional outlay as £375 per mile. He could not, however, conceive the idea of canals superseding railways as a general mode of communication over large tracts of a country like India. Although not in all cases, yet in a great many, particularly in the transport of troops and military material, speed of transit was a very necessary element, and in this instance, not only would the canal be affected by the ordinary causes of slow travelling, but this evil would be increased by the current against which the return boats would always have to contend. Assuming, however, that railways, and not canals, were to afford the means of travelling in India, the great thing was to construct them cheaper, so as to cover more ground, and thus tend to increase the trade and prosperity of the country. Their cheapness would possess the further advantage of comparatively easy renewal after being swept away by the heavy floods so fatal to such works in India. He submitted that what was wanted for India was an extensive system of railways constructed upon a cheap plan, for he never could believe that navigable irrigation canals could form an adequate means of intercommunication in that country.

Mr. Bruce said, on some of the drawings banks 50 feet high were represented as having been built on sloping ground; while on the high side he understood there was hardly any bank at all. He did not see why it was necessary to make walls of that height, if by slightly moving the direction of the canal laterally this could have been avoided. He thought Sir Arthur Cotton had injured his advocacy of canals by contrasting them with railways, because in India both railways and canals were wanted. It had been asserted that it was proposed to make an extension of this canal at the rate of £375 per mile, that the Indian railways had cost on the average £20,000 a mile, and that the latter could only carry goods at 2*d.* per ton per mile, while the canals could carry goods a great deal cheaper; and that therefore, in the proportion of £20,000 to £375, railways were worse than canals, independently of the greater cost of carriage by the former: but the fact was this very canal had cost about £9,000 a mile.

Mr. Phipps remarked that Mr. Bruce was under a mistake. It had not been stated that the canal could be made for £375 per



mile, but that that amount would render an irrigation canal navigable.

Mr. BRUCE said, he understood that the extension to Nellore was to cost £375 per mile for navigation, while this canal cost nearly £9,000 per mile; but if the £375 was only to do a portion of the work of making the canal, so much the greater the unfairness of putting that in contrast with the entire cost of the railways. In the Presidency of Madras the railways had not cost £20,000 a mile, and this estimate of £375 per mile had been put against the cost of carrying the railway across the Ghâts, instead of taking the cost of the railways in the presidency, which he believed did not exceed £12,000 per mile in the case of the Madras railway, and in the Great Southern it was the same as this canal. Of course rolling stock was included in the case of the railways in that amount, not so in the canals.

Lieut.-Col. J. G. MEDLEY, R.E., remarked on some points of detail in which this canal differed from those in the N.W. Provinces of India, that such comparisons were useful if only because the Engineers of Northern and Southern India had so little opportunity of seeing one another's works.

He should be glad to know if there were any masonry falls in the main canal, and if so, what form of fall had been fixed on? In Northern India, the vertical fall with a grating was now admitted to be the best yet devised. A cistern of water was sunk below the level of the lower bed, on to which the water fell as on an elastic cushion; while its force was also broken by its being first made to pass through a set of bars fixed obliquely in the crest of the fall, similar to the teeth of a comb. If there were no falls, the profile of the country must be very favourable, and the difficulties of navigation would be considerably lessened; but the combination of irrigation and navigation in the same canal involved difficulties which had never been successfully overcome in Upper India.

He inquired whether the under-slucices in the weirs placed across the main channel at the heads of the branch canals were found sufficient to prevent silting up? In the N. W. P. of India, regulating heads with wide sluices would be required across both channels at the points of bifurcation. He also asked whether the irrigation was all surface irrigation, or whether the water had to be lifted? And whether the water was delivered into the village water-courses from the main canal, or by intermediate distributaries? It was stated that measuring sluices were not needed. In the N. W. P. the difficulty had always been how to insure a constant discharge with a head of pressure continually varying; and

though various attempts had been made to overcome this difficulty, they had been unsuccessful, owing chiefly to the flatness of the country preventing there being any spare fall beyond what was actually required for the flow of the water. Hence the water rate was always assessed on the area irrigated, instead of on the amount of water delivered—an objectionable method, as it led to waste of water, and to continual expense in measuring irrigated areas, besides opening the door to disputes and interference with the cultivator's arrangements.

With regard to the formation of the banks, it might be noted that the great embankments by which the Ganges canal was carried for 3 miles across the Solani valley, at an elevation of from 10 to 40 feet above the bed, were formed of earth, with a double revetment of brick masonry built in steps. These had stood well, and there was no leakage. Puddled banks, without further protection, would be perforated by rats in Northern India, and there was no stone or gravel to protect the puddle by pitching: brick was the only material available.

It was estimated by Mr. Latham that 2 cubic yards of water per hour were only sufficient to irrigate 1 acre of rice. This was only  $\frac{1}{4}$ th of the irrigating duty now obtained from canal water under favourable circumstances in the N. W. P. when applied to wheat, the great staple of Upper India. One cubic yard per hour would there irrigate 2 acres; or, to use N. W. P. nomenclature, 1 cubic foot per second would be thought fully equal to the irrigation of 267 acres of wheat, in any canal where the irrigation was fully developed. On the Eastern Jumna canal, the most perfect in this respect in Upper India, 306 acres were irrigated in 1868-9. On the Ganges canal, where the distributaries were not yet completed, only 232 acres.

Of course the amount of water required for rice was very different from what was wanted for wheat; and although there was some rice irrigation in Upper India, it was in the autumn, when there was plenty of water available; whereas the chief crop, or wheat, was watered in the cold weather, when water was most scarce and precious. The water-rate assumed in the Paper, Rs. 6 per acre, would seem very high in Northern India, where sugar was the only crop that paid as much as Rs. 5 per acre for surface irrigation (Rs.  $3\frac{1}{2}$  only if the water had to be lifted). Rice paid Rs. 3 only, and wheat Rs. 2.4. For so large a discharge at the head of the canal as 400,000 cubic yards per hour, or very nearly 3,000 cubic feet per second, the length, 100 miles, seemed very small. This was the calculated discharge of the Barce Doab

canal, which when completed would be 470 miles long; and this difference made it of little use to compare the cost of canals under such different circumstances as those of Northern and Southern India. He had roughly estimated the cost of an irrigation canal in Northern India at about Rs. 4,000 per cubic foot per second of calculated discharge, or Rs. 30,000 per mile of length. The Soonkésala canal had apparently cost Rs. 50,000 per mile, or Rs. 3,330 per cubic foot per second.

Mr. BATEMAN said, the account of the failures which had taken place afforded some confirmation of the fears he entertained from looking at the sections of the embankments. With reference to the quantity of water required for irrigation, a cubic yard of water per acre per hour was equal to a depth of  $\frac{1}{8}$ th of an inch of water per day. In the south of Europe, in Valencia and Murcia in Spain for instance, where there were still many of the old Moorish irrigation canals at work, the ordinary irrigation amounted to  $2\frac{1}{2}$  inches in depth, renewed every fortnight in certain periods of the year, which was about the same quantity as was used in this case, if put on the land once a fortnight instead of daily; but rice required four or five times as much water as the ordinary crops of the country, and for about ten weeks of the year.

Mr. REDMAN observed that the remarks upon the formation of the embankments, rather confirmed the propriety of the criticisms of Mr. Aird on a previous occasion,<sup>1</sup> as to the absence of puddle, when it was said that the method of construction by basket-work, by men, women and children, was such as to knead the material into a very compact mass, so that it became of the nature of a puddle bank, the slope of the bank being 2 to 1. In the Bann reservoirs, County Down, the slope in some cases was 3 to 1; on an average  $2\frac{1}{2}$  to 1, with a puddle bank 10 feet in thickness.<sup>2</sup> In 1843 Mr. Thom rather curiously advocated the disuse of puddle for reservoir embankments, and described a peculiar arrangement of the laminae of the banks.<sup>3</sup> It occurred to him that the reply to the objection of Mr. Aird, that no puddle was used, viz., that the entire mass was so trodden down and consolidated as to be of the nature of puddle, might apply to some extent to the criticism of Mr. Bateman in this case.

Mr. BATEMAN explained that it was not the embankments he objected to, but the revetment walls, as being made too light in section.

Mr. RUSSELL ATKEN did not think any advantage had been gained

<sup>1</sup> *Vide* Minutes of Proceedings Inst. C.E., vol. xxviii., p. 410.

<sup>2</sup> *Vide* Ibid., vol. i. (1841), p. 109; and vol. vii., p. 256.

<sup>3</sup> *Vide* Ibid., vol. ii. (1843), p. 191.



by a departure from the old method of constructing earthen canal embankments, viz., a core of solid retentive earth, with a puddle trench in the centre of the bank to stop any leakage. Even in England there were serious objections to facing the slopes of embankments with puddle; and in India especially it was highly dangerous, because, when the puddle was not covered by water, the heat of the sun dried it up, and caused it to crack to a great depth. In India, too, vermin were a source of great annoyance and danger, and one bank of which he had charge was perforated by land crabs. Indeed it was almost impossible to keep vermin out without masonry when the puddle was near the surface of the bank. They forced their way through the loose stones, and he had no doubt the banks of the Soonkêśala canal would one day give a good deal of trouble from this cause. True, he had while in India successfully repaired one embankment by placing a puddle apron on the face of the embankment; but in order to prevent the heat of the sun and vermin injuring the puddle, he had covered it with pitching in Portland cement, through which vermin could not penetrate. The embankment was watered once a day to prevent it cracking.

He had some time since looked over Sir Arthur Cotton's writings, and he thought that officer's views would be very well represented by the following extract from one of them: "Several lines of railway have sealed up their tract of country probably for ever against cheap transit, and even against irrigation, for the railway men, must as it were for their lives resist irrigation works in the neighbourhood of their lines, as inevitably leading to cheap transit. . . . If the 30 millions to be spent in railways become a real warning to us, and make us consider, whether proposed works are really suited to the circumstances of India or not, they will not have been spent in vain. . . . Every shareholder, and every person in any way committed to that dreadful mistake is now in theory at least a necessary opponent of the works that are essential to the material progress of India."<sup>1</sup> That opinion did not agree with the North-Western Provinces Public Works Report for 1869-70, when, without the Ganges canal and other irrigation canals, there would have been a famine. It was there laid down that the irrigation canals by producing, and the railways by carrying the produce, warded off a famine from Northern India. He believed Sir Arthur Cotton overrated the advantages of canals as a means of communication. The Ganges canal, although con-

<sup>1</sup> Vide "The Madras Irrigation and Canal Company." 8vo. Madras: Graves and Co., 1860, pp. 55 and 56.



structed for and used by barges, was almost worthless as a means of transit; nor was the revenue derived from tonnage dues of any material importance.

It was stated in the Paper that 50 per cent. of the cost of the works was spent on engineering and for unused stores. That seemed to be a very large percentage indeed, and he could only attribute it to the fact, that the money expended on these works was capital guaranteed by the Government of India. He had obtained from Mr. Fleming, who conducted the affairs of the Elphinstone Reclamation Company in Bombay, an unguaranteed work, to a successful termination, a return showing the cost of engineering during the construction of those works, from which he found that when, as in 1866, the expenditure was £350,000 for the year, the engineering cost  $2\frac{1}{2}$  per cent.; afterwards it was, on £280,000, 3 per cent.; on £140,000,  $6\frac{1}{2}$  per cent.; on £180,000,  $4\frac{3}{4}$  per cent.; and in 1870, on £100,000, it was 7 per cent. In 1868, Mr. Aitken reported that the cost of engineering many miscellaneous works in the town and island of Bombay, aggregating several hundred thousand pounds, was 4·8 per cent. on the expenditure. In the Public Works Department, which was burdened with a number of persons who were not available for strictly engineering work, the cost of engineering was understood to be 25 or 30 per cent. on the money expended. He therefore thought some explanation on this point was due; for, even allowing £500,000 to have been expended on engineering and unused stores, there was still a sum of about £250,000 unaccounted for, and available for cost of management, &c.

If there was no error in the Paper, it condemned most effectually the guarantee system when applied to canals, which ought to be treated as remunerative works. Doubtless the guarantee system, when applied to railways, had enabled a great deal of work to be done rapidly; but railways were required for political and military purposes, and could not in India, up to this time, be considered simply as remunerative works.

Mr. R. RAWLINSON, C.B., said he could not tell whether the diagrams of reservoir embankments exhibited were for instruction or for warning. If for instruction, he thought they were calculated to teach a very bad lesson; if for warning he would point out a few of their mal-arrangements. Looking at the diagrams, they seemed to represent ordinary cross sections of a waterworks impounding embankment; having slopes of 3 to 1 on the inside and of about 2 to 1 on the outside. No puddle trench was shown below the surface, nor any puddle wall in the main portion of the bank.



The outside half of the embankment was of porous material—purposely, as it seemed: the inner portion he assumed was intended to be water-tight, or, at all events, to be made water-tight when protected by puddle on the surface. He cautioned young engineers against following such an example as that; for a lining of puddle laid on the surface was most troublesome, especially if it lay on a mass of earth liable to subsidence and motion such as water-works banks would have, and especially if the material on which it rested was in any degree porous. Now, although he did not in all respects agree with the modern practice of sinking a puddle trench to a great depth (150 feet in a recent case) to get to what was supposed to be a water-tight stratum, yet he held that the practice of sinking a puddle trench to a moderate depth was one which might be safely followed; and he also held that the modern practice of constructing a puddle wall in the centre of the bank had some advantages if the puddle wall was supported by carefully-selected material, that was, by a pyramidal core of water-tight material. The tail of the outer half of the bank might then be of porous material, and even the inner foot of the bank also, the core being sound and water-tight; but to him a porous bank in the way shown on the sections, either for first construction or subsequent repair, was, in his opinion, very defective engineering, and might prove to be a very misleading, because dangerous, operation. If the inner slope was of a material not in itself water-tight, there was a method to make it so far better than by putting puddle on its surface. If, when the reservoir was being filled with water, and as the water gradually rose against the bank, a number of men were placed along the water line with flat bars or gaffing tools, and were instructed to run them down well into the material, and shake them so as to wash in any loam with the water as it rose, that would make the surface non-porous to the depth the operation was carried down; and such process would be less costly than puddle; the sun would not cause cracks, nor would vermin have the same facilities for getting through it as through puddle.<sup>1</sup> He agreed with the Author that it was better to lay broken rubble

<sup>1</sup> The mass of an embankment to impound and confine water under pressure should be sound and perfectly water-tight without the aid of puddle-lining, or surface washing and warping, as described, or risk of a catastrophe would be incurred. A little care in forming a reservoir embankment is of more value than a large expenditure in subsequent repairs to patch leaks, which, as a rule, cannot be patched. The three rules in reservoir works may be thus stated—care in selecting a site, in placing the material, and in filling and subsequent working.—R. R.

on the inner slope in preference to masonry pitching. He thought masonry pitching, or wall stone, or block-in-course, formed a dangerous coating for the inner face of a waterworks bank, as the stones were liable to jam and make an arch beneath which cavities might form, and the mischief go on for a time till a failure occurred without the engineer knowing it. When a puddle trench was in rock or stable material, it was sometimes the custom to cut vertical steps. He cautioned persons who had puddle trenches to construct never to make anything of the kind, because of the liability of subsidence of the bank. If a tangent line of the subsidence was drawn, and the lines then brought down at right angles, it would be seen that the tendency would be to draw the vertical line from the upright face. Much mischief had been caused through the drawing away of the puddle from the vertical face. It was therefore expedient to let the puddle trench rest upon a slope not much dissimilar to the slope of the side of the hill where the work was. Supposing the site of the reservoir was not absolutely water-tight, instead of sinking a puddle trench 150 or 160 feet he would go down, say 30 feet, and would put a thick bed of concrete at the bottom and up the outer side, and then form drains from the outer face of concrete away from the trench into a man-hole, where the water that came through could be seen; so that if there was leakage it would be known that it was leakage through the substratum in contact with the concrete, and would come to daylight at the foot of the slope, and could be sent into the gauge basins for compensation without causing mischief to the bank. The engineer must exercise his ingenuity as to when and how he would do these things. Under any circumstances the outer half of the embankment, commencing from the puddle trench, should be perfectly drained in a way that the drains should remain permanent, so that the engineer should have the opportunity of seeing any water coming from that portion of the subsoil of the bank, and if the water did not come away muddy he might rest satisfied it was not doing his bank any harm. If after-repairs to the bank were necessary in the line of the puddle wall, he recommended engineers not to make the repairs good with puddle, supposing it was a soft bottom which caused leakage, but to use concrete.

Mr. E. A. COWPER asked how the clay was to be got into the bank? Mr. RAWLINSON had suggested a means of dibbling in clay as the water rose, but he did not see how the clay was to be mixed by the grafting tool.

Mr. RAWLINSON replied that clay was not necessary. Supposing there was a gravel or sand substratum to be made water-tight,

loam or soil incorporated with the gravel would make a sort of concrete and would render the bank water-tight. It was not an idea which originated with himself, but was practised by early canal engineers, as on the Bridgewater canal. He had made a service reservoir, situated on sand, perfectly water-tight by the process of washing in loam with flat bars as described.

Mr. BEARDMORE said he had known several banks in which no puddle was used; for instance, the North Level sea-banks were said to be chiefly composed of sand. If there was liability to rapid lowering of the water in the Soonkêsala canal the puddle slopes would be liable to slip, and in that respect a centre puddle wall was to be preferred.

Lieut.-Col. J. G. MEDLEY, R.E., asked whether the system suggested by Mr. Rawlinson would do for running water, or did it only apply to reservoirs or still-water canals. Such puddle banks in Upper India would have to be made in some cases where there was a velocity of water of 3 or 4 miles an hour, where, as fast as the dirt was thrown down, it would be washed away.

Mr. RAWLINSON said it was self-evident that during the operation the water must be comparatively still, and there must be a sufficiency of water and no more.

Mr. R. E. FORREST said, although no one had greater respect and veneration for Sir Arthur Cotton's works on India than he had, yet he thought the views put forward with regard to canals might do great damage to the cause of irrigation. It was foolish to compare canals with railways as means of transit and carriage. Irrigation was absolutely needed; but Sir A. Cotton wanted to combine navigation with irrigation. Now it was difficult to combine the two, the requirements being so different. A navigable canal required a sluggish flow of water; but for an irrigation canal the faster the current flowed the better. A high velocity saved cost and gave a better irrigating machine. The ordinary problem that presented itself was two big rivers with a tract of land between them; and the water had to be taken from one of those rivers to irrigate that tract. The best line for carrying the canal was on the ridge between the two rivers, because it then commanded the land on each side. But this central ridge was generally the poorest and least populated, and that was the reason why an irrigation canal was wanted there. All the large cities lay along the big rivers, and to carry goods canals must be made from city to city. Therefore at starting it was found the irrigation canal ran where there was no traffic; in fact, did not go near the large markots.



The slightest change in the section of a canal of the usual size in India made such a difference in the cost as to affect the whole question of the returns. For a canal, which he projected a short time since, he was told that to enable boats to stem the current the velocity must not exceed  $2\frac{1}{2}$  feet per second. Supposing the current had a velocity of  $3\frac{1}{2}$  feet per second, to make it navigable it would be necessary to change the whole design, and the cost would be nearly doubled. In his opinion it was preferable to keep the two questions of irrigation and navigation entirely distinct; and as food was the first necessity for the resident population, he thought it would be better to construct irrigation canals at once, leaving the consideration of the facilities to be provided for its transport to more distant localities, whether by navigable canals or otherwise, to be dealt with hereafter.

The system of canals in India was not generally understood, but it was very simple. The canal started from a big river to irrigate a tract of land, with the water running at as high a velocity as the bed would stand. It was necessary to design the canal to carry 3,000 cubic feet of water per second in the monsoons, and only about 1,800 feet in the winter season. When in addition arrangements for navigation had to be made, it swelled the cost to such an extent as to make the returns almost problematical. He spoke from experience of some large canals which had been projected by European engineers. Without the arrangements for navigation, such as locks and still-water reaches, and as irrigation canals alone, they were calculated to give a return of 8 or 9 per cent., but when arranged for navigation it would be rather difficult to make them pay 4 per cent.

Considering that it was so difficult to get money for irrigation works, that in India there was a disinclination to raise more money by additional taxation, and that railways were better adapted for carrying than any other means of conveyance, he thought it would be better to make the irrigation canals, and to leave the navigation alone.

Mr. J. H. LATHAM, in reply upon the discussion, said, with regard to the face walls, Fig. 8, that there were 5-foot counterforts, 16 feet apart, from centre to centre, on the water side of the wall. Considered as a retaining wall, it was stronger than many to the west and south of London, but not so strong as would be built were the sleepers of the permanent way laid close behind the coping. The gravel was not water-worn, but quartz split into irregular crystals, and was much rougher than water-worn gravel.

The masonry revetment, Fig. 9, was not lying on clear sand, as

had been supposed; it was silty river sand, and a section would stand vertically 12 feet high when dry; but water would percolate through it. The puddle at the toe ran across the whole of the canal bed, and so made it water-tight, and prevented any percolation. In the flood of August, 1870, when 12 inches of rain fell in twelve hours, the water topped the masonry revetment, and it was then not a question whether the wall was a sound one or not, for the sandy bank behind must have been washed away. The revetment wall, which was not a self-supporting wall, but rested upon the bank, of course failed; but the face-wall (Fig. 8) had never suffered.

The Soonkêsala anicut (Fig. 4) was generally upon solid gneiss, and occasionally trap; but hitherto there had been no danger from the rock being carried away. The Rajôli anicut (Fig. 6) was upon limestone, about 10 inches thick in the bed; and though limestone was a treacherous formation when beds of dirt lay between the strata of stone, in this case the stone was solid, and, as the fall was not great, it was uninjured. The Jutoor anicut (Fig. 5) was in a part of the river that contracted below the weir, and consequently, before there was much water flowing over, the crest of the weir was almost 'drowned.' The fact that the water-cushion had not suffered therefore proved little. Indeed, the spoil, or rocky deposit of the river, rose in rear of the water-cushion, and when the water ceased flowing over the weir the standing water almost concealed the crest of the lower wall of the water-cushion. Nothing with regard to water-cushions could be learnt from that. He supposed, from the fact of the face-wall (Fig. 8) not having given way under the great flood,<sup>1</sup> that the work was good. Great care was taken with it, and it was built under close supervision and inspection over very short lengths at a time.

As to the imaginary sections, he considered it an advantage to have puddle in front, where it could be got at, not quite on the slope, but protected in front. Care had to be taken of the quality of the puddle. If it was liable to run it could be put further into the bank, and a greater weight of gravel and shingle laid in front to hold it up. But the puddle was not the only protection; it lay upon earth; and a sun-crack running through the puddle would not be liable to run continuously into the earth, which was not homogeneous with it. Even if leakage existed, the bank might

<sup>1</sup> When a portion of the old wall gave way, as Mr. Dodson described, under the flood of August, 1870, the water was suddenly lowered in the canal in front of the face-wall; but the face-wall stood that test without any cracking or failure.—J. H. L.



theoretically be constructed so as to be secure, as in Fig. 14. In practice such a delicate arrangement of stone and sand would be difficult to obtain, but with puddle in front the leakage was so small that such refined selection was not necessary. In cases of rock foundation, or of irregular foundations of different kinds of strata, the subject was too wide to enter upon. But he had shown a puddle trench, with sheet piling in the centre (Fig. 17); the object being to throw down the leakage, so that whatever there should be must flow out clear of the bank, without any tendency to scour or remove the material of the bank itself, or the material on which the rear of the bank rested.

The relative merits of railways and canals in America and India were very different. In the former case railways had been used for opening out the country; but in India canals were more suitable.\* In America every man understood a good deal about the repairs of railways. In almost every hamlet the first thing erected was a sawmill, and in the larger towns wooden lattice girders could be bought ready for use. In India the people knew little or nothing about railways; but they did understand irrigation. In every village there were a number of woddahs, or native navigators, and in every district a large expenditure was incurred annually in repairing tanks, wells, &c. While in America the country was opened out by railways before it was inhabited, in India the first thing was to provide some means of irrigation, if it were only by wells; but after the country had been opened out by canals, railways would be necessary for developing trade. He believed that if a tract of country were opened out by a canal it would often be found the cheapest means of commencing a traffic to make that canal navigable; and he thought that this course had been wisely pursued in the canal under discussion. It had a series of up-takes from different rivers; and consequently never got so far from the large towns, which were generally near the river side, as the Ganges canal. It was the reverse in another point: the Ganges main canal had a fall of about 18 inches a mile, and the distributing channels less fall; and thus, when the distributing channels were full, there was a current of 3 miles an hour: whereas in the Soonkêśala canal the usual fall was 6 inches and under; that of the channels was 2, 4, or 6 feet a mile; and there was scarcely a mile and a half in any portion where the current at all approached the velocity of 3 miles an hour. In the Soonkêśala canal the chief supply of water for irrigation was taken off from the canal just above the first drop-lock in each branch; so that if irrigation

were in full action, the navigation down to the locks, and of course in the ponds between the locks, must be complete. This was not the case in the Ganges canal. The banks of the canal almost necessarily ran across some rather deep hollows. An investigation was made of the relative cost, and additional length, of running round some of the valleys instead of across them, and the balance was struck. In one case, where the circuit of the valley was made, 1 mile was thereby lengthened into 3 miles. In other cases the ratio of increase would be greater, so that it was best to carry the canal across these valleys. There were no masonry falls in the canal, and the scouring action of the under sluices in the weirs was local. In more recent works the head sluice was at right angles to, and close upon, the under sluice, the latter being 3 feet lower, so that the scour took place across the whole face of the head sluice. The sand in the Soonkésala anicut for almost the whole length lay within about 18 inches of the crest.

No attempt had been made to deliver water by measurement; and though he had taken 2 cubic yards per hour from the Madras Government as the datum on which to calculate the capacity of irrigation, he had no more faith in that than he had in the previous Madras practice as regarded provision for drainage, which turned out fallacious. There had been no experiments to indicate how much water per hour per acre was required in that part of India. In the consideration of works of irrigation in Jamaica in 1871, the Surveyor-General of Jamaica, after careful inquiry, adopted 1 cubic yard of water per hour for rice irrigation; he imagined that was enough for a rice crop, and that 2 cubic yards an hour would be too much.

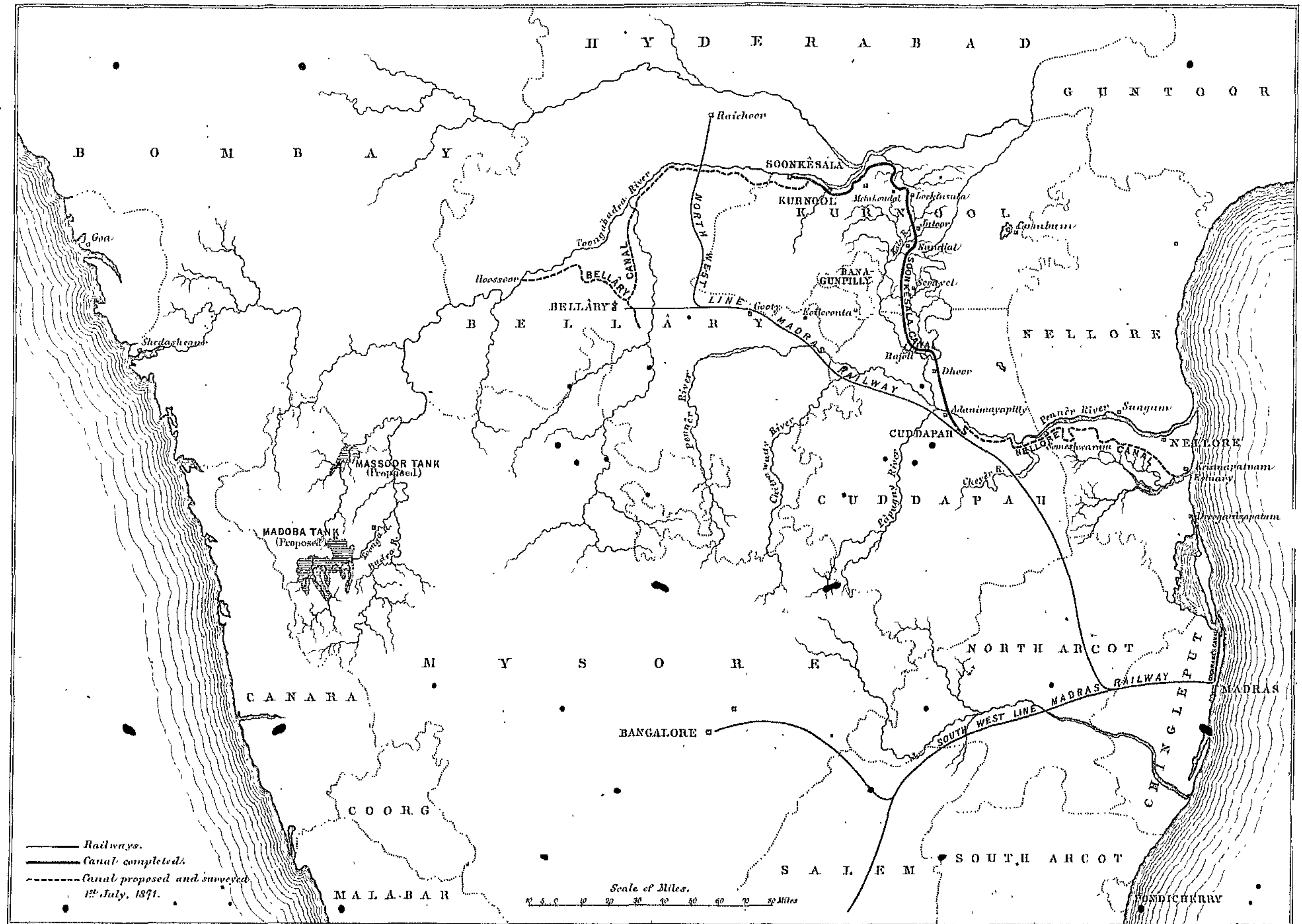
The cost of the engineering staff on these works included that of the surveys for the Nellore part of the works, the Bellary scheme, and the reservoirs; also stores sufficient for executing the whole of these works; so that it was an exceptionally large percentage. But there were no contractors; the engineers themselves did the work which was usually done by contractors; and he did not think engineers would be content to carry out works of this kind at 4 or 5 per cent., including the cost of all the subordinate staff, and of both Home and Indian establishments.



# THE SOONKESALA CANAL

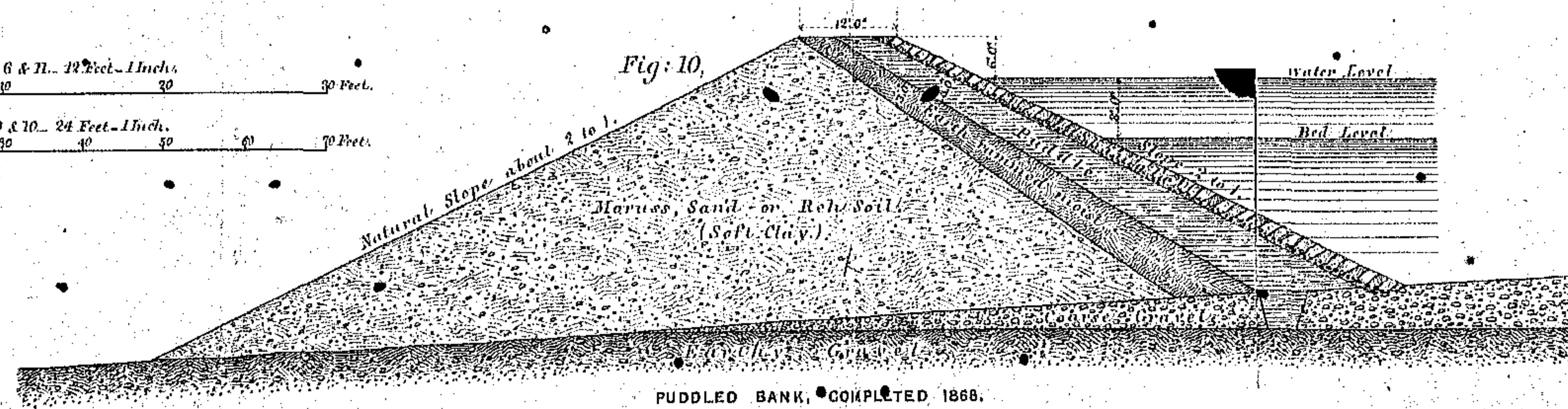
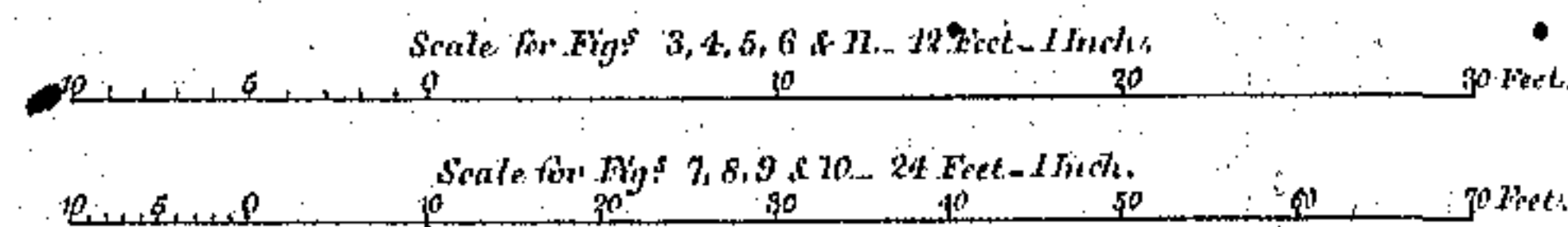
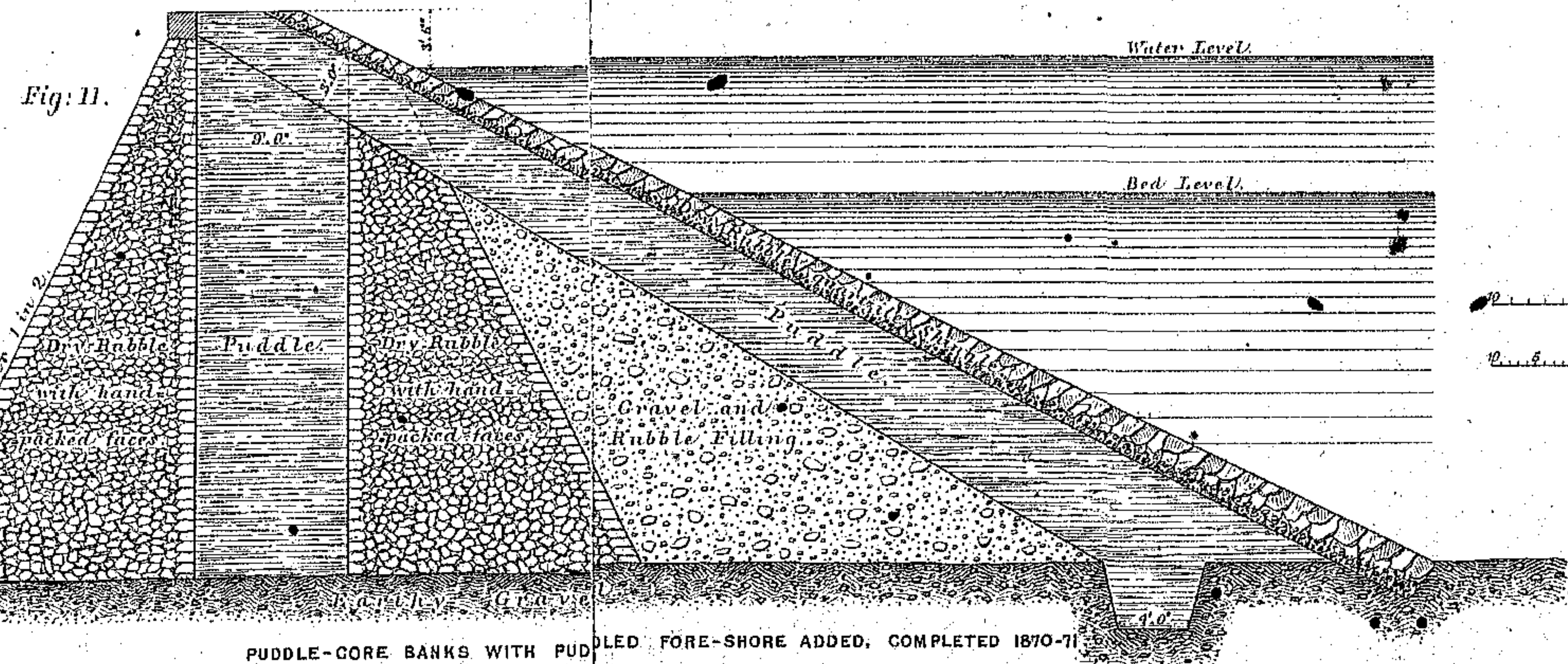
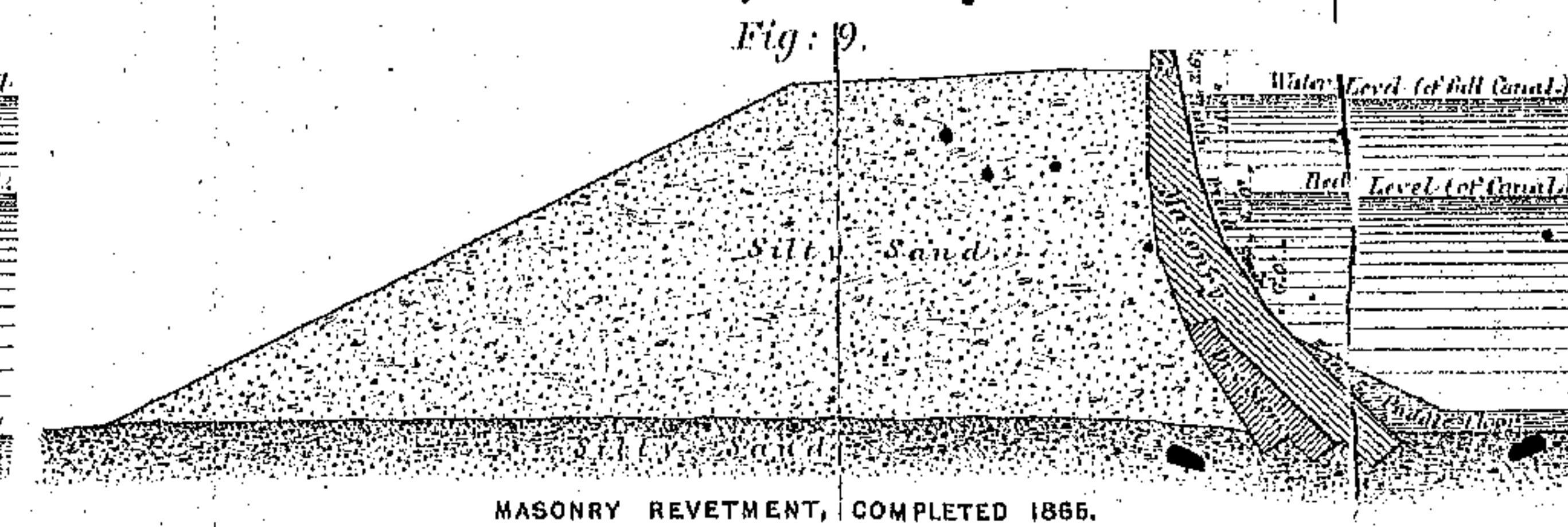
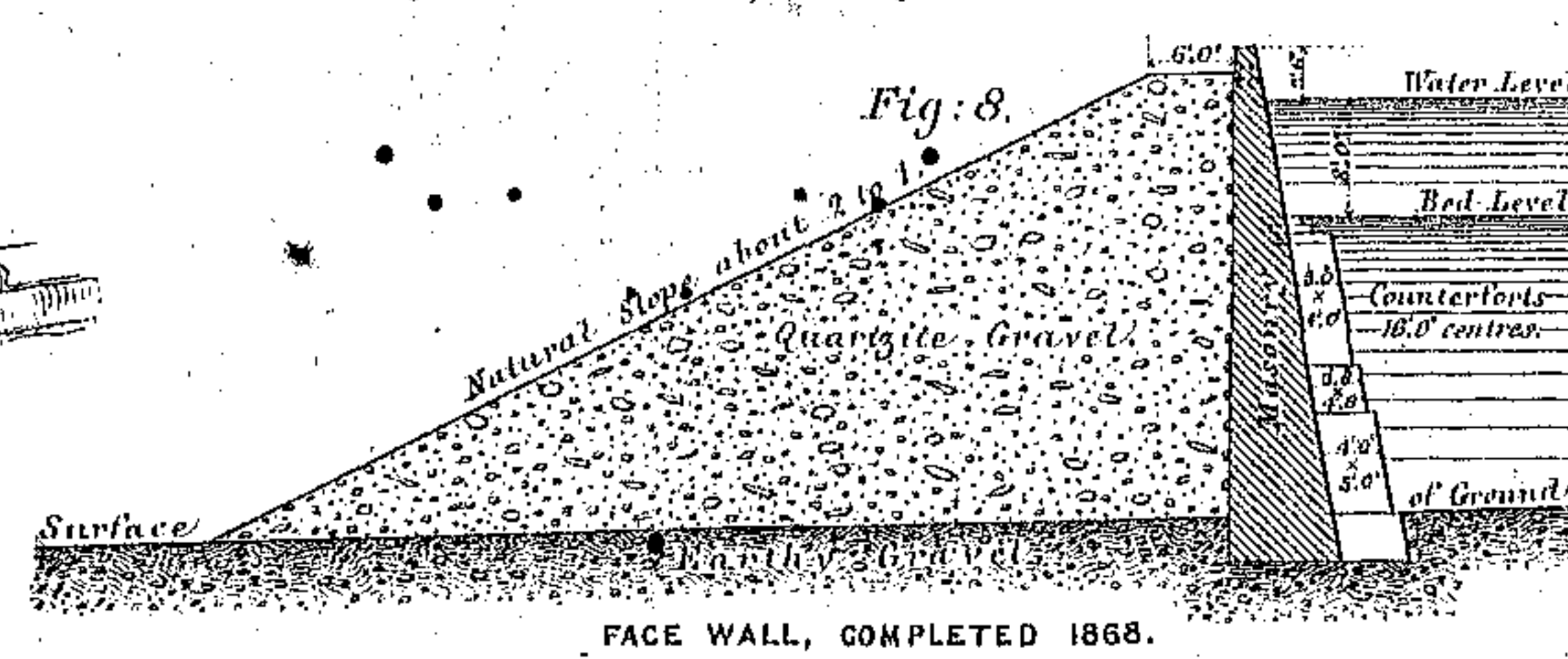
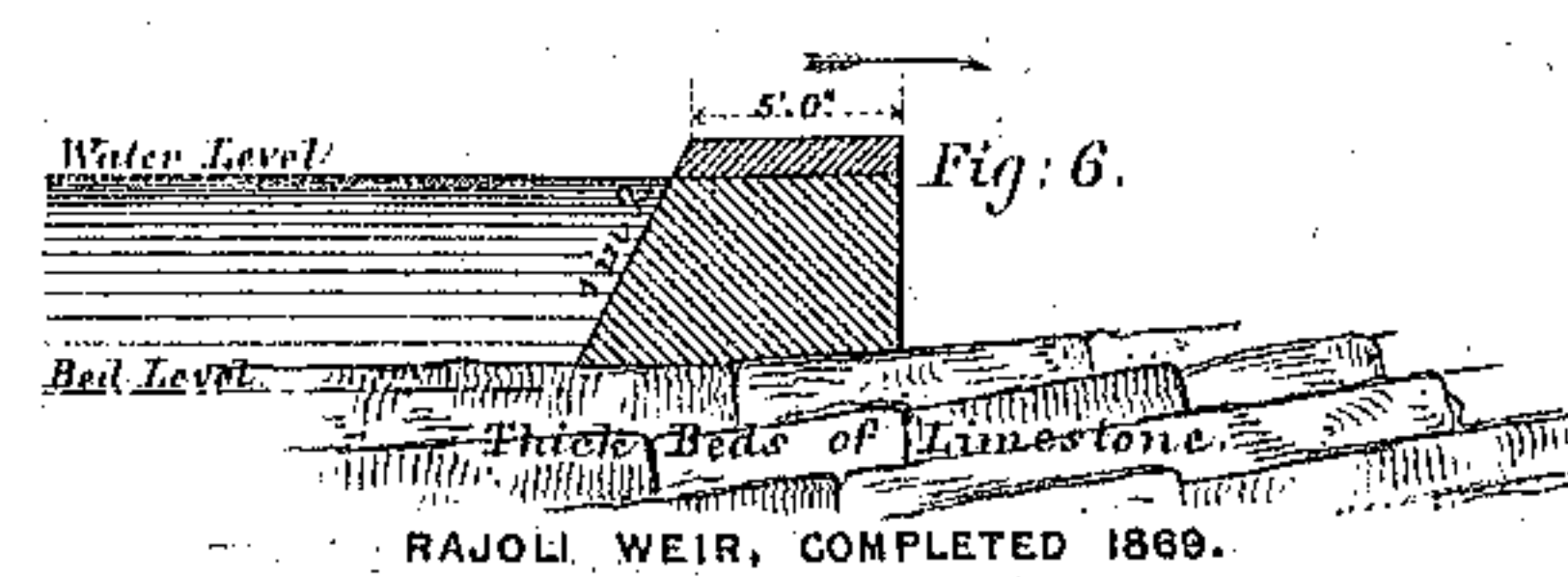
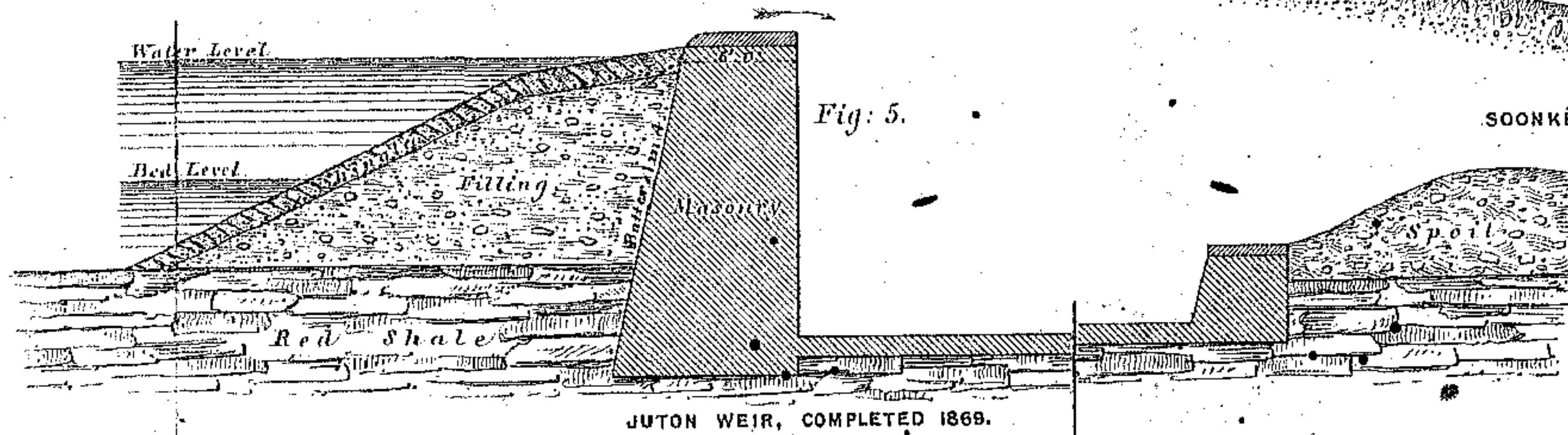
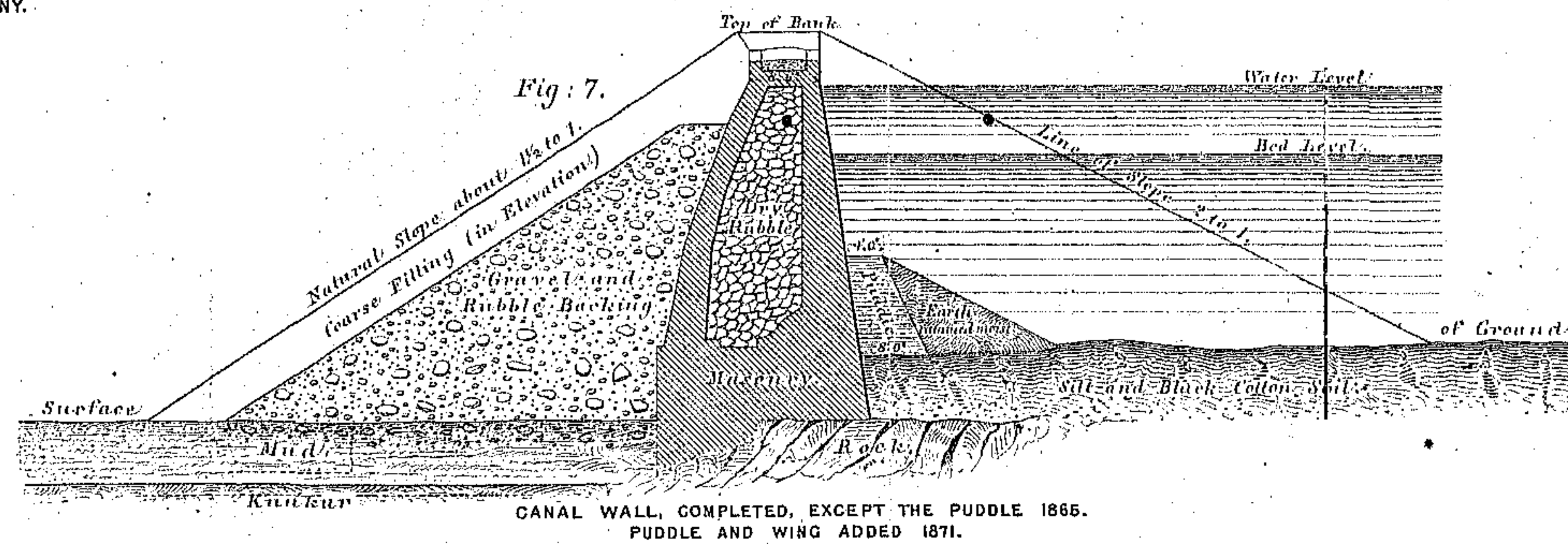
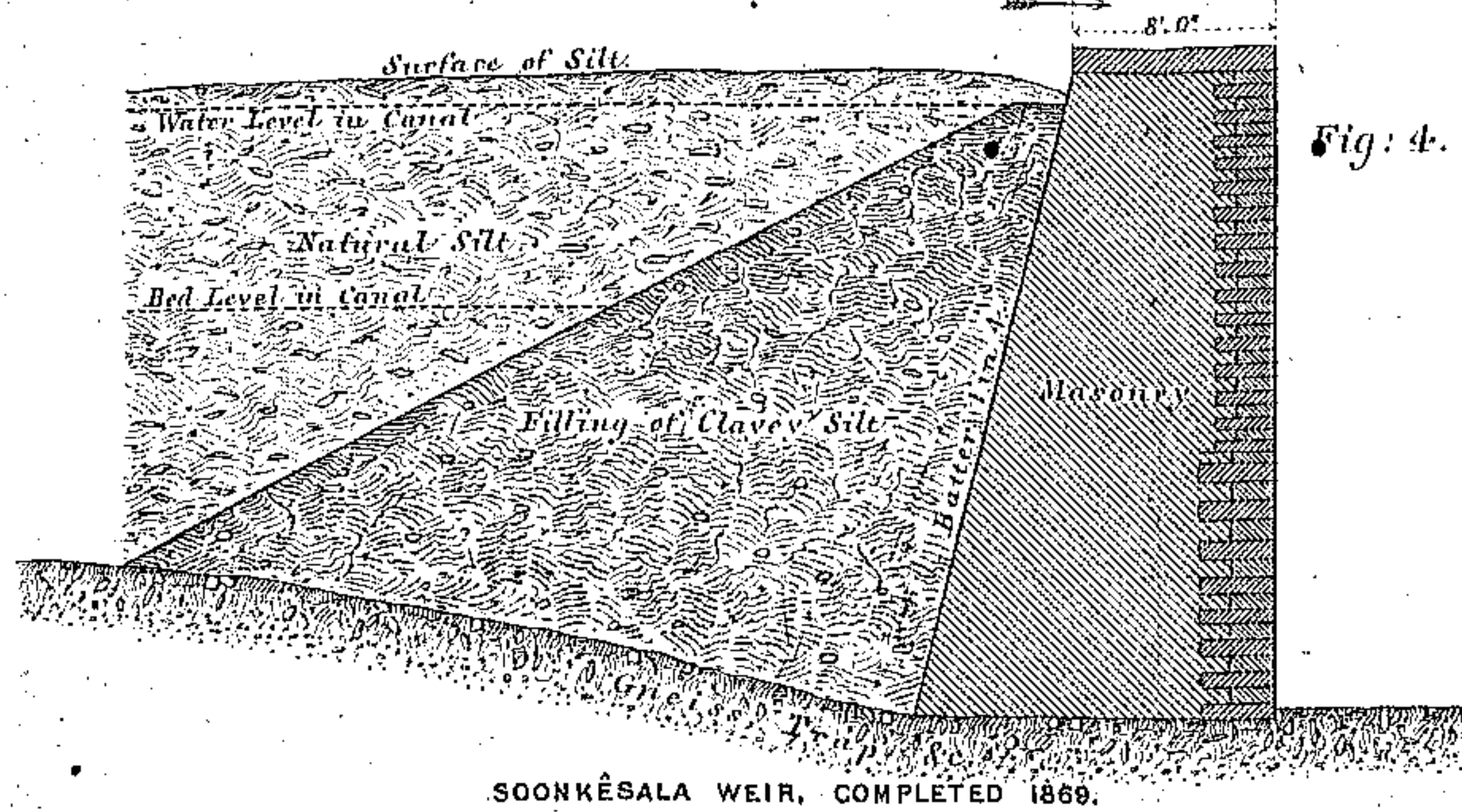
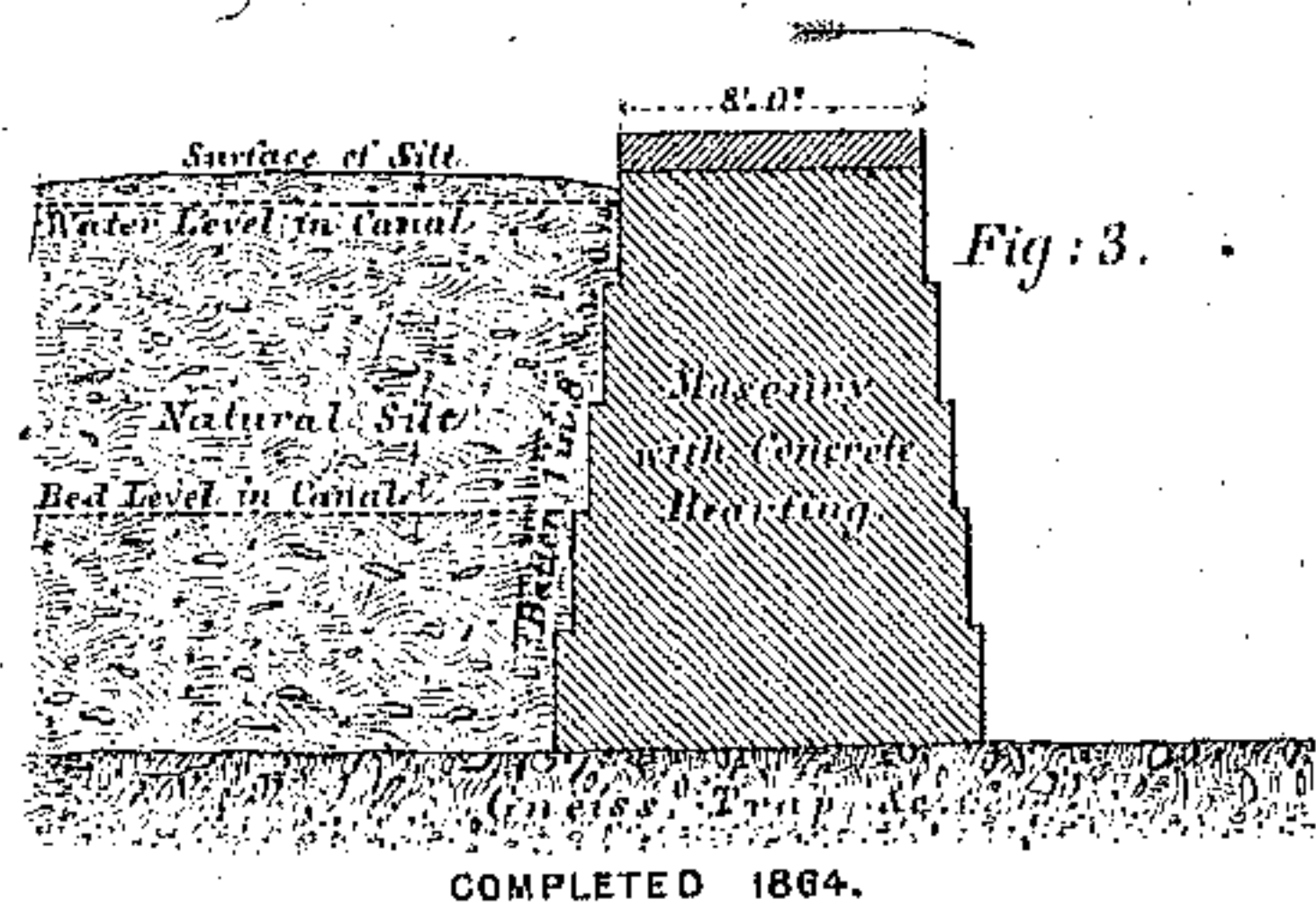
MADRAS IRRIGATION AND CANAL COMPANY.

PLATE 14.





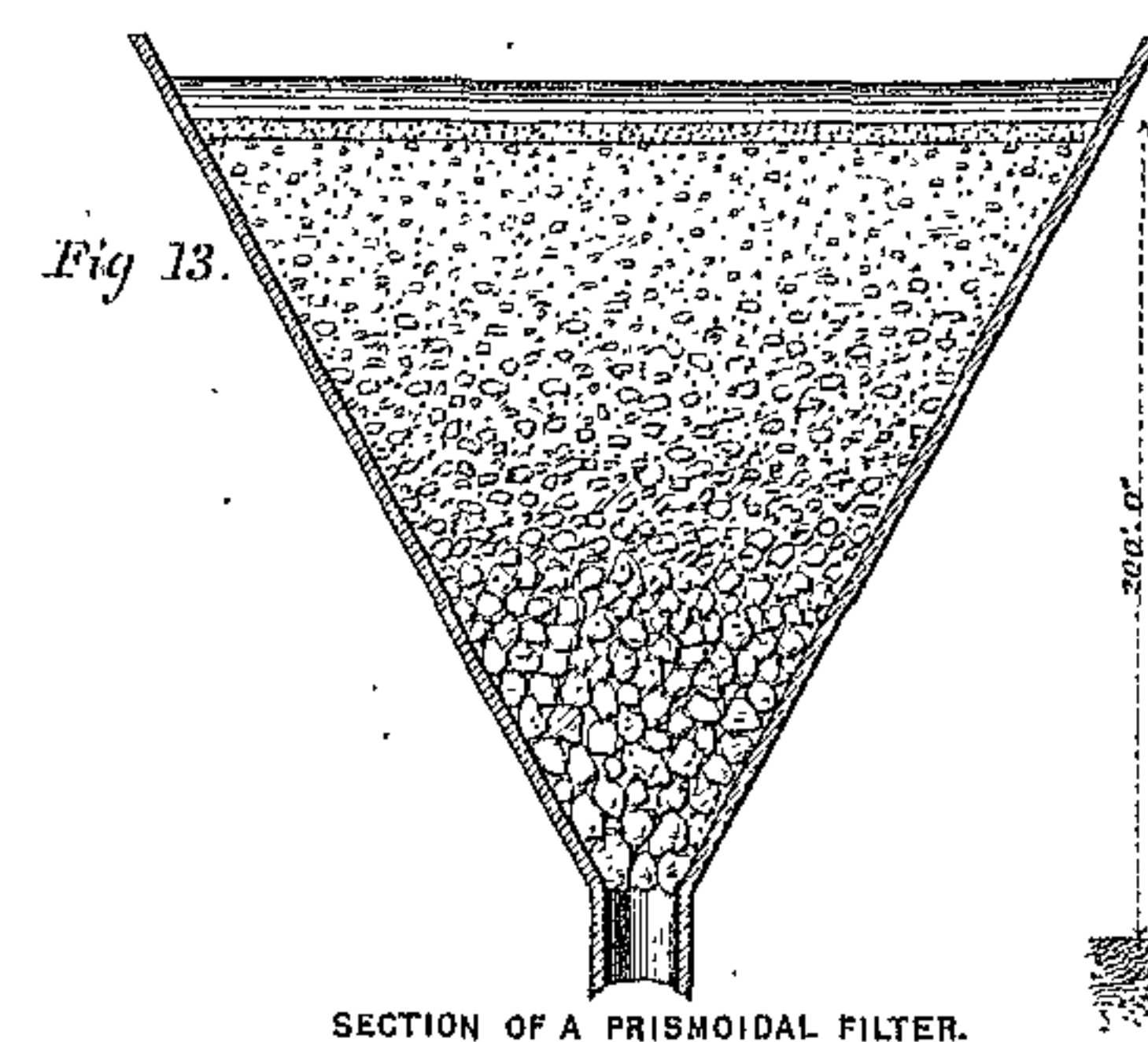
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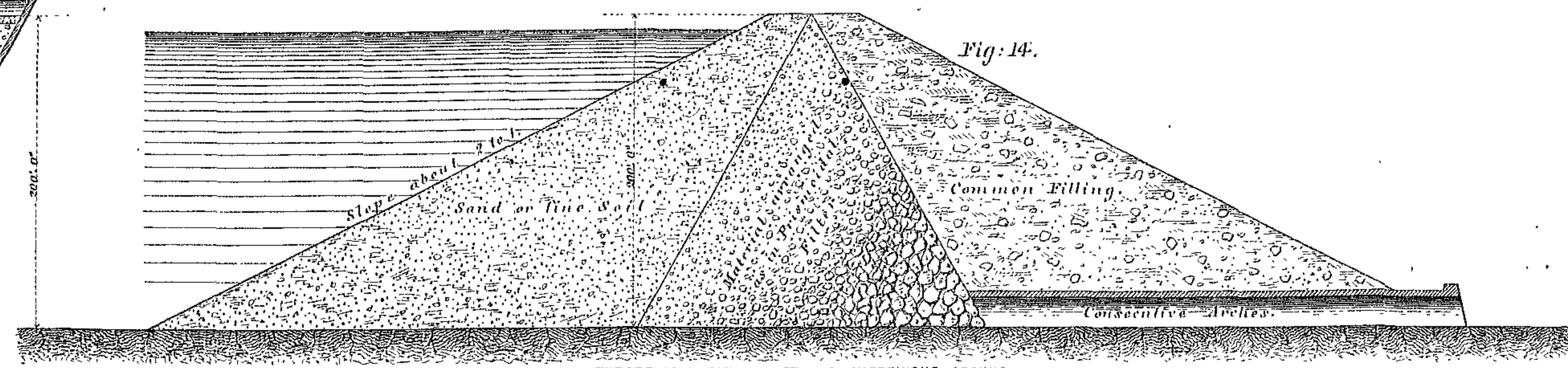


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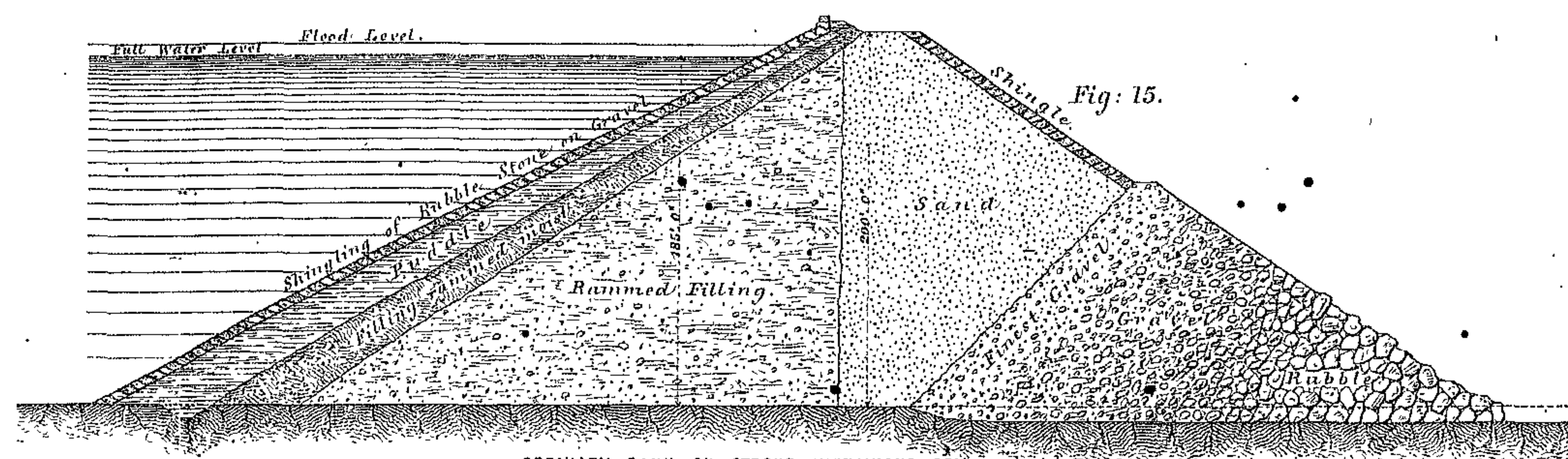
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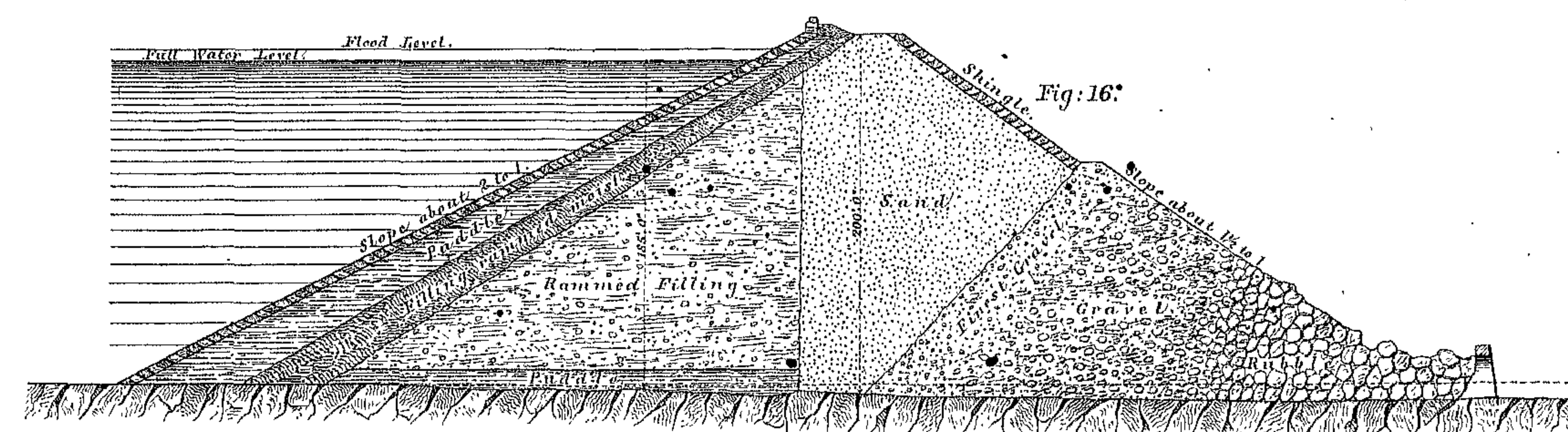
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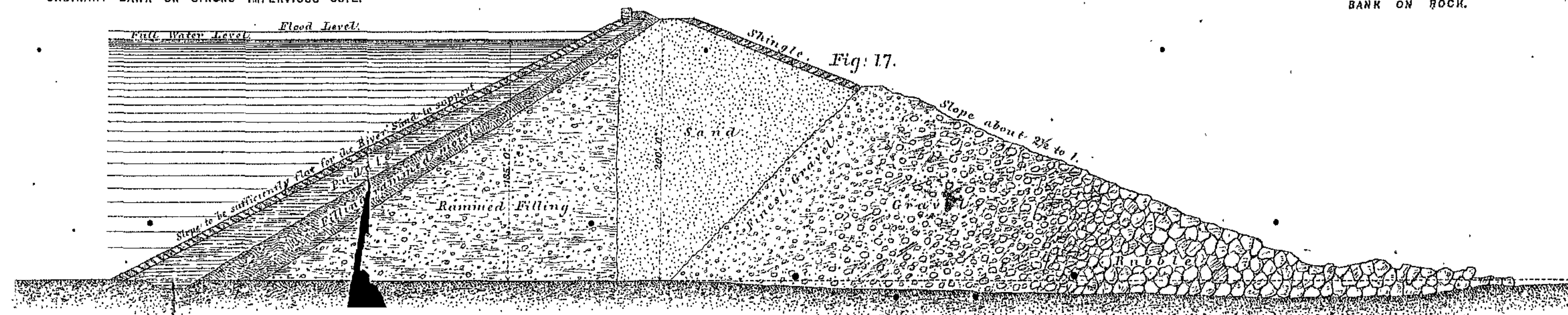
THEORETICAL BANK ON STRONG IMPERVIOUS GROUND.



ORDINARY BANK ON STRONG IMPERVIOUS SOIL.



BANK ON ROCK.



BANK ON RIVER SAND.



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AND CHURCH LANE.

ON  
THE VALUE OF WATER,  
AND  
ITS STORAGE AND DISTRIBUTION IN  
SOUTHERN INDIA.

BY  
GEORGE GORDON, M. INST. C.E.

WITH AN ABSTRACT OF THE DISCUSSION UPON THE PAPER.

EDITED BY  
JAMES FORREST, Assoc. INST. C.E.,  
SECRETARY.

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1872.

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# THE INSTITUTION OF CIVIL ENGINEERS.

January 30, 1872.

JOSEPH CUBITT, Vice-President,  
in the Chair.

No. 1,318.—“On the Value of Water, and its Storage and Distribution in Southern India.”<sup>1</sup> By GEORGE GORDON, M. Inst. C.E.

It is not intended in this Paper to discuss the value of water in its widest sense, or to consider the indirect benefits which would follow the control and abundant distribution of the enormous wealth of water now, for the most part, rolled into the sea—benefits among which are to be reckoned, the prevention of famines and of scarcity in the districts concerned, as well as the permanent improvement of agriculture, and the numberless social and political advantages resulting from enhanced prosperity and increase of population.<sup>2</sup> The object of this communication is rather to afford, from well-authenticated data, some means of estimating the more direct profits of works of irrigation which have been, or could be, undertaken as commercial speculations in the present day. For this purpose some preliminary remarks on the works employed for storage and distribution, on the ancient and modern systems, seem needful.

## I. TANK IRRIGATION.

The existing tank irrigation dates chiefly from ancient times. The number of tanks, large and small, in Southern India is enormous; some of them attain the dimensions of lakes, others suffice only for the irrigation of a few acres. They may be divided into three classes: 1st. Where advantage is taken of a narrow gorge in a range of hills, to close the passage of a river, by a dam or embankment of considerable height, and so to convert the valley above into a lake. 2nd. Tanks formed by the construction of embankments across one or more streams in the flat country, this class being often of considerable superficial extent, but compara-

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<sup>1</sup> The discussion upon this Paper occupied portions of three evenings, but an abstract of the whole is given consecutively.

<sup>2</sup> The population of the Bellary district, which is unirrigated, is 109 to the square mile. The irrigated districts of Tinnevely and Tanjore support populations of 348 and 442 to the square mile respectively.



tively shallow. 3rd. Such as may be considered intermediate between the 1st and 2nd classes.

Most of the tanks of the 1st class are now ruined. In many cases the earthen embankment has been breached, in consequence of the water finding a passage along the outside of the discharge culvert, which was generally placed under the embankment, and not in a tunnel at a distance. The dams were, it is believed, invariably made of earth, without any puddle core, and the inner slope was always protected with heavy stone pitching.

The Author is not aware that high masonry dams were ever constructed for storage purposes in Southern India; but there is, near Ahmednuggur, in the Bombay Presidency, an instance of the combined use of masonry and earth, in a dam for a large ancient tank, described by Colonel Fife, R.E., in the Roorkee Prof. Papers, Vol. V. This dam, however, was never finished.

The number of disused tanks, of all sizes, is very remarkable. Many of these are not breached, but the discharge culvert is left open, and no water is collected. In many cases this is, probably, owing to the bed of the tank having been gradually raised by silting, and converted into so productive a soil, that it yields as much as, or more than, could be obtained by means of the diminished quantity of water applied to the comparatively barren soil below the tank; but generally it results from the ascertained fact, that the rainfall in some districts has materially diminished (markedly so even within the memory of man), on which account the tanks would never fill, and in most years would receive so small, and especially so uncertain a supply, as to render wet cultivation to any large extent not to be depended on. Dozens of such abandoned tanks are met with in the hilly parts of the Ceded Districts; as, for instance, along the foot of the inner slope of the eastern Ghâts, where, in many cases, both the bed of the tank and the cultivated land below it have reverted to jungle.

A good specimen of the tanks of the first kind is one which the Author was deputed to examine a few years ago, with a view to its restoration. A short description of it will afford an idea, both of the construction of ancient works and of the untrustworthy nature of the data which old works seem to afford for the construction of new works.

#### *Description of the Mudduk Masoor Tank (Plate 7, Fig. 1).*

This great work is believed to have been constructed under the Annagoondy dynasty, about four centuries ago. It was formed by an embankment, resting on the sides of a narrow

gorge through which the river Choardy passed, supplemented by two bunds, or dams, on saddles in the range of hills; that on the east being 1,350 yards, and that on the west 670 yards from the main bund. The length of the main bund is 550 yards on the top. The inside slope, of  $2\frac{1}{2}$  to 1, in some parts 3 to 1, was revetted with large stones, up to a cubic yard in bulk. It is from 945 to 1,100 feet broad at the base, and is now from 91 to 108 feet high. There was a sluice under the dam at the east end about the level of the ground. The dam is composed of a strong red earth, with a considerable admixture of gravel, taken from the sides of the hills on which it rests. The east supplemental bund has its base 74 feet above the sluice in the main bund, and had also a sluice under it at the ground level. The west supplemental bund, the breaching of which destroyed the tank, seems to have been of similar construction to the others, and its base was perhaps 50 or 60 feet above the bed of the tank. There is no trace of any waste-weir, and it is probable that the want of this was the cause of the ruin of the tank. On the main bund there are what seem to be traces of the water having topped it, and having cut into the rear slope in two deep gullies. The west bund had, probably, a sluice in it which weakened it, as cut stones were found in the river some way down. After this bund was breached, the water cut into the ground on which it stood to the depth of 100 feet, and would have completely emptied the tank but for a reef of rock some distance from the dam, on the inner side, which now causes a waterfall 25 to 30 feet in height, and retains about 10 feet of water in the tank. On this reef a weir has been built.

From the heights of the dams and the levels of the sluices, it is probable that the depth of the tank was 90 or 95 feet, and at that level its area would have been 40 square miles, and its contents about 1,400 million cubic yards of water. The drainage basin is about 500 square miles, and three-fourths of it lies within the jungly district containing the spurs of the western Ghâts. It is found, from observations of the discharge of the river, that a good average monsoon supply would not exceed 668 million cubic yards, or 16 inches running off. It is not probable that the average annual rainfall so near the Western Ghâts has diminished much, although it may, to some extent, from land having been cleared of jungle; nor is there anything to show that the ancient tank filled every year. The difference between the present supply, and what it must be supposed to have been when the tank filled and was breached (even supposing that to have occurred in an exceptional year) is probably owing, in part, to the construction of small

tanks on some of the feeders. The tank, as proposed to be restored, would have contained about 644 million cubic yards; and the results are given subsequently. As regards capacity, this is the largest reservoir in Southern India of which the Author can find any record.

*Tanks of the 2nd Class : Flat-country Tanks.*

These are so numerous in some districts that, looking at a map, it would appear as if as much land is occupied by tanks as is left to be irrigated by them; and where the tanks are very shallow, this would be necessary for complete irrigation. But in reality, many of these tanks are breached or abandoned, and their beds cultivated. The embankments of flat-country tanks are often of great length, not unusually 1 mile or 2 miles, while that of the Veeranum tank is 12 miles, and the ruined bank of the Poonairy tank, in the Trichinopoly district, is said to be 30 miles in length. Their height is generally inconsiderable, being, in many hundreds of cases, only sufficient to hold 10 feet, or even 6 feet of water. Some works, however, of this, or of the intermediate class already mentioned, are (or were) 20, 40, and even 60 feet deep. The inner side is generally revetted with stone, and has a slope sometimes of 1 to 1, but oftener of 2 to 1, or more. In some cases it is a masonry wall backed with earth. Clay puddle is not used in forming the banks, but the best earth in the immediate neighbourhood is employed, and the dimensions are made large and sometimes excessive. The height above the water-level varies; for instance, the Nundyal tank bund (Fig. 4, Plate 7) is, at one place, 18 feet high, 2 feet above the water-level, 16 feet wide on the top, with an inside slope of 1 to 1 and an outside slope of  $2\frac{1}{2}$  to 1. The Kolevoy (Fig. 5) tank in the Nellore district has a bank 36 feet high, 9 feet above the water-level, a top width of 12 feet, and slopes, inside and outside, of  $1\frac{1}{2}$  to 1.

*Tanks of the 3rd, or Intermediate Class.*

Of this class, the Darojee tank (Fig. 6), in the Bollary district, is a good example. The embankment is about 2 miles in length, and rests on two rocky hills, two small hillocks being also included in the line of the bank. The area, when full, is about  $2\frac{1}{4}$  square miles. Its height is about 40 feet, the depth of water being 26 feet at the level of the waste-weir. This is of modern construction, and 400 feet long, the old native one having been breached. The contents of this tank are roughly estimated at 25 million cubic yards.



## II. CHANNEL IRRIGATION.

As the smaller streams in Southern India are merely torrents which quickly carry off heavy falls of rain and then become dry again, their powers of supply being reckoned by hours at a time rather than by weeks or months; they are, if utilized for irrigation at all, in most cases intercepted by chains of tanks of the 2nd or 3rd class built across their course. Therefore it is only the more important rivers that can supply means of extensive irrigation by channels diverted from them, and it is believed that all of these rivers were, to some extent, laid under contribution in former times.

Naturally their deltas formed the best ground for irrigation, and, consequently, the Godavery and the Kristna deltas, and the lands in the lower parts of the course of the Pennair, Palar, Cauvery, &c., have been, to a large extent, irrigated for ages, and the works have been much extended and improved by the British Government. It is chiefly from these exceptionally favoured districts that the wonderful—and in some cases almost incredible—results of channel irrigation have been obtained. As descriptions of many of these works are accessible to the members, it seems unnecessary to occupy time in giving any account of them in this Paper, further than to say that, with one important exception, the conditions under which they were constructed are as favourable as they could be, viz., ground sloping moderately towards the sea and from the river—the source of supply, so that distribution of the water commences almost immediately; the absence of deep or hard outtings in the canals; and, in the case of the modern improvements, the presence of a considerable population accustomed to the construction of such works and alive to the advantage of their extension. The one disadvantage referred to is the difficulty of constructing and maintaining weirs across the wide sandy beds of the rivers. This was beyond the skill of the native constructors. Very interesting accounts of some of these works will be found in the Professional Papers of the Madras Engineers, and in the Government records in the Library of the Institution.

But it is not only in the deltas that the rivers are tapped. In the middle reaches of the large rivers also there are many ancient weirs, generally admirably situated, but of rude and imperfect construction, so that many are ruined and others require extensive annual repairs. Advantage was usually taken of a reef of rocks running across the river, the low places being filled in with rubble,



faced on both sides with large blocks of stone laid dry, occasionally fastened together. There is some leakage through the body of these native weirs, but not sufficient to account for the fact that, although they are not provided with scouring sluices, the bed of the river on the upper side of them has in several cases not been raised, as is the case where weirs have lately been built with scouring sluices at one end or both.

Where new weirs have been built on rock, they are generally of masonry, with a vertical or slightly battering face on the lower side. It is frequently necessary to protect the rock from the action of the falling water by a water cushion, formed by a low wall built a short way below the weir. The Author has seen a block weighing several tons picked out of what seemed, before the weir was built, a solid bed of gneiss with no visible seams; the height to the crest of the weir was, speaking from memory, not more than 7 feet, and there may have been 5 or 6 feet going over the crest. The Author knows of no rule for determining the depth of the water cushion, by the height of the fall and the volume of the water. The greatest depth of the hole formed by the water-fall in the new outlet of the Mudduk Masoor tank is 24 feet. At the low state of the river, the height of the lip of the fall is  $27\frac{1}{2}$  feet above the surface of the water below. In ordinary states of the river, the general depth of the cushion, or well, is to the height of the fall as 3 to 4 where the greatest action takes place, and 1 to 2 in the other places. At the Gaisoppa Falls, in the Western Ghâts, the Rajah fall, which through its whole height falls clear of the rock, is 825 feet high, and the pool into which it falls is 138 feet deep in the low state of the river. Perhaps 8 feet on the edge of the fall would be the depth in floods, and then the surface of the cauldron below, if it could be said to have one, would be raised many feet: it would be impossible to measure it. An experimental fall on the Barce Doab canal (Fig. 3, Plate 7) had a height of 6·9 feet, depth of well 9 feet, and 3·6 feet on the crest, which gives the depth of the well to the height of the fall as 3 to 4; and it is said the water had no injurious effect on the bottom of the well, and that a bottle, loaded so as to be of the same specific gravity as the water, and passed over the fall, did not reach the bottom by a foot and a half.<sup>1</sup> As an illustration of the force of the water, where the volume and height are both considerable, but by no means exceptional, a sketch from measurements by Major

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<sup>1</sup> The subject of water cushions is one which is well worthy of attention, but is too extensive to be included in this Paper.

Johnson, Assoc. Inst. C.E., is given in Fig. 2, showing the boil of the water below the Sreeramadavara dam, in Mysore.

In sandy-bedded rivers, the modern practice is to build the weir on a foundation of wells filled with concrete, to give it an apron sloping about 1 in 12 from the crest, with a toe wall, and if the slope is long, one or more intermediate walls, also built on wells, and below all a broad layer of rough rubble of large dimensions. A good example of this kind is the Madras Irrigation Company's weir across the Pennair, near Cuddapah, of which a description will be given to the Institution by Mr. Higginson, M. Inst. C.E.

All the ancient irrigation channels from above weirs, that have come under the Author's notice, have far too great a fall, and consequently cannot get away from the river, and thus only a narrow strip of land is irrigated; the sides and bed of the channel got cut away in some places, and the material deposited in others, so that annual repairs and clearing out are necessary. There is also invariably a great waste of water in distribution; but as the surplus runs into the river it is not lost, being picked up again at the next weir. The tail of one channel generally overlaps the head of the next for some distance in the native system. There can be little doubt that this system of numerous weirs and small channels, with a rapid fall, is radically wrong, when applied to large rivers for extensive irrigation. On smaller rivers, having a steep fall, say of 10 feet or more per mile, rocky beds, and widths so moderate as to make the cost of the weir a small part of the whole work, it may sometimes be well applied—the more so as in such situations the soil is likely to be of a light and porous nature, requiring a large quantity of water to be spread over it, and delivering the surplus by drainage into the river again. Generally speaking, however, in the case of large rivers, it will be found more economical to take off a canal of larger dimensions from one head. The surface fall of the water can then be much less than in a channel the depth of which is small; the canal will rapidly recede from the river bank, and command, compared to its length, a much larger area of land; it will wind less, as it will cross the drainage valleys higher up, where they are less deep; these drainages will require less expensive aqueducts and approaches; there will be a shorter length of unproductive canal at the head (from the off-take to where the canal level is high enough to deliver water on to the surface of the ground); and it will supply water to lands and villages where it is more urgently needed than it is close along the banks of a river. Careful estimates, however, are needed, in each case, of considerations on the other side. For instance, the canal must not be made of so large

a capacity that a great part of the water must be carried very many miles before it can be used. The cost of distribution, too, must be considered. Although the natural channels of streams can often be used to convey part of the water to the fields, it is generally the case that, for extensive irrigation, artificial channels, carried down the ridges crossed by the canal, are more economical, but they must not be too long.

It is desirable that a main canal should command a much greater area of arable land than the water it carries can irrigate constantly. Some land may not be suitable for irrigation at all; and in no case could all the land be converted from dry to wet cultivation under many years, as three times the population would be required to cultivate it. There should, therefore, be facilities for completely irrigating detached areas at considerable intervals, and for giving occasional irrigation to dry crops. This last would be an immense boon, since in many parts complete failure of the crops now grown happens every few years from drought, and a good crop is a rare exception; while from one to three waterings would insure a good crop every year. A failure of the crop means a famine; and although, in the few districts traversed by railways, food and seed grain for next year could, at a great cost, be provided for the people, fodder, and, above all, water for the cattle, could not, and they must be driven away or perish. At one large military station, so great was the scarcity of water in the early part of the year 1871, that arrangements were actually completed for carrying water a distance of 8 miles on railway-trucks for the use of the inhabitants. As to drink water thus provided would be contrary to the religious obligations of caste-men, their dismay was great. Fortunately, a heavy rain furnished a supply for two or three months.

### III. DISTRIBUTION OF WATER.

The large storage tanks already described as of the 1st class do not have more than a limited area of land irrigated immediately from them. Their duty is to store flood-water which would otherwise run to waste, and to let it down the river as it is required, to supplement, if necessary, at the end of the season, the regular monsoon supply for the first crop, or to give a supply for a second, and to be distributed either by channel irrigation from the river, or from the flat-country tanks, if it is used to supply them. From the 2nd and 3rd class of tanks the distribution is generally effected directly, beginning close under the tank, the water being let out



on to the land by sluices at different levels. In some cases, however, as in that of the Darjee tank already mentioned, the water is also carried down the beds of the intercepted streams and picked up by weirs put across them at intervals; but this is the less frequent plan. One advantage of it is, that the drainage and also the superfluous water from the fields, for it is always wastefully used, are not lost.

Distribution from a canal is most economically effected when the latter runs along a ridge between two valleys, so that it can supply water on both sides; for the nearer the irrigated land lies to the supply the less do the distribution channels cost. This situation, in the case of a large canal taken from one of the main drainages of the country, can obviously happen only in rare instances. When the main canal is carried along sidelong ground crossing the drainage of the country, the main irrigating channels will generally be carried down the ridges between the streams, giving off secondary branches right and left. Occasionally, when the main canal passes by a cutting through a ridge crossing its course, a channel on a falling contour will be required on the upper, and another on the lower slope of such ridge, uniting when the crest of the ridge falls to their level. The first kind, or ridge channels, have the advantage of crossing no drainage, of being thus less liable to damage from heavy rains, and of commanding a given area with the least length of side channels. In most cases both kinds of channels will be needed. In the Ceded Districts, distribution can be carried out for 5s. per acre, including the sluices in the main canal bank, and all necessary works for crossing roads and streams built in a permanent manner, but excluding the cost of terracing the land to prepare it for wet cultivation,—this being done by the occupier.

Of course, any system of irrigation must include ample means of drainage. This is afforded naturally in the part of India under consideration, the fall of the country being generally steeper than is necessary. Only surface drainage is practised. For rice cultivation the water must not be carried off too rapidly, but should be retained for months at a depth of 6 inches on the surface of the ground, by surrounding the plots with a small bank, through which a slight stream is allowed to pass on and off. For dry crops the ground never holds too much rain: the more careful cultivators endeavour to retain, by small dams of dry rubble or boulders, the finer parts of the soil, which would otherwise be carried off by the very heavy rains; but, except in irrigated lands, drains are never out, as far as the Author is aware.



## IV. VALUE OF WATER TO THE CULTIVATOR.

The following three statements of the cost and profits of cultivation are given from information supplied to the Author by the Deputy Collector, who made the calculations from actual experiments on fields in the Bellary district. The prices of produce are those which prevailed before the great scarcity, amounting to a famine, in 1865-6.

(a). COST OF CULTIVATING AN ACRE OF CHOLUM (SORGHUM), the staple dry grain.

|                                            | R. a. p. | R. a. p.                                                                |
|--------------------------------------------|----------|-------------------------------------------------------------------------|
| Land cess. . . . .                         | 1 8 0    | Average. From experiments in the village of Amawutty; an ordinary crop. |
| Labour . . . . .                           | 2 6 2    |                                                                         |
| Use of cattle . . . . .                    | 5 8 7    |                                                                         |
| Manure . . . . .                           | 6 2 6    |                                                                         |
| Seed . . . . .                             | 0 9 10   |                                                                         |
| Fees to village servants . . . . .         | 0 13 0   |                                                                         |
| Total expenses . . . . .                   | .. ..    | 17 0 1                                                                  |
| RETURNS.                                   |          |                                                                         |
| Grain, 236 Bellary seers, at 18 per rupee. | 13 1 9   |                                                                         |
| Straw, 2 loads . . . . .                   | 8 0 0    |                                                                         |
|                                            |          | 21 1 9                                                                  |
| Net profit per acre . . . . . Rs           |          | 4 1 8                                                                   |
|                                            | or, £    | 0 8 2½                                                                  |

This dry crop is sometimes assisted by irrigation from wells, the water being raised by bullocks. The wells cost, in the Bellary district, from £30 to £100 each, and the cost of raising the water is said to be £4 12s. per acre. No well will supply more than three acres in that district. The Author has no results from actual experiment of the profits of such cultivation, but it is not probable that a greater direct profit can be made from it than from the dry cultivation. The gain is in the certainty of the crop.

To compare the above with the profit from rice cultivation, the water rate and the cost of preparing the land, or of converting it into terraced land, must be assumed. The former varies considerably, and was established when grain was much cheaper than it is now. It was the opinion of the collector of the Bellary district, in 1866, irrespective of the scarcity then prevailing, that the ryots could well afford to pay for new irrigation £1 per acre for the first crop, which is the most valuable; and the Author has been assured, both by cultivators themselves and by native revenue officials,

that they would be glad to do so. The Government Superintending Engineer for Irrigation recommended for that district a rate of 17s. for the first, and 13s. for the second crop. The Madras Government, however, decided that 12s. per acre for each crop should be the standard for calculations. As a matter of fact, ryots in the Nizam's country, adjoining the Bellary district, pay as much as £3 for wet land. In the following statements the Government rate of 12s. is assumed. The cost of preparing the land is taken at £1 per acre, which, at 12 per cent., the usual rate of interest, gives 2s. 6d., nearly, per acre per annum. (See Tables b and c, next page.)

The difference between this and two dry crops, supposing two could be got, is £17 10s., in favour of the wet crop.

Sugar-cane, however, as well as garden cultivation, which is also extremely profitable, would generally bear only a small proportion of the breadth of land that would be under rice and dry crops, and in the following Table I. (p. 388), showing the comparative yield of wet and dry crops, they are neglected.

As the Bellary district is peculiarly unfortunate in its annual rainfall, the above valuation of an average dry crop may be under the average of that in the districts which could be supplied with channel irrigation; and in the following Table, the average yield per acre in the Kurnool district and the prices there prevailing, which are lower than in Bellary, both of wet and dry crops, have been used for the purpose of comparison between wet and dry cultivation. It should be noted, however, that land irrigated from a river gives a better return than that under a tank by, it is said, 25 per cent. in those parts. Whether this is principally due to the brackish quality of the water locally collected, or to the insufficient supply from tanks, the Author cannot say; probably both causes contribute.

The following Table is intended to show the money value of irrigation, and the gross returns per acre which would be got by the construction of suitable works in the Ceded Districts, and in others similar to them in climate and other circumstances. Nos. I. and IV. are compiled from official statements of the average value of crops in the five years 1861 to 1865 in the Kurnool district. Nos. II., V., and VI. from actual experiments by the Deputy Collector in the Bellary district. No. III., col. 4, from the same source, and cols. 1, 5, and the rest from official statements in the revenue department. The price of grain is steadily increasing, when taken over a number of years; thus the price of rice in the Table, 1861-65, is double what it was in the disastrous famine year of 1854, and 78 per cent. higher than the average of the period

TABLE I.

SHOWING the COMPARATIVE YIELD

|      | DESCRIPTION OF CROP.                                       | 1.          | 2.                 | 3.                         | 4.                                 |
|------|------------------------------------------------------------|-------------|--------------------|----------------------------|------------------------------------|
|      |                                                            | Gross Value | Deduction for Risk | Gross Value for Assessment | Cost of Cultivation and Conveiston |
|      |                                                            | R a p.      | R a p              | R. a. p.                   | R. a. p                            |
|      | DRY CROPS.                                                 |             |                    |                            | *                                  |
| I.   | Grain, 248 Madras measures, at per Gaico Rs. 278 . . . . . | 21 1 9      | 1                  |                            |                                    |
|      | Straw, 50 bundles, at 4 annas . . . . .                    | 12 8 0      |                    |                            |                                    |
|      | Revenue returns, 5 years' average . . . . .                | 33 9 9      | 8 6 5              | 25 3 4                     | 15 8 1                             |
| II.  | Grain, 288 Bellary measures, at 18 per rupee . . . . .     | 13 1 9      |                    |                            |                                    |
|      | Straw, 2 loads, at Rs. 14 . . . . .                        | 8 0 0       |                    |                            |                                    |
|      | Deputy Collector's experiment . . . . .                    | 21 1 9      | .. ..              | .. ..                      | 15 8 1                             |
| III. | The same, with occasional Irrigation.                      |             |                    |                            |                                    |
|      | Grain, 388 Madras measures, at per Gaico Rs. 278 . . . . . | 28 15 0     | 1                  |                            |                                    |
|      | Straw . . . . .                                            | 20 0 0      |                    |                            |                                    |
|      | Collector's official statement . . . . .                   | 48 15 0     | 8 2 6              | 40 12 0                    | 15 12 0                            |
|      | WET CROPS—RICE.                                            |             |                    |                            |                                    |
| IV.  | Grain, 1,066, at per Gaico Rs. 213 . . . . .               | 70 15 3     | 1                  |                            |                                    |
|      | Straw . . . . .                                            | 12 8 0      |                    |                            |                                    |
|      | Revenue returns, 5 years' average . . . . .                | 83 7 3      | 18 14 6            | 69 8 9                     | 47 1 0                             |
| V.   | Grain, 1,675 Bellary measures, at 18 per rupee . . . . .   | 98 0 0      | 1                  |                            |                                    |
|      | Straw . . . . .                                            | 10 0 0      |                    |                            |                                    |
|      | Deputy Collector's experiment . . . . .                    | 103 0 0     | 17 2 8             | 85 13 4                    | 47 1 0                             |
| VI.  | SUGAR-CANE.                                                |             | 1                  |                            |                                    |
|      | 288 maunds jagherry, at Rs. 2 . . . . .                    | 576 0 0     | 96 0 0             | 480 0 0                    | 379 4 0                            |

\* Col. 4. For details of cost, furnished by the Deputy Collector, see Sect. IV. ante

† Col. 5. From the amounts in Col. 3, a sum of Rs. 1 2a land rent, has to be deducted to show the clear profit to the cultivator. The rent has been deducted in Col. 11.



TABLE I.

of WET and DRY CROPS.

| 5.<br>Net Value<br>of<br>One Crop | 6.<br>Second Crop<br>at Three-<br>quarters First<br>Crop | 7.<br>Value of<br>Water. | 8.<br>Sum of<br>Cols 5 & 6. | 9.<br>Assessment<br>at Half<br>Net Produce. | 10. 11.<br>Profits of Water to |                      |                        |
|-----------------------------------|----------------------------------------------------------|--------------------------|-----------------------------|---------------------------------------------|--------------------------------|----------------------|------------------------|
|                                   |                                                          |                          |                             |                                             | Cultivator<br>One-third.       | Works<br>Two thirds. |                        |
| R. a p.                           | R. a. p.                                                 | R. a. p.                 | R. a. p.                    | R. a. p.                                    | R. a. p.                       | R. a. p.             |                        |
| †                                 |                                                          |                          |                             |                                             |                                |                      |                        |
| 9 11 8                            | .. ..                                                    | .. ..                    | .. ..                       | 4 13 6                                      |                                |                      |                        |
| 5 9 8                             | .. ..                                                    | .. ..                    | .. ..                       | 2 12 6                                      |                                |                      |                        |
| 25 0 6                            | .. ..                                                    | 15 5 3                   | .. ..                       | 12 8 3                                      | 5 1 0                          | 9 2 6                |                        |
| 22 7 9                            | 18 13 7                                                  | {12 12 6<br>29 10 1}     | 89 5 4                      | {11 4 0<br>19 8 0}                          | 4 4 2<br>9 14 0                | 7 6 4<br>18 10 0     | 1 crop.<br>2 ,,        |
| 38 12 4                           | 29 1 8                                                   | {29 1 1<br>58 2 4}       | 67 13 7                     | {19 0 0<br>84 0 0}                          | 9 11 0<br>19 6 1               | 17 14 0<br>37 10 2   | 1 crop.<br>2 ,,        |
| †                                 |                                                          |                          |                             |                                             |                                |                      |                        |
| 100 12 0                          | .. ..                                                    | 81 5 6                   | 100 12 0                    | 50 0 0                                      | 27 2 0                         | 52 12 0              | {10 months'<br>supply. |

† Col. 5. It is generally reckoned in the Ceded Districts, that the profits per acre of sugar-cane are Rs. 200, or a little more than those given in the Table, without the deduction for risk in Col. 4.



## (b). Cost of CULTIVATING an Acre of RICE.

|                                             | R. a. p. | R. a. p.                                               |
|---------------------------------------------|----------|--------------------------------------------------------|
| Land cess . . . . .                         | 1 8 0    | { For good land.<br>Assumed Government<br>proposal.    |
| Terracing land . . . . .                    | 1 4 0    |                                                        |
| Water rate . . . . .                        | 6 0 0    | { From experiments in<br>the village of Chit-<br>wady. |
| Labour . . . . .                            | 18 15 0  |                                                        |
| Use of cattle and implements . . . . .      | 11 0 0   |                                                        |
| Seed . . . . .                              | 9 8 0    |                                                        |
| Manure . . . . .                            | 2 10 0   |                                                        |
| Village fees, &c. . . . .                   | 3 12 0   |                                                        |
| Total cost of cultivation . . . . .         | .. ..    | 54 9 0                                                 |
| RETURNS.                                    |          |                                                        |
| Paddy, 1,675 Bellary seeds, at 18 per rupee | 98 0 0   |                                                        |
| Straw, 40 bundles . . . . .                 | 10 0 0   |                                                        |
|                                             |          | 108 0 0                                                |
| Net profit per acre. . . . . Rs.            |          | 48 7 0                                                 |
|                                             | or, £    | 4 16 10½                                               |

Or a difference in favour of wet cultivation of £4 8s. 8d. per crop per acre.

(c). Cost of the CULTIVATION of an ACRE of SUGAR-CANE, which requires the same quantity of water as an Acre of Rice, but spread over ten months, and thus liable to the double water rate, or Rs. 12.

|                                                        | R. a. p. | R. a. p.                                                       |
|--------------------------------------------------------|----------|----------------------------------------------------------------|
| Land cess. . . . .                                     | 1 8 0    | { Assumed Government<br>proposal.                              |
| Terracing land . . . . .                               | 1 4 0    |                                                                |
| Water rate . . . . .                                   | 12 0 0   | { From the Deputy Col-<br>lector's experiments<br>in Chitwady. |
| Labour . . . . .                                       | 232 0 0  |                                                                |
| Use of cattle, &c. . . . .                             | 10 0 0   |                                                                |
| Manure . . . . .                                       | 50 0 0   |                                                                |
| Plants, 6,000, at rupees 5 per thousand . . . . .      | 30 0 0   |                                                                |
| Fuel, 48 loads . . . . .                               | 48 0 0   |                                                                |
| Village fees, &c. . . . .                              | 8 0 0    |                                                                |
| Total cost of cultivation . . . . .                    | .. ..    | 392 12 0                                                       |
| RETURNS.                                               |          |                                                                |
| 288 maunds of jaggery, at rupees 2 per maund . . . . . | .. ..    | 576 0 0                                                        |
| Net profit per acre . . . . . R                        |          | 188 4 0                                                        |
|                                                        | or, £    | 18 6 6                                                         |

1856-60. The Author believes that the new settlement rates of assessment of land are about one half the clear net value of the crop, after a deduction for risk of loss by bad seasons, &c., has been made from the gross returns, of  $\frac{1}{4}$ th for dry and  $\frac{1}{8}$ th for wet crops; and column 9 in the Table has been made in accordance with this principle. It is probable that, in addition to the direct increased value of the crops, some further advantage would have to be given to the ryots, to induce them to convert their land from dry to wet cultivation, in districts where wet cultivation is but little known; and supposing the total advantage to be divided in the proportion of one part to the cultivator and two parts to the agency or works supplying the irrigation, the results are given in cols. 10 and 11. The sum of R. 1 2a., to represent the average land cess already paid by the ryot to the Government, has been deducted in col. 11; it is not included in col. 4 because, to show the value of water applied to land already paying that dry rate, it is necessary to exclude it from all the items in col. 5, and it is assumed that this rent of the land is not raised, but only a charge is made for the water. As No. V. represents good land, it would, perhaps, be too much to assume that in average cases the out-turn would be as high as is entered in col. 8 of No. V. On the other hand, No. IV. is the result of tank irrigation; and the results ought, in dealing with river irrigation, to be increased 25 per cent. But even excluding No. V., and taking No. IV. as it stands, and excluding also No. VI., on account of the comparatively small area sugar-cane would occupy, the results of Nos. III. and IV. show that, provided a water-rate proportioned to the value of the water were fixed, irrigation would, even taking the most unfavourable cases, benefit the cultivator to the extent of 10s. and 8s. 6d., and yield a gross return to the works of 18s. 3d. and 14s. 9d. per acre respectively in the two cases of occasional watering of dry crops and of rice or wet cultivation; and in the latter case, supposing water to be stored for a second crop, the gain to the cultivator would be 19s. 9d., and the return to the works 37s. 3d., which cannot be considered as other than very favourable terms to the former, who is not to be supposed to have expended any capital on the improvements beyond 1 rupee per acre for the conversion of the land, and this has been allowed for. As 18s. 3d. and 14s. 9d., or the average of them, 16s. 6d., represents the gross income from the sum expended on the construction of the canal and distribution channels, so (37s. 3d.—14s. 9d.) 22s. 6d. represents the gross additional return per acre from storage water applied to a system of works already constructed.

## V. COST OF WORKS.

First, of canals as they are needed either to distribute water directly or to fill existing tanks. It has been laid down by the Madras Government, as a basis for calculation, founded on experiments made by their orders, that 2 cubic yards per hour, or 0·015 cubic foot per second, in the main canal is sufficient for the irrigation of an acre of paddy. Where more is used in porous soils, the surplus will, in a good system of distribution, be caught up again in the drainages and redistributed. For dry crops three waterings in the season, of 4 inches in depth, in years when the rainfall is at the lowest, and 2 inches, or 1 inch, in less unfavourable years, would suffice to insure a good crop of cholam. The first quantity is equal to 1 cubic yard per hour per acre, nearly. It is convenient, for the sake of comparison, to reckon the cost of a canal in terms of its carrying capacity at the head; and if the above allowance of water be assumed, the cost can readily be compared with the returns per acre. Table II. gives the cost of several works which have been constructed, or carefully estimated on data obtained from constructed works, in the Ceded Districts :

TABLE II.

| NAME OF WORK                                           | Cost per Cubic Foot per Second at Head. | Cost per Acre. | Number of Acres Irrigated. |
|--------------------------------------------------------|-----------------------------------------|----------------|----------------------------|
|                                                        | £ s. d.                                 | £ s. d.        |                            |
| Kurnool Canal, for irrigation and navigation . . . . . | 538 6 0                                 | 8 0 0          | 200,000                    |
| Bellary high level . . . . .                           | 480 0 0                                 | 7 6 2          | 150,000                    |
| Bellary low level . . . . .                            | 398 6 0                                 | 5 18 0         | 212,500                    |
| Toombaganoor Canal . . . . .                           | 526 14 0                                | 7 18 0         | 55,000                     |
| Average . . . . .                                      | 473 1 6                                 | 7 5 6          | 151,250                    |

It is to be remarked that the Kurnool canal is also a navigable canal, which raises its cost considerably; probably  $\frac{1}{4}$ th may be deducted to reduce it to its cost for irrigation only, that being the proportionate amount of cost found by estimates to be necessary to make other irrigation canals navigable. It would then cost per cubic foot per second, £426 12s., and per acre, £6 8s.; and the average would be reduced to £446 8s. per cubic foot per second, and £6 17s. 8d. per acre. The following is the cost, ascertained or estimated, of large canals in other parts of India :



TABLE III.

| NAME OF WORK.                                | Cost per Cubic Foot per Second at Head | Cost per Acre. <sup>1</sup> | Authority.          |
|----------------------------------------------|----------------------------------------|-----------------------------|---------------------|
|                                              | £ s. d.                                | £ s. d.                     |                     |
| Ganges Canal with navigation . . . . }       | 497 12 0                               | 7 8 9                       | Roorkee pamphlet.   |
| Ganges Canal without navigation, assumed . } | 398 1 7                                | 5 18 5                      | ½th deducted.       |
| Baire Doab Canal . . . .                     | 466 12 0                               | 7 0 0                       | Capt. Forbes, R.E.  |
| Sutlej Canal . . . .                         | 358 6 0                                | 5 6 0                       | Capt. Crofton, R.E. |
| Soane Canal . . . .                          | 434 8 0                                | 6 10 0                      | Col. Dickens, R.E.  |
| Average . . . .                              | 413 2 0                                | 6 3 7                       |                     |
| The Orissa system . . .                      | 200 0 0                                | 3 0 0                       | Col. Rundall, R.E.  |

The Orissa system of canals is not included in the average, as the works are in a deltaic country. The low rate of cost bears out what has been already stated. It seems safe to assume, that canals large enough to irrigate 75,000 acres and upwards can, on an average, be constructed for £7 per acre, and that, with the distribution of profits before proposed, the outlay of £7 will yield a gross return of 16s. 6d. Deducting 2½ per cent. on the cost of construction for establishment, repairs, and collection of revenue = 3s. 6d. per acre, the net returns ought to be, at rates extremely favourable to the cultivator, 13s. per acre. The works, according to their magnitude, would occupy a good many years in construction; and although partial irrigation might take place after the head-works and one-half of the other works were constructed, still the whole profits could not be realized till some years after the works were complete. If 5 per cent. on one half the capital for ten years be added to the cost, it is brought to £8 15s. per acre, and the net profits would then be 7·4 per cent. This applies to channel irrigation only, where all the works have to be constructed; the profits would be greater were there tanks along the line of the canal and at its terminus which could receive a partial supply, for a second crop, or for flooding dry crops, during the time when the water was not required to be turned on to all the fields.

Secondly. In considering the cost of tanks, it is to be remembered that those of the 1st class, or storage reservoirs, would rarely be available for direct distribution, and would rather be consi-

<sup>1</sup> Of ice land at the Madras rate, 2 cubic yards per hour per acre.



dered as subsidiary to a system of works already constructed. The flat-country tanks, on the other hand, affording as they do means of directly distributing the monsoon supply, may be compared as a means of irrigation with the head-works and channels from a river. Those of the intermediate class add, in some cases, to the functions of the last mentioned, that of storing a certain amount of water for a second crop of rice, or of other grains which require a supply of water in the dry season. Taking the flat-country tanks first: it can well be believed that the old ones, constructed as they, no doubt, chiefly were by the voluntary, or sometimes forced, labour of the villagers whose lands they were to benefit, have, in the course of centuries, amply repaid the labour expended on them; but it would only be under exceptionally favourable circumstances, such as have never come within the Author's personal observation, that their construction would be a profitable investment for capitalists now. This is in a great measure owing to the loss by evaporation in shallow tanks. If the main slope of the country be assumed at as little as 8 feet per mile, and the lateral slope towards the stream to be closed at 10 feet per mile, then a rough calculation will give the contents of a tank whose greatest depth of water is 9 feet at about 3 million cubic yards; and, taking the evaporation<sup>1</sup> at 42 inches in four months on the mean area, it amounts to 2.18 million cubic yards, leaving only 820,000 cubic yards for irrigation, or sufficient for 205 acres. The cost of the work would be:

|                                    |                 | R. n. p. | Rs.    |
|------------------------------------|-----------------|----------|--------|
| Earthwork . . . . .                | C. Y. 52,792 at | 0 2 0    | 0,600  |
| Stone pitching . . . . .           | „ 4,200 „       | 0 8 0    | 2,100  |
| Waste-weir and sluices . . . .     | „ „             | „ „      | 2,000  |
| Distribution to 205 acres . . . .  | „ „             | 2 8 0    | 512    |
| Contingencies, &c., 15 per cent. . | „ „             | „ „      | 1,588  |
| Total . . . . .                    | „               | Rs.      | 12,800 |

Or about £6 5s. per acre for an extremely favourable imaginary case, where it must also be assumed that the minimum rainfall would suffice to fill the tank. An actual example of this kind of tank, which intercepted the water of three streams and included cuttings to connect them, was estimated by the Author to cost £15,000 for 3 million cubic yards of available water, or about £25 per acre. As another example, both of the varying cost of flat-

<sup>1</sup> One-third of an inch per day is the observed evaporation in the plains.

country tanks and of the value of water to a cultivator, the Author is acquainted with the following illustration. Chinna-veerappa, a wealthy landowner, had expended £2,500 on a tank, which was still unfinished, and would eventually cost at least £3,000, and be equal to the supply of about 240 acres. Adding the cost of distribution, this would be at least £14 per acre; and the man said it would pay him well. And there is no doubt of it; for the land would raise sugar-cane, and he would reap both the cultivator's and the capitalist's profit.

Although the construction of new works of this kind must be considered a doubtful investment, there are many cases where a small outlay in repairing breached banks, and in supplementing the water supply by digging catch-water drains, or diverting neighbouring streams into a tank, or even by the construction of feeders of considerable length from well-supplied rivers, would be speedily repaid; but without regular surveys it would be impossible to guess even at the number and capacity of tanks that might be thus restored. Many have so silted up that they are best left as they are. This silting up, and the consequent abandonment of flat-country tanks, though a matter of time, is also one of certainty.

The intermediate class of tanks show a better result, as might be expected from their greater depth (as a rule), and consequently less loss by evaporation. The Sholapore tank was estimated by Col. Fife, R.E., to cost about £100,000, which at Madras rates for rice would be £11 per acre. The loss by evaporation was estimated at 29 per cent.; the depth at the dam being 60 feet. This rate of £11 per acre for rice cultivation is stated for the sake of comparison; but rice is not the chief grain irrigated under it, and the net return of the tank was estimated to be 9 per cent. at the low rates of Rs. 4 for a four-months' crop. The Bourg reservoir in Ganjam, constructed by the Madras Government at a cost of £1,075, waters an area of 1,632 acres, and yields an increase on the old revenue of the land of £184 10s., or, deducting repairs, 16½ per cent.

The storage reservoirs of the first class which have been designed and estimated show a very different result from that given by the other classes. The Author is informed that the result of the investigations of the Bombay Engineers is that, in favourable cases, 700 cubic yards of water can be stored per rupee, which nearly agrees with his own estimates in detail of several reservoirs, one of which would store 750, another 425 cubic yards; while the restoration of the Mudduk Masoor tank previously described would yield 960 cubic yards per rupee. The evaporation, calculated

from observations, is  $7\frac{1}{2}$  per cent. in the two proposed new reservoirs in seven months, and 5 per cent. in the Masoor reservoir if emptied in four months. A further deduction has to be made for evaporation in the course of conveyance to the fields to be irrigated, which will vary with each case. In these cases it will be  $2\frac{1}{2}$  and 8 per cent. Assuming the correction for evaporation to be 12 per cent., and the allowance of water per acre at 5,000 cubic yards per acre, which is a little in excess of 2 cubic yards per hour, and adding, as in the case of the channels, 25 per cent. for interest during construction, the rate of storage becomes, for the proposed new reservoirs, 440; the Bombay rate, 493, and the Masoor reservoir, 674 cubic yards per rupee; and the cost per acre, £1 2s. 6d., £1, and 14s. respectively. Such storage reservoirs, when built on main rivers rising in the Ghâts, would have a supply that could always be reckoned on; and on the larger rivers the difficulty would be, not the filling of any reservoir, but the construction of one large enough to intercept a large portion of the floods of one season, or failing that, the disposal of the surplus water. As an example of this: in one of the proposed reservoirs just referred to, which had a depth of 160 feet at the dam (about the same as that built in the Clouffie d'Enfer in France), the water toward the upper end of the laké would overtop the summit of the water-shed of the river Toonga and the Gurget, a river flowing to the western sea; and yet the quantity of water contained by the reservoir would only be about  $\frac{3}{4}$ ths of the ordinary monsoon supply. The above sites for reservoirs were selected as likely to be very favourable, the capacities of two of them being also very great; and therefore the rates are probably cheaper than the average at which water could be stored in rivers having a certain supply, and undoubtedly so as compared with those on rivers with a much more fluctuating supply. Taking the least favourable of these sites, however, 340 cubic yards per rupee, there is still only a prime cost, after all deductions, of £1 12s. 9d. per acre for giving a second crop of rice, or a crop of sugar-cane. The cost of establishment and maintenance on a masonry dam would not be great, and may safely be put at 2 per cent., or 7d. per acre, or even less. The additional maintenance of the channels would not exceed 1s. per acre; so that it will appear that an outlay of £1 12s. 9d. will return about £1 1s. This allows a large margin for the profitable construction of reservoirs on rivers having a less certain or regular supply.

The following estimates of Government works are examples of the profits to be made by repairing, improving, or adding to works



already in existence. In one instance, that of the Trivady Anicut in South Arcot, an expenditure on repairs of £1,100 or £1,200 produced a revenue of £3,000, or 250 per cent.<sup>1</sup>

TABLE IV.

| Name of Work or Project.     | Nature of Works to be Constructed.                        | Cost per Acre.    | Net Returns at Rs. 6 per Acre. |
|------------------------------|-----------------------------------------------------------|-------------------|--------------------------------|
| Tambiapoorney .              | Weir and channels, and enlargement of old ditto.          | £ s. d.<br>2 12 0 | 16½                            |
| Kanagiri, in Nellore         | Head works and channel to a tank which is to be enlarged. | 3 2 0             | } Not stated.<br>? 17          |
| Muddoor, in Mysore           | Weir and channels to old tanks                            | Not stated.       |                                |
| Siceeramadavaia, Mysore.     | Ditto ditto ditto                                         | 2 3 1             | 45<br>27                       |
| Bhatodee, Bombay Presidency. | Restoration of old tank and channels.                     | 6 0 0             | 10                             |

## VI. GENERAL CONCLUSIONS.

As there seems to exist a general impression, that the estimates of the benefits of irrigation are merely estimates, more or less coloured by personal views, the Author has, in the statements of the comparative results of wet and dry cultivation, confined himself to ascertained facts, and has endeavoured to keep the estimates of returns on works within the limits of certainty, by excluding all doubtful or unascertainable profits, such as those from plantations for firewood (a very profitable investment where the earth can be kept sufficiently moist), water supplied to towns and villages for domestic and municipal purposes, water-power, &c. Also, he has taken as the standard of productiveness that of irrigation under tanks, and has not added the 25 per cent. additional crop said to be due to channel irrigation.

As this Paper is intended to deal with works for irrigation only, navigation is not included in either the cost or the returns; but the Author begs leave to make one or two remarks on this subject, on which so much opposition exists in the views of Engineers. This opposition he believes arises from each side attempting to form general conclusions, and to lay down a general rule founded on the observation of particular works, which in each case seem to bear out its advocate's views. The question does not admit of a general answer, either in favour of or adverse to the combination of irrigation and of navigation in one channel. Assuming that a navigable

<sup>1</sup> On the authority of the late Col. J. C. Anderson.



canal is desirable, if it can be constructed at a small outlay, the question whether an irrigation canal should be adapted to that use or not seems to depend for its solution mainly on two circumstances: first, the nature of the ground through which it passes, and, secondly, on its dimensions. If the former is such that a rapid current can be given to the water, it is very desirable to do so in cuttings, in order to reduce their cross section, and this generally to such an extent as would prevent upward navigation. If, on the other hand, the country is very level, as in deltas, and the soil so light that the velocity of the canal has to be small, then the addition of works required for navigation bears so small a proportion to the whole outlay, that to make the irrigation canal navigable is the cheapest way of attaining the end. Thus, in the Orissa scheme, the cost of the navigation works is said to be about one-eighth of the whole cost; and a complete network of navigable lines is obtained at an outlay of £650 per mile. In a less easy country the Author has found that when a canal has to carry from 150,000 to 500,000 cubic yards per hour, and when it has to pass through cuttings, it would be cheaper to have a separate navigation taken round, or in some other way avoiding the difficult parts, than so to enlarge the irrigation canal as to reduce its current within navigable limits. But when a canal has tapered down to 150,000 or 100,000 cubic yards per hour, then it is cheaper to combine irrigation with navigation in one canal. In a tract of country comprising both characters of ground, it was found that to combine a system of navigation with irrigation would add 25 per cent. to the cost of the latter, and would cost from £2,000 to £3,000 per mile, according to the dimensions of the work; but in difficult ground, if the canal were of large dimensions, carrying 450,000 cubic yards per hour, £6,000 per mile would be required to make it navigable. The parts of the canal used for navigation only would cost £1,200 or £1,500 per mile, exclusive of the locks, which, if 100 feet long and 20 feet wide, would cost about £200 per foot of lift. These rates per mile suppose a supply derived from the canal, and do not include headworks or storage reservoirs, as these works are supposed to be charged to irrigation, inasmuch as the water used for lockage would also be expended in the fields.

In the above estimates no account has been taken of the value of the land occupied by the works. It has generally a low value in such districts as require irrigation.<sup>1</sup> In the Orissa system of works it cost 1·8 per cent. of the capital expended; and in any

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<sup>1</sup> Colonel Rundall's Report.

case it becomes quite insignificant, when compared with the indirect advantages accruing to Government from the improvement of the country by irrigation. The most obvious of these is the saving of remissions of land revenue, which have often to be made in consequence of partial or total failure of crops. There is also the relief from uncertainty in the amount of the revenue. In the irrigated districts of Tanjore, the fluctuations in the revenue have declined since the construction of the Government irrigation works from 52 per cent. to 3 or 4 per cent.<sup>1</sup> Other sources of gain to the State are—waste lands brought under cultivation, and so under a charge for rent; increase of the customs and taxation in general; and a large saving of money relief in times of famine. These gains cannot be estimated, and no account has been taken of them in the above calculations, except as a set-off against the value of the land.

No special notice has been taken in this Paper of the great and very remunerative works in the Kristna, Godavery, and Tanjore deltas, the works in the last yielding, according to an independent authority,<sup>2</sup> after deducting repairs and 5 per cent. on the capital, 23½ per cent. direct profits, and those on the Godavery from 50 to 60 per cent. They are omitted because these deltas are so occupied as to offer no opportunity of constructing new works on a large scale.

Table V. shows how the 12s. rate for water, fixed by Government a few years ago as the basis of all calculations for new works in the Ceded Districts, alters the aspect of matters regarding the profits of the cultivator and the supplier of water from that given by the "equitable" or "mutual benefit" rate adopted in Table I. The Author believes Table V. to be nearly correct, although, for reasons already mentioned, the returns may be a little understated.

Persons unacquainted with the native character will be apt to ask why, if irrigation works are so profitable, the natives have not already utilized every drop of available water; but this will be no ground of wonder to those who know their ignorance of the practice of any but their own neighbourhood, their worship of custom, and their habit of relying on their rulers to do everything for them. In the Godavery districts, on the completion of the works, the Government officers are said to have acted in a paternal manner to the ryots by turning the water on to their fields, with or without their consent, and they have been rewarded by the unexampled prosperity of the district.

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<sup>1</sup> Colonel Baird Smith.

<sup>2</sup> Colonel Baird Smith.

TABLE V.

| Kind of Works to be Constructed.                                                                  | Cost of Works per Acre. |    |    | Water Rate. |    | Cultivators Profit per Acre. |    |    | Net Return on Works per Acre |    |     | Per Cent. of Capital. |
|---------------------------------------------------------------------------------------------------|-------------------------|----|----|-------------|----|------------------------------|----|----|------------------------------|----|-----|-----------------------|
|                                                                                                   | £                       | s. | d. | s.          | d. | £                            | s. | d. | £                            | s. | d.  |                       |
| 1. Irrigation by channels for one crop of rice . . . . .                                          | 8                       | 15 | 0  | 14          | 10 | 1                            | 8  | 0  | 0                            | 11 | 8   | 6.7                   |
|                                                                                                   | ..                      | .. |    | 12          | 0  | 1                            | 10 | 10 | 0                            | 8  | 5   | 4.3                   |
| 2. Ditto ditto for occasional irrigation of dry crops . . . . .                                   | 3                       | 2  | 0  | 18          | 4  | 1                            | 9  | 6  | 0                            | 14 | 10  | 23.0                  |
|                                                                                                   | ..                      | .. |    | 6           | 0  | 2                            | 1  | 10 | 0                            | 2  | 6   | 4.0                   |
| 3. Mean of 1 and 2, supposing equal areas irrigated, and three waterings to dry crops . . . . .   | 5                       | 18 | 6  | 16          | 7  | 1                            | 8  | 9  | 0                            | 13 | 0   | 11.0                  |
|                                                                                                   | ..                      | .. |    | 9           | 0  | 1                            | 16 | 4  | 0                            | 5  | 6   | 4.6                   |
| 4. No. 2 with one watering, and the water provided for the other two wasted or not used . . . . . | 3                       | 2  | 0  | 6           | 0  | 2                            | 1  | 10 | 0                            | 2  | 6   | 4.0                   |
|                                                                                                   | ..                      | .. |    | 2           | 0  | 2                            | 5  | 10 | 0                            | 1  | 6   | Loss.                 |
| 5. Mean of Nos. 1 and 4 . . . . .                                                                 | 5                       | 18 | 6  | 10          | 5  | 1                            | 14 | 11 | 0                            | 6  | 10½ | 5.8                   |
|                                                                                                   | ..                      | .. |    | 7           | 0  | 1                            | 18 | 4  | 0                            | 3  | 6   | 3.0                   |
| 6. Application of storage water to existing works, giving a second crop of rice . . . . .         | 1                       | 9  | 5  | 22          | 6  | 0                            | 9  | 0  | 1                            | 1  | 0   | 71.0                  |
|                                                                                                   | ..                      | .. |    | 12          | 0  | 0                            | 19 | 5  | 0                            | 10 | 6   | 36.0                  |
| 7. Combined storage and distribution works; two crops of rice . . . . .                           | 10                      | 4  | 5  | 37          | 3  | 1                            | 19 | 2  | 1                            | 13 | 9   | 16.5                  |
|                                                                                                   | ..                      | .. |    | 24          | 0  | 2                            | 12 | 5  | 1                            | 0  | 6   | 10.0                  |
| 8. Ditto ditto, sugar-cane . . . . .                                                              | 10                      | 4  | 5  | 105         | 6  | 4                            | 13 | 0  | 5                            | 2  | 9   | 50.0                  |
|                                                                                                   | ..                      | .. |    | 24          | 0  | 8                            | 15 | 8  | 1                            | 1  | 8   | 10.0                  |

The first rate in each case is taken from Col. 2, in Table I.; the second is the Government rate, and in Nos. 2 and 4 the rate allowed to the Madras Irrigation Company.

The object of this Paper will have been attained if it has shown :

First. That all works of irrigation benefit the cultivator to such an extent as will enable him to pay a water-rate equal to two-thirds of the increased value of his crop, and not exceeding one-half the net value, and still to leave his own profits by 100 to 400 per cent.<sup>1</sup> in excess of those derived from dry cultivation.

Secondly. That of the three kinds of works mentioned in Table V., under 1, 6, and 7, the storage of water for the raising of a second

<sup>1</sup> In sugar-cane cultivation 950 per cent.



crop, under distribution works already in existence, is the most profitable, and would, after paying one-third of the gross revenue to the existing works, still yield a net return of 46 per cent. on the outlay, and increase the revenue of the existing works, supposing them to have cost the average sum, by  $4\frac{1}{2}$  per cent.

Thirdly. That the arbitrary rate of 12s. per acre is insufficient, on the data assumed by the Government, to yield a fair return directly on the average of new irrigation works, unless those include the storage of water, when the Government rate will yield a net profit, on storage and distribution works combined, of 10 per cent.

And Fourthly. That as a consequence of the last, the profitable employment of unguaranteed capital in irrigation works depends chiefly on the recognition of the principle, that the water-rate should be fixed with reference to the value of the crop produced. This value will, in all probability, continue to increase, as will also the cost of the works as wages increase; and unless the water-rate is fixed with due regard to the value of the water to the consumers, and to the cost of work in each district, many beneficial projects will remain unexecuted.

The communication is accompanied by a series of diagrams, from which Plate 7 has been compiled.



Mr. J. H. LATHAM said that his personal experience of the district in India embraced by Mr. Gordon's Paper enabled him generally to corroborate the facts stated. The old Hindoo system of village tanks must gradually come to an end, owing to the natural and inevitable silting up of their shallow beds, unless fresh tanks were continually added, as of old, to supply the place of such as became inefficient for irrigation from this cause. Mr. Latham quoted Col. Playfair, R.E.,<sup>1</sup> to show that, in the Deccan and South Mahratta country, the same difficulty existed in the way of this renewal as existed in the Madras Presidency, viz., that village tanks, as a rule, were not paying works. On this account a Government could not fairly spend public money upon them, for the benefit of the local villages, nor would private speculators build them. As a fact, charitable persons did not any longer come forward to build them. The old system of village tank irrigation\* was therefore dwindling away, and any useful system meant to replace it must involve, to a certain extent, novelty. The Madras Government seemed especially to have appreciated this, and had proved the most speculative and successful of the Indian Governments. Permanent irrigation had been secured on the coast by their well-known works at the heads of the river deltas, of which the most important on the Cauvery, Kristna, and Godavary were calculated to pay from 23 per cent. to 60 per cent.; and by the purchase of the Orissa works from a private company, which were calculated to pay this year 12 per cent. Again, in the Neilgherry hills, there seemed to be no reason why their bold attempt to construct a tank 140 feet deep by the silting process should not ultimately prove successful. But these plans were not applicable for up-country irrigation, for which the system most advocated, amongst others by Mr. Gordon and Col. Playfair, was that of river channels, combined with reservoirs for storing the water from the monsoon rains. Since the commercial success of such schemes was of primary importance, any information bearing on the actual cost of the works, or on the commercial value of water provided by them, would be interesting. A most important matter affecting the cost of the works was the provision of an adequate escape for surplus water, the quantity of which was, in some schemes now proposed, very large, necessarily delivered at a great height, and requiring costly works. Adopting the formula

$$D = C n^{\frac{2}{3}},$$

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<sup>1</sup> "Report on Irrigation in the Deccan and South Mahratta Country." Bombay, 20th April, 1866.

where  $D$  was the quantity of water for which escape was required for a drainage from  $n$  square miles of country, and  $O$  some constant; then, taking  $D$  in cubic yards per hour, in the designs for the Elcrooka tank, near Sholapoor, under construction by the Bombay Government,

$$D = 61,523 n^{\frac{2}{3}}.$$

On the Ganges and Godavery works it was stated that escape would be provided for

$$D = 75,000 n^{\frac{2}{3}};$$

and on the Madras Irrigation and Canal Company's works Mr. Latham was providing escape sufficient for

$$D = 100,000 n^{\frac{2}{3}}.$$

These differences showed how important it still was to have more information on the subject.

The value of the water stored depended primarily upon the area of irrigated crop for which a given quantity of water sufficed. About this great differences also existed. The supply of each cubic yard of water per hour was taken in the Elcrooka scheme to suffice for  $\frac{9}{10}$  of an acre\* for a year's irrigation, and for  $1\frac{1}{8}$  acre for crops grown during the wet months. In the Lakh project on the Pailra, as sufficient for  $\frac{3}{4}$  acre and  $\frac{8}{9}$  acre, respectively, for these crops; and by the Madras Government, as sufficient for  $\frac{1}{2}$  an acre only of either crop. The experience of irrigation on the Soonkêsala canal of the Madras Irrigation and Canal Company was too brief to give a definite result, but indicated that, where due care was used to prevent waste, the Bombay practice was nearer the truth than the Madras. That the Madras estimate was too low seemed also indicated by Col. Baird Smith's estimate, that a cubic yard an hour sufficed for  $1\frac{1}{2}$  acre of irrigation in India. The water-rate to be charged per acre would, of course, be different for different districts, and was a mere question of the value of produce in the locality. Perhaps Mr. Gordon could give more definite information on the subject of escapes, and on the irrigating power of water in India.

Since the amount of drainage water to be provided for in these reservoirs affected their cost seriously, he would give a few particulars of the rainfall in Southern India during the time he was there. Excepting an extraordinary fall, to which he would refer presently, the greatest depth registered at Kurnool in any one month in the ten years, 1862-71, was 18.77 inches, in September, 1862; the greatest depth in one day being 4 inches, on the

night of the 24th of that month. The only other occasions on which a total depth of 7 inches fell in a month were in August, 1865, 7·73 inches; and in August, 1868, 7·35 inches. Since January, 1868, when the Kurnool Observatory was established, a depth of rain exceeding 2 inches in twenty-four hours was registered on three occasions, in no case reaching 3 inches. But on the exceptional night of the 6th of August, 1870, an extraordinary storm from the south-west occurred, and 12·01 inches of rain fell in twelve hours. At a distance of 13 miles west of Kurnool, the storm was felt in the daytime of the 7th, after rain had almost ceased at Kurnool, and only 7·22 inches fell. At a distance of 30 miles east of Kurnool, an unusually heavy rain occurred during the night of the 6th. This proved that ten years' experience of one place was quite inadequate to determine the frequency of such excessive falls. Two other storms deserved notice; one at Gooty, and the other at Tâdamurri, adjacent talooks in the Bellary District, in the autumn of 1864, when a depth of above 8 inches of rain fell in one night. The other was a short storm, which he gauged, at Bôanassey, on the 72nd mile of the canal, when for thirteen minutes rain fell at the rate of  $3\frac{3}{4}$  inches an hour.

The interests of the Canal Company had hitherto required that water should be given to the village cultivators in excess of what they used for cultivation. As to observing an experimental patch of ground, there were insuperable difficulties in the way; for if the patch were isolated the water percolated through the soil and irrigated the surface for yards around, besides passing away through the subsoil. On the other hand, if the patch were surrounded by wet cultivation, the result could not be trusted, so easy was it to transfer from one field to another surreptitiously; and if the result were trustworthy it would not give the average requirements for cultivation. The only proper observation would be to see how much water per hour per acre was actually used—when it was served out without waste; and that he had not been able to ascertain.

Colonel J. T. SMITH said, as far as he could make out the Table on which the results given in the Paper were founded, there was one important element neglected, viz., that half the value of the produce was taken by the Government in assessment. The results of commercial speculation depended upon, first, what was paid for an article, and, secondly, upon what it could be sold for. To begin with the sale of the water, he had not been able to make out how it was deduced that £1 1s. per acre irrigated was the value; but the value so calculated was not important, for when discussing



a commercial speculation connected with a concession from the Government, the company was bound to accept the terms of the concession; and the Government concession of the privilege of storing water in South India was connected with a condition to sell it at the rate of 12s. per acre irrigated. Therefore he conceived the real commercial result ought to be based upon the 12s. per acre, and it would mislead the public if they were induced to believe that a return of 46 per cent. was to be obtained by selling the water at a guinea when there was actually no power to do so. He, therefore, concluded that the results ought to be based upon 12s. per acre.<sup>1</sup>

He now came to the cost of the water. He thought the Author had acted with great impartiality in the statements of cost, yet he could not agree with the results. The calculation was based upon an average reservoir, able to store water at the rate of 4,250 cubic yards per £1. That was an imaginary reservoir; but a description was more particularly given of one reservoir which was proposed to be immediately restored, viz., the Mudduk Masoor tank. He would say with regard to that, as well as with regard to the statement of past profit derived from Government irrigation works, that it was one thing to construct a work, and another thing to take a work already constructed, and simply out of order. If he brought forward a project for taking up a large number of houses out of repair, and showed that by putting them into good order he could make 23 per cent. by it, the scheme would appear very attractive; but the question would arise—who would give so valuable a concession? The Government, as possessors of these old tanks, had little to do to put them in order, and consequently made very large profits. It was stated that the Mudduk Masoor reservoir was about 40 square miles in superficial area when full; and that it contained 1,400,000,000 cubic yards of water. It was proposed to lower the dam from 90 or 108 feet height to about 70 feet, and then the area would be about 24 square miles. The Author, by experiments on the spot, found that an average monsoon rainfall yielded about 668,000,000 cubic yards of water; consequently he proposed to provide a reservoir which would contain a little short of that, viz., 644,000,000 cubic yards,

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<sup>1</sup> The Author guarded his statements by the express provision that the actual values were to be realised, but there was no such qualification in the second conclusion submitted to the meeting; and although it is quite possible that an increase in the water-rate might hereafter be allowed, yet such an increase ought not to be assumed in stating the present value of a mercantile speculation.—J. T. S.



which would be the capacity of the Masoor reservoir with a dam 70 feet high. Upon this it might be observed that, unless the monsoons were of great uniformity, it was not sufficient to provide reservoirs equal to the average expected: they ought to be capable of holding the maximum as well as the minimum rainfall. The question, therefore, arose whether the district was one in which the seasons were uniform, or fluctuating. He had the following reason to believe the seasons were extremely fluctuating. It so happened that the Company who proposed to construct this reservoir suggested another in the same neighbourhood, called the Maury tank. The Chief Engineer sent home a report, founded upon observations, the result of which showed that there was abundance of water to fill the tank, and it was resolved to make application to the Government for it. But the Government hesitated to grant the concession, on the ground, partly, that the supply of water was insignificant compared with what was estimated, and partly because it was not more than the country required, and they therefore finally resolved to keep it for the use of the inhabitants. He had also been informed privately, but on good authority, that a similar hesitation was now felt as to granting the concession of the Masoor tank, and for the same reasons, namely, that the supply of water was much less than was supposed, and not more than was required for existing demands. Now he did not attribute these different estimates of the probable rainfall to errors of observation on the part of the various officers who made them, but to the fact that they were made at different times, and that the fall of rain in the district was very uncertain. Hence if the parties constructing such reservoirs made their calculations on the ground of storing the average monsoon rainfall, they must have a larger tank than the average rainfall would fill. Calculating without this would tell in one of two ways. Either the tank would cost more from building it larger, or there would be less water on the average than was anticipated; and on those grounds he thought some deductions ought to be made from the Author's estimate of the value of the produce of these tanks.

The next point was the evaporation from the tank. The specimen or representative tank was supposed to contain 4,250 cubic yards for every £1 sterling laid out upon it; which, allowing for interest on the money during construction, was calculated to yield 340 cubic yards per rupee; but it was necessary to modify this calculation, because it was one thing to have the water in the tank, and another to have it on the land.

Reverting to the Mudduk Masoor tank of 24 square miles area, and 640 millions of cubic yards capacity, the Author had estimated the evaporation during four months from that tank while it was being emptied, and his calculations had been made upon proper data, which corresponded with experiments carried out by order of the Madras Government, whereby it was deduced that in the middle of the tank the evaporation was about one-third of an inch per day, or 10 inches per month, which in four months amounted to 40 inches. This result was however subject to a deduction of one-half, inasmuch as there was a reduction of surface from 24 square miles at the beginning of the discharge to a greatly diminished surface at the end. That brought the evaporation down to 20 inches in the four months, over a surface of 24 square miles, and amounted to 40 million cubic yards, or  $6\frac{2}{3}$  per cent. of the 640 millions of cubic yards which the Masoor tank was to hold. Now,  $6\frac{2}{3}$  per cent. during the four months was equal to twenty per cent. during the year. For it must be noted that, although it was quite sufficient to calculate the evaporation from the surface of the reservoir during the months of discharge only, if the object was, from a given quantity at the beginning of the discharge, to determine the quantity which left the reservoir, yet the case was different when, with a given average monsoon rainfall, it was intended to ascertain the loss by evaporation during the time of its collection in the reservoir, its preservation there, and also its discharge. For this purpose the evaporation for the whole year must be taken into account, at an average of half the surface during collection and discharge, and during the remainder as for the whole surface. Hence the loss for the whole year would be 20 per cent. without reckoning the full rate during the interval of repose.<sup>1</sup> And here he would mention that when the experiments were made on which the rule of the irrigation department was founded, viz., that  $\frac{1}{3}$ rd of an inch per day was evaporated from the middle of a large tank, the gentleman who had charge of the experiments reported at the end of the season that  $\frac{5}{8}$  of what had left the tank left by evaporation, and only  $\frac{3}{8}$  had gone on the land: that was,  $62\frac{1}{2}$  per cent. was evaporated, and only  $37\frac{1}{2}$  per cent. had gone on to the land: the fields referred to being in the immediate vicinity of the tank, so that there could not have been a length of more than from 10 to 20 miles of irrigation channels.

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<sup>1</sup> Owing to a strange clerical error the Author had omitted to make the deduction of 12 per cent. which he allowed, so that the £1'9s. 5d. per acre was based upon the supposition that every drop of water in the tank was spread upon the land.—J. T. S.



The next question to be considered was that the water let out of the Masoor tank did not irrigate the fields immediately, but went down the bed of a river for 200 miles. He believed the bed was in some places rocky, and in others sandy and absorbent. Thus the water was in motion for 200 miles before it reached the irrigation canal, and an allowance must be made for evaporation and absorption. After reaching the head sluices the water had, on the average, 100 miles of main canal to traverse, and that canal was very leaky. There was a great deal of loss by leakage, not, however, owing to any fault of the Engineers, for they had done their duty perfectly. But it was leaky, partly owing to the extreme badness of the soil, and partly because, owing to financial considerations, it was thought advisable to let it remain as it was for the present, as it would have required a considerable expenditure of money to have made those banks tight; and it was thought better to postpone that expense till the water was more valuable than it would be for the first few years. In addition to the distance already traversed, there were between 300 and 400 miles of distributing channels finished, which might possibly be increased to 500 or 600 miles before they were all completed.<sup>1</sup> He would prefer that others should judge what was the proper allowance to be made for the losses referred to—first, by evaporation in the reservoir; secondly, in the bed of the river; thirdly, by leakage and evaporation in the main canal; and fourthly, in the distributing channels.

In estimating a scheme of this kind, and calculating the financial results, it was proper to be on the safe side. The Government decided that 2 cubic yards per hour for each acre was necessary; but he observed that Mr. Gordon had calculated 5,000 cubic yards per acre only. He thought it should be 6,000 cubic yards. The average time of cultivation was about one hundred and thirty days, and 2 cubic yards per hour per acre for one hundred and thirty days was more than 6,000 cubic yards. Again, the mere evaporation alone, from the surface, at the rate he had stated, namely,  $\frac{1}{8}$  of an inch per day, would come to 8,000 cubic yards for the six months, and more than 5,800 cubic yards for one hundred and thirty days; and hence, taking also into consideration absorption and other losses, he thought 6,000 cubic yards was the least that ought to be allowed for.

To recapitulate his remarks respecting the formation of the tanks,

<sup>1</sup> It was not hereby intended that the water must traverse these 300 or 400 miles; the distance run would of course vary with the situation, from a few chains possibly, to a number of miles—J. T. S.

Mr. Gordon's estimate, after allowing for interest during construction, was 340 cubic yards per rupee. Now he had given reasons for thinking there ought to be an increase in that estimate, or, in other words, a diminution in the number of cubic yards stored per rupee. If, for instance, the Masoor dam were built of the full size, to secure the whole monsoon rainfall in every year, it would cost double the money estimated by the Author, and instead of 960 cubic yards per rupee, there would only be 480 cubic yards. In the same way, in regard to the specimen tank, instead of 340 cubic yards per rupee, there ought to be much less, if the whole rainfall were calculated. As he wished to take a most moderate view of the case, he would only strike off the 40 cubic yards from the 340, leaving the estimate at 300 cubic yards per rupee. But this did not represent the quantity actually put on the field; and in his opinion, if the Madras Irrigation and Canal Company got one half of the water upon the fields, they would do very well. In that case they would have 150 cubic yards per rupee on the field, and the 6,000 cubic yards required for the irrigation of each acre would cost Rs. 40, for which they would receive Rs. 6 return. Now Rs. 6 for every Rs. 40 amounted to 15 per cent.; and if 3 per cent. were allowed for repairs, superintendence, and management, it left 12 per cent. to be divided between the proprietors of the old and new works; and he believed this to be a fair estimate. He had no wish to exaggerate; but he thought it was right to sift an important question like this, and if he had made any mistake, the Chief Engineer of the Company would no doubt correct him.

There was one more point he must advert to—a point of expenditure, viz., Who was to insure these large works against accident after completion? He thought Government would, on general principles, be disinclined to grant concessions for reservoirs, if they believed the parties were likely to realise 46 per cent. from them. They might still more hesitate to give a concession unless they had security that, in case of failure, there would be some funds to meet the loss. To give an idea of the magnitude of these works, he might state that the proposed reservoirs were four hundred times the size of the Bradford reservoir, near Sheffield, the failure of which caused so much disaster and loss of life and property some years ago. It was true the country was not densely populated, but there were towns and villages, and a good many inhabitants within reach of danger. Therefore it might be supposed the Government would require security, in connection with works of the magnitude referred to, and the provision of some party responsible for, and able to make good, any damage.



Mr. RUSSEL AITKEN said, the quantity of water required to irrigate a certain area depended very much upon the nature of the soil, as well as the crops to be raised. In the case of sandy soils a large quantity was wasted, as the water soaked into the ground, thereby raising the spring-level of the country. The value of water depended very much upon the nature of the rainfall. In the Concan in Bombay and other places, where the monsoon rainfall was most abundant, a supply for one crop could always be depended upon, but this was not the case in other parts of India. Then, as regarded the crops raised, in some parts the produce could not be disposed of without great cost for land-carriage. The distance from a market made an enormous difference in the value of water for irrigation purposes. Those who embarked in irrigation projects were apt to consider that, as soon as the water was provided, it would be taken up immediately; but that was often not the case. In the first place, there must be population to cultivate the ground; then the cultivators must acquire capital to buy bullocks, build houses, and obtain agricultural implements. Therefore the expectation of an immediate return from these works was, he thought, a great mistake. The returns from the Ganges canal varied from 1 per cent. up to  $2\frac{1}{2}$  per cent., after paying working cost, which, even in a fully-developed canal, amounted to 25 per cent. of the total revenue; and it was only in 1868-9 that it paid  $7\frac{1}{4}$  per cent., and that was an exceptional year. In the case of the large returns reported of some of the Government works, they had been constructed under very favourable circumstances, so far as regarded the natural facilities afforded by the ground, and also by the comparatively low rates of labour which then prevailed.

Large canals in the doltas of Madras had been constructed for about Rs. 7,000 per mile, and that was a very cheap rate when compared with some new canals there, the construction of which had cost at least Rs. 70,000 per mile. Thus, returns which now paid 30, 40, or 50 per cent. on the smaller cost, would give but 3, 4, or 5 per cent. on the larger expenditure; so that the first cost of the works produced a material effect upon the returns of profits.

The actual value of water in any canal varied so much that no definite conclusions could be given. On the Ganges and the Eastern Jumna canals, the annual revenue for a discharge of one cubic foot of water per second was as under:

|         | Ganges Canal. | Eastern Jumna Canal. |
|---------|---------------|----------------------|
|         | Rupees        | Rupees               |
| 1866-67 | 374           | 522                  |
| 1867-68 | 390           | 519                  |
| 1868-69 | 525           | 653                  |

The water-rate was only about Rs. 2 per acre per crop; whereas in Madras and Bombay it was much higher.

In Bombay he had made a number of observations fruitlessly to find the quantity of water required to cultivate land. Waste, as in waterworks in England, was the chief difficulty. As to the different values of water, he might give one instance to show how it varied. In calculating the value of water from a proposed reservoir about 50 miles from the town of Bombay, he came to the conclusion that a cubic foot per second, for eight months of the year, was worth Rs. 715 per annum for field cultivation, while in the Island of Bombay water was worth, for market gardens, Rs. 8,200 per cubic foot per second, or nearly twelve times as much. It depended upon the crops cultivated, the nearness of the market, and whether there was population to take up the water supplied.

Although irrigation works in India did not, as a general rule, offer a field for profitable speculative investment, yet there could be no doubt as to the duty of the Government of India in this matter. Not only did the Government get large revenues from the water-rates, but canals contributed to the revenue in many indirect ways. In 1868-9 there would have been a famine in North-western India but for the Ganges' canal and other canals. The Government, being the proprietors of the land, derived revenues from the land-tax, as well as the water-rates; and if there had been no crops to gather, the Government would have lost the land-tax, whereas they had the benefit of both land-tax and water-rates. In many places, where it would not pay a private company to construct works for irrigation purposes, it paid the Government to do so. In Poonah, a large garrison town, the Government were constructing irrigation works; but he doubted whether they would give any considerable return upon the outlay, though, when the effects of irrigation in reducing the price of forage, and other benefits resulting from a supply of water were considered, there was no doubt whatever of the necessity for those works being undertaken.

One other point he would mention, viz., the difficulty there was in following this discussion owing to the varying quantities that were spoken of. In Madras the calculations were at per cubic yard per hour; in the north-west the rates were taken at per cubic foot per second; while in Bombay he had been in the habit of calculating in million gallons. It was very desirable that the measurement of water in irrigation works should be reduced uniformly to the cubic metre per minute, which would be better than when several varying standards were employed.

Mr. J. AIRD observed that, from the drawings there appeared to

be a total absence of any puddle-gutter—a work which was accustomed to be regarded as an important element in the construction of large reservoir banks. Experience showed that, when a leak occurred in a reservoir bank, it was difficult to stop it in the absence of a puddle-gutter, or some protecting material of that sort. He would be glad to hear what means had been taken to protect the slopes of these reservoirs. If they were of the enormous area described, with the varying climate, heavy rains, and strong winds, they must be exposed at times to much wash, and without adequate protection upon the slopes there might be considerable danger.

Mr. A. JACOB stated that there was a large waste of water in the beds of the rivers. He had gauged many rivers in India, and found that the amount of water discharged at the head was nearly the same as at the outfall. The tributary streams discharging into the main channel were numerous, and it was evident that much of the water must be lost by evaporation. There was an old saying in India, that irrigation works on rivers increased the discharge of the river; or, in other words, that there was more water got out of the river than it appeared to discharge above the works. Keeping this in view, it was surprising to see the important results produced by placing dams across rivers at intervals of 5 or 6 miles asunder.

He dissented, to some extent, from the views expressed by the Author as to the superiority of high embankments. No doubt a reservoir of great depth gave a less degree of evaporation, *ceteris paribus*, than a shallow one. But shallow tanks were easier of construction by native labour, and for a given quantity of earth-work the tanks were cheaper, because the material was at hand; and when the work was performed by basket-labour, everything, as regarded cost, depended on the distance from which suitable material had to be carried, which in large banks was sometimes very great. At the present time the Government fixed 12s. as the basis on which the financial return was to be calculated. Seven or eight years ago, a uniform rate of Rs. 1 per acre was fixed by Government; and though he had matured many projects, none of them could be calculated to pay on such a low basis. It seemed very small, when it was notorious that the natives were prepared to take water at Rs. 15 to 20 per acre irrigated. Unless the Government would charge at a fairly remunerative rate, as the natives would do themselves, neither Government nor private companies could expect to get a reasonable return for their money.

Mr. HEMANS, Vice-President, remarked that 5,000 cubic yards turned into cubic metres, or tons, represented 3,750 tons, equal to a depth of  $37\frac{1}{2}$  inches of water per acre. That, at the rate of 12s.



per acre, would be at the extremely low price of  $\frac{3}{100}$ ths of 1*d.* per ton. He did not understand how a crop of rice could absorb such a large amount of water as 3,750 tons per acre. Colonel Smith said it should be 6,000 cubic yards. It was customary in England to irrigate with diluted sewage at the rate of 5,000 tons per acre; but from that land 60 or 70 tons per acre per annum of the rankest and richest grass crops were taken, in a series of crops of 5 or 6 tons each. He wanted to know how that quantity of water could be absorbed or necessary, in addition to the natural rainfall, and whether the quantity stated was applied to one crop or two crops of rice per annum; and further, how it was possible the profits stated could result from the price of  $\frac{3}{100}$ ths of 1*d.* per ton of water.

Mr. H. CONYBEARE had given some attention to the impounding of water, having constructed for the water supply of Bombay<sup>1</sup> a reservoir covering 1,400 acres, and in parts upwards of 80 feet in depth, which he believed was one of the largest modern works of this description. No one could have witnessed the almost magical results of irrigation in tropical and semi-tropical climates, in converting a desert into a garden, without feeling a strong desire to be able to make out a good case in favour of the extension of irrigation as a commercial undertaking. It was therefore with great regret that he had come to the conclusion, that no such case had as yet been made out, at least as regarded tank irrigation. Obviously the most important element in the calculation was the cost at which the water could be stored; but, unfortunately, there was still great uncertainty, and widely differing opinions, as to the number of cubic-yards of water that could, under average circumstances, be impounded for a rupee. The Author of the Paper had assumed the quantity to be 700 cubic yards in favourable cases, and 340 cubic yards in unfavourable cases. The cost of the earthwork in the dam was taken at only 3*d.* per cubic yard, but it was doubtful whether such work could be executed under 6*d.* per yard. Moreover, these calculations appeared to be entirely based on estimates; whereas on a point of this practical nature, and of such great importance, it was only safe to rely on the basis of accomplished facts. To be satisfied on such a matter there should be official records showing the actual particulars of cost, and also the contoured plans of a number of reservoirs actually executed, by which the storage capacity of each might be computed, together with such detailed drawings of the dams, &c., as would allow of the quantities of the work involved in impounding

<sup>1</sup> Vide Minutes of Proceedings, Inst. C.E., Vol. xvii., p. 555.



the water being accurately checked; such data, in fact, as had been afforded, in respect to the irrigating tanks in Ajmeer and Mairwara, by Colonel Dixon's work.<sup>1</sup> A book had been published by Sir A. Cotton,<sup>2</sup> in which reference was made to the enormous returns that works of irrigation were calculated to yield in India as commercial investments, and in which this work of Colonel Dixon's was grievously misquoted. Sir A. Cotton stated (page 123) that under ordinary circumstances storage reservoirs could be constructed at as low a rate as R. 1 (2 shillings) for each 2,000 cubic yards of water stored, and under favourable circumstances, to store thrice the amount; and he stated (page 254) that in the one hundred and twelve irrigating reservoirs constructed by Colonel Dixon in Ajmeer, in Rajpootana, the average cost of water was one rupee for each 8,000 cubic yards of water stored.

Colonel Dixon's work for impounding water in Rajpootana, of which Sir A. Cotton spoke so highly, afforded the most economical examples as yet on record of works of this description. The Government of India were of opinion that "it would have been impossible, in almost any part of India, or under any other superintendence than Major Dixon's, to have constructed such works." Accordingly the Court of Directors requested that Colonel Dixon would prepare a report of what he had effected in Mairwara, and a detailed account of the improvements recently made in Ajmeer, accompanied by scientific plans, sections, and drawings, of his more important works, founded on actual survey and measurement. They further ordered that, when prepared, such report and illustrations should be printed and circulated at the expense of the Government of India, for the guidance of officers engaged in similar operations. The report so called for was subsequently published in a quarto volume, containing scientific descriptions and illustrations of eight of Colonel Dixon's principal storage reservoirs, together with a general description of the remainder.

A comparison between the rates at which Sir A. Cotton so positively calculated on impounding water, and at which he stated that Colonel Dixon had impounded water, with those actually obtained in the most economical works of Colonel Dixon's extensive practice in Rajpootana, would afford no unfair criterion

<sup>1</sup> *Vide* "Sketch of Mairwara; giving a brief account of the origin and habits of the Mairs; their subjugation by a British force; their civilisation, and conversion into an industrious peasantry; with descriptions of various works of irrigation in Mairwara and Ajmeer, &c." By Lieut.-Col. C. J. Dixon. 4to. Maps, plans, and views. London, 1850.

<sup>2</sup> *Vide* "Public Works in India." By Lieut.-Col. A. Cotton. 8vo. Madras, 1851.

for testing the general accuracy of Sir A. Cotton's figures and calculations. It would appear, on instituting such comparison, that Sir A. Cotton had calculated the cost of storing water about ten times too low; and that the final cipher ought in most cases to be abated from his numerical statements. For it was to be presumed that the eight examples of reservoirs which Colonel Dixon had selected for detailed illustration, out of a total of one hundred and twelve, would be considerably more than average specimens; as it was, indeed, known they were from the particulars afforded by his tables regarding his less important and unillustrated works.<sup>1</sup> Yet, on analysing the elements of the eight model works so selected, it appeared the most economical result obtained was 688 cubic yards of water per Rupee, the lowest only 102 cubic yards per Rupee, and that the average number of cubic yards of water stored for each Rupee, expended merely in labour and materials, was only 284 cubic yards per Rupee, and for four of the eight model examples, was under 200 cubic yards per Rupee. Whereas Sir A. Cotton stated (p. 123), "I calculate that water can be stored at 2,000 cubic yards per Rupee (2 shillings), an estimate which is the result of long experience among the tanks of the Carnatic. Without any remarkable advantage in the site, a bund may be made almost anywhere at this rate; but in many situations where the form of the ground favours it, thrice this amount may be stored for a Rupee (2 shillings)." He also estimated the average results of Colonel Dixon's practice in Ajmeer at 8,000 cubic yards per Rupee. Moreover, Colonel Dixon's tanks were constructed at exceptionally low rates. The masonry in mortar was only 1s. 6d. per cubic yard, and the earthwork, "well beaten and rammed," was executed at the low rate of 1½d. per cubic yard. Now, Engineers of Indian experience would know that, earthworks of that sort could not be sublet in India at the present time at less than four times the rate that Colonel Dixon paid for his work. Sir A. Cotton remarked in his book, that if these reservoirs had been larger (the eight selected for illustration in this work were much larger than the average of such works in India), the water

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<sup>1</sup> The following Table, compiled from the scientific descriptions and illustrations of eight of Colonel Dixon's principal works at Maiwara and Ajmeer, will give the principal elements and the cost of water-storage in each. Colonel Dixon gave no contoured plans of the sites, from which the cubical contents might be exactly ascertained; but it was found in practice, that the area of a reservoir multiplied by two-thirds of its greatest depth would afford a fair rough approximation—and usually in excess rather than otherwise—of its cubical contents; and the contents of Colonel Dixon's reservoirs had been thus calculated.

could have been more economically stored. That was true theoretically; but, on the other hand, the sites where enormously large quantities of water could be economically stored were very exceptional, and where they did occur they usually involved exceptional sources of expense, which detracted materially from their theoretical economy. In the case of the large reservoir which he had made at Bombay, covering 1,400 acres, and 80 feet deep, with every attention to economy, he was only able to store 162 cubic yards per Rupee, and that work was done by contract. Therefore he was afraid no case had been made out for the extension of tank irrigation, as a commercial speculation, in India. The results were so uncertain; there were so many circumstances to cause variation in the profits; and, as he had shown, the actual cost of impounding water was so much greater than it was usually stated to be. But

TABLE showing the Cost of IMPOUNDING WATER in RAJPOOTANA (compiled from COLONEL DIXON'S WORK.)

| NAME OF TANK.                                                               | Surface Area in Square Yards. | Greatest Depth in Yards. | Contents in Cubic Yards (being two-thirds of greatest Depth into Area). | Cost (exclusive of Survey, Superintendence, &c. &c.). | No. of Cubic Yards stored per Rupee. | Lineal Yards of Dam to Acre of Surface. | Proportion borne by Length of Dam to Total Elevation. | Description of Dam.                 |
|-----------------------------------------------------------------------------|-------------------------------|--------------------------|-------------------------------------------------------------------------|-------------------------------------------------------|--------------------------------------|-----------------------------------------|-------------------------------------------------------|-------------------------------------|
| 1 Kabra . .                                                                 | 968,000                       | 6½                       | 4,302,222                                                               | Rs 2s 6,248                                           | 688                                  | 10½                                     | 21                                                    | Earth faced with masonry.           |
| 2 Juwaja . .                                                                | 1,161,000                     | 5                        | 387,200                                                                 | 8,781                                                 | 102                                  | 22                                      | 18                                                    | Earth faced with loose rough stone. |
| 3 Roopana .                                                                 | 135,520                       | 6                        | 524,080                                                                 | 2,205                                                 | 216                                  | ..                                      | ..                                                    | Earth faced with masonry.           |
| 4 Gohana .                                                                  | 503,360                       | 8                        | 2,684,586                                                               | 4,260                                                 | 629                                  | 11½                                     | 17                                                    | Do. do.                             |
| 5 Kalee Kankur                                                              | 616,666                       | 9                        | 3,699,996                                                               | 16,549                                                | 223                                  | 9                                       | 17                                                    |                                     |
| 6 Lohurwara .                                                               | 780,000                       | 5                        | 3,900,000                                                               | 7,743                                                 | 503                                  | 49                                      | 11                                                    | Do. do.                             |
| 7 Durathoo .                                                                | 813,750                       | 8½                       | 4,701,666                                                               | 25,995                                                | 188                                  | 22                                      | 11                                                    |                                     |
| 8 Sreenuggur .                                                              | 526,444                       | 8½                       | 2,924,688                                                               | 14,648                                                | 200                                  | 5                                       | 11                                                    |                                     |
| Total of 8 Tanks . . . .                                                    |                               |                          | 23,142,433                                                              | 81,441                                                | ..                                   |                                         |                                                       |                                     |
| No. of cubic yards of water stored for one Rupee—average of the 8 tanks . . |                               |                          | .. ..                                                                   | .. ..                                                 | 284                                  |                                         |                                                       |                                     |

The rates at which the Kabra embankments were constructed were as follows: Lime masonry, 1s 6d. per cubic yard; earth in bank, well beaten and rammed, 1½d. per cubic yard. The rates at the other reservoirs were nearly the same.



there were a very large number of ancient tanks throughout India and Ceylon, that had become breached for want of a waste weir, the repair of which could not fail to prove remunerative as a commercial investment. Even in cases where irrigation would not answer as a commercial investment to outsiders, it would still be worth the while of the Government to undertake such works; because in most parts of India Government stood in the position of being the universal landlord, and the amount of indirect profit they would get in saving the remissions of land-tax in seasons of drought would make to them the difference between a loss and a profit. Moreover, were a large proportion of the land in any district under irrigation, famine and its incidental calamities and losses would be rendered impossible. There was, therefore, no question regarding the enormous importance to the Government of the extension of irrigation.

He was not acquainted with any dam in India, constructed by natives, which had a puddle wall; but the bank was usually an enormous mass of earthwork, and being built up with basket-labour, and being thus deposited in very thin layers, by means of the constant trampling of the men, women, and children, employed in carrying the baskets, the whole structure was rendered almost as compact and impervious as puddle. Some of the great reservoir dams in Central India, like that of the Saugur lake, consisted of two parallel walls enormously massive, and built at so considerable a distance apart, that in the interval (filled in with well-packed earth) there were often forest trees and hamlets: thus the fort, and a portion of the city of Saugur were built on the dam of the Saugur lake. He knew of no native reservoir with a byewash, and even a waste weir was often absent.

Mr. F. C. DANVERS said he had endeavoured to ascertain, from published reports, the commercial value of water in India, and had been struck with the variation of returns from canal and other irrigation works. He found, from the reports annually issued by the Government, that the sum of £5,712,000 had been spent upon irrigation works in Madras, the Punjab, and the North-western Provinces, the returns upon which were as follows: Madras, 29·41 per cent.; Punjab, 7·01 per cent.; and the North-west Provinces, 5·06 per cent.; yielding an average return, on the whole, of 10·5 per cent.

In Madras, of the thirty-two principal irrigation works, eighteen showed a balance of income over expenditure, and fourteen yielded no direct net return, but showed a deficit. Of the remunerative works he might mention the following:



|                           | Cost    | Net Revenue. | Return    |
|---------------------------|---------|--------------|-----------|
|                           | £       | £            | Per Cent  |
| Lower Coleroon . . . . .  | 11,647  | 89,442       | Over 838  |
| Upper Coleroon . . . . .  | 23,986  | 42,561       | 177       |
| Vellaur Anicut . . . . .  | 8,215   | 10,442       | 127       |
| Godavery Anicut . . . . . | 432,886 | 175,116      | 40·1      |
| Pennai . . . . .          | 59,050  | 6,470        | Nearly 11 |
| Krishna Anicut . . . . .  | 271,720 | 20,747       | 7·6       |

In the Punjab the direct income gave 7·01 per cent.; but if the indirect income was added, the return was equal to 12·52 per cent. upon the capital outlay for irrigation works. The indirect revenue, in the shape of enhanced land-tax, arising from the beneficial effects of irrigation upon the land, was calculated at 12 annas, or 1s. 6d. per acre. Of the six large irrigation works in the Punjab only two returned a profit from direct revenue, viz., the Western Jumna and the Baree Doab; but including indirect profits, all but the Upper Sutlej were profitable. The Western Jumna canal showed a direct net profit of 35·82 per cent.; and the Baree Doab of only 2·86 per cent. The former was one of the oldest of the Mogul canals, and irrigated 496,543 acres; the latter, a work of modern times, irrigated 233,927 acres.

It had been stated that, in the North-west Provinces, the net returns were 5·06 per cent. on the entire capital expended; but a portion of the expenditure was upon works not yet opened. With that deduction the return was equal to 5·13 per cent., and it was estimated that if a fair addition was made for increase of land revenue, the returns would be equal to upwards of 8 per cent. Of the seven large canal systems in the North-west Provinces only three returned a net profit, viz., the Ganges, the Eastern Jumna, and the Dhoon canals. The other four worked at a loss, so far as direct revenue returns were concerned. The Ganges canal showed great fluctuations in the returns obtained respectively in seasons of drought and good monsoon rain. In the year 1868-9 the net profit was 7 per cent., and in the following year only 4 per cent., which was mainly owing to the difference of rainfall. The Eastern Jumna canal returned a profit of 23·33 per cent., and the Dhoon of only 2·58 per cent.

With reference to the value of water, Colonel Dickens, in his Report on the Soane canal, laid it down that, "Excepting in the rich land near the Ganges and a few other favoured spots, the unirrigated crops of wheat and barley are very scanty, and are said to produce only 256 to 640 lbs. per acre; and those irrigated once or twice yield only from 512 to 1,024 lbs. per acre: irrigated

three times, the crop is said to yield from 896 to 1,280 lbs. per acre; but the people told me if they could irrigate four times, using abundance of water, they would get from 1,280 to 1,920 lbs. per acre."<sup>1</sup> To irrigate thoroughly, Colonel Dickens considered 17,600 cubic feet of water per acre were necessary for the season. The average assumed in drawing out the projects for the Baree Doab and the Ganges canals, derived from data afforded by the Jumna canals, was that each cubic foot of discharge per second was capable of actually irrigating 218 acres. In the Soane canal project, Colonel Dickens estimated the effective duty of water at a somewhat higher rate.

The actual results obtained from some of the principal canals in Northern India were as follow: Area irrigated per cubic foot per second of water actually employed in irrigation, after deducting volumes escaping at terminals—

|                 | Ganges. | E. Jumna. | W. Jumna. | Baree Doab |
|-----------------|---------|-----------|-----------|------------|
| Acres . . . . . | 186.03  | 268       | 210       | 154.91     |

He was unable to obtain definite information as to the extent irrigated by a cubic foot of water per second per acre in the Madras Presidency; but he had seen a calculation in which the rate laid down was 2 cubic yards per hour per acre, which was equivalent to 200 acres for each cubic foot of water per second, and that agreed nearly with the estimate for the canals of the North-west Provinces. In older works, as had been already shown, the value obtained was higher, viz., 240 acres to 268 acres; while the Ganges and the Baree Doab yielded the less return of 186 acres and 154 acres respectively.

The water-rates realised per cubic foot of discharge per second were—Ganges, Rs. 378; Eastern Jumna, Rs. 538; Western Jumna, Rs. 499; Baree Doab, Rs. 127.9; and the water-rate per acre irrigated was nearly the same in each case, viz., Ganges, Rs. 2.25; Eastern Jumna, Rs. 2.32; Western Jumna, Rs. 2.41; and Baree Doab, Rs. 2.35. This was for the autumn and spring crops. The rate varied slightly according to the crop; thus, on the Ganges canal, for the autumn crop it was Rs. 2.57 per acre; and for the spring crop, Rs. 2.00 per acre: the mean being Rs. 2.25.

In conclusion, he would draw attention to recent numbers

<sup>1</sup> *Vide* "A Project for Canals of Irrigation and Navigation from the River Soane in South Behar," p. xix. 8vo. Calcutta, 1861.

of "Professional Papers on Indian Engineering," in which the semi-official correspondence addressed to the private secretary to the Viceroy, by Major Corbett, B.S.C., on the question of, "Is Irrigation necessary in Upper India?"<sup>1</sup> was published by desire of the Viceroy. It was contended that superior cultivation to what now exists was alone necessary; that, at present the ground was only scratched a few inches deep with the native plough; and below that there was a hard crust which prevented the water filtering through; and that if that was broken up, and the cultivation carried deeper, there would not be the same necessity for irrigation, because evaporation from the land would not take place to so great an extent.

Major J. BROWN, R.E., stated that in Upper India tanks were not generally employed, as the slope of the ground was so great that it would require dams of great height to hold in even a moderate supply of water. In some parts, the foot of the hills afforded an opportunity for building tanks; but they were on a small scale, and generally ended by drying up and being taken up for cultivation. Mr. Gordon had mentioned that the proper method of defending the masonry in falls, against the violence of the water going over them, was to provide water cushions. No doubt these were beneficial; but another method was employed in the canals of Upper India, which he believed was more efficient; and that was to place on the crest of the dams stout timber gratings, composed of baulks about 6 inches by 6 inches, and about 2 or 3 inches apart, and slightly slanting upwards. The effect of this grating was to cause the water going over the crest of the weir to fall in thin films, and consequently with less destructive effect; the velocity of the water was also thereby materially checked. Besides, in Upper India destruction was caused by the drift logs that floated down the canals in floods; and these great logs, 20 or 30 feet long, taking headers over the falls, smashed everything before them; but the grating protected the masonry from this cause of demolition. These gratings had been used for many years by Colonel Dyas, and they answered as a most efficient protection to the masonry of the falls.

Mr. Latham had mentioned, with regard to the discharge to be provided for in catchment basins, that the formula was represented by—The discharge, equal to a constant quantity, multiplied by the drainage area, raised to the power of  $\frac{2}{3}$ ds. That was Colonel

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<sup>1</sup> *Vide* "Professional Papers on Indian Engineering," Second series. Vol. i., pp. 3-20, 101-125.



Dickens' formula, with one slight difference, viz., that the drainage area was raised to the power of  $\frac{3}{4}$ ths instead of  $\frac{2}{3}$ rds. This did not make much difference in a small drainage area, but it did in large catchment basins.

At the foot of the Himalayas the rainfall was very great, and exceeded anything that had been mentioned; coming up to 4,  $4\frac{1}{2}$ , and 5 inches per hour. In such districts the formula which gave the best result, taking the discharge in cubic feet per second, and the drainage area in square miles, was—Discharge equal to 1,200, multiplied by the drainage area raised to the power of  $\frac{3}{4}$ . He believed the circumstances in Madras were somewhat different; but in Upper India, and particularly in the Punjab, it appeared to him that canal irrigation was largely supplied to districts where it was not so much required, and denied to districts where it was most required. The rainfall in the Punjab varied inversely as the distance from the great Himalayan chain which ran to the north, and on which the rainfall varied from 80 to 210 inches. In the Sub-Himalayas it varied from 40 to 60 inches; at 120 miles from the hills it was not more than 30 or 40 inches; going to 250 or 300 miles from the hills, the rainfall came down as low as 3 or 4 inches; while in Scinde it was scarcely more than 2 or 3 inches.

The depth at which water was found in wells followed the same rule, varying as the distance from the mountains. Where the rainfall was not under 30 inches, and the depth of the wells did not exceed 30 feet, canal irrigation, though advisable, was not absolutely necessary. The great difficulty was to get sufficient water to irrigate those districts where canal irrigation was alone possible. Most of the water that came down the Baree Doab canal, and a great portion of that which came down the Ganges canal, was taken up by those districts where the wells were not more than 30 feet deep; and the result was that the villagers had allowed their wells to choke up, and had become entirely dependent upon the canals.

The moral of this was, that in the great projects that had now to be taken in hand, well irrigation should not be entirely lost sight of. There was no water to spare; and it seemed to him economy had not been observed, where canals were employed in districts where irrigation could be practised, even to a small extent, by wells. No doubt canals must sometimes be taken through districts where well irrigation was possible; but the canal ought to go through such districts not as an irrigation canal, but merely as a channel conveying water down to the lower districts, where the rainfall was so small that irrigation was absolutely necessary. He was



aware that there was a great deal to be said against well-irrigation, and that it cost so many pounds, shillings, and pence, to hoist so many cubic feet of water from a given depth. As a purely mechanical arrangement, he did not put well-irrigation in competition with canal-irrigation; but in a commercial and social point of view there was a great deal to be said in favour of well-irrigation. Except perhaps the Civil Courts, there was no greater cause of discontent in India than canal-irrigation. Villagers who used their own wells were not exposed to be bullied by canal understrappers, who might threaten to cut off the water, and compel their attendance in Civil Courts; and they were free from official restrictions in the distribution of the water. Then, again, as a commercial speculation, canal companies must necessarily lay out a great sum, which could not return any interest at first starting, and probably for a very long time; whereas money laid out in wells, if it paid at all, would pay very quickly; as a well could be started, and be in full operation, if not more than 30 feet deep, within a month after it was begun. A company for well irrigation could feel its way without risk; whereas a canal company must lay out money freely, and getting no return for a long time, might find itself, perhaps after twenty years, in the receipt of 1 per cent. dividend per annum. As to hoisting water from the well, in many parts of India, particularly below the hills, the wind was for the most part very steady during the morning and evening, and a good deal could be done by windmills. Then, again, by irrigating by wells the waste was avoided, which always resulted more or less from canal-irrigation, and spoilt the crops by souring and oversouking the soil. He had always understood from such cultivators as he had spoken to, that crops raised from well water were of a better quality than those raised from canal water. He could not say whether it was due to the higher temperature of the well water, or to any chemical difference in the water itself, but canal-raised were, he believed, generally inferior to well-raised crops.

He did not wish it to be supposed that he at all undervalued the vast benefits of canals. They were indispensable, no doubt, where irrigation could not be obtained by other means; but in the ambitious projects of the Government and of private companies, he thought they had too much lost sight of the question of well-irrigation; and it had apparently been forgotten that there was possibly as much water below as above the surface. It was admitted, that in Upper India, there was barely enough water on the surface to irrigate those districts where well-irrigation

could not be employed. Therefore, for every acre of land irrigated by canals which might have been irrigated by wells, an equal acreage in another part of the province was condemned to perpetual barrenness; and this would be the case whenever canal water was supplied to districts where well-irrigation was possible.

In a social and commercial point of view irrigation by wells had many advantages, although as a mechanical arrangement he did not wish to defend it. It seemed to him that, with the improved means of communication in India, well-irrigation was a means of preventing, to a great extent, and at a very early period, the recurrence of those famines which might come at any moment, and which might occur for years before those more ambitious projects, which he did not, however, undervalue, had been well started, and had begun to do any good to the country.

Mr. G. GORDON, in reply upon the discussion, said Mr. Latham had inquired what allowance had been made for the discharge of storm-water from the reservoirs, and as to the calculation of it in reference to maximum rainfalls in India. He had used no formulæ. He had ascertained what the maximum flood discharge of the rivers had been during a period of fifteen or twenty years, and that was exceeded by a recorded flood by perhaps nearly twice as much. It could not be accurately measured, because there were no reliable marks to go by; and that extraordinary flood was calculated as the measure of the maximum discharge. He did not think any general formula could be used for all places; a formula founded on observed rainfalls and floods in one district would be useful for other districts similarly circumstanced, where the rivers had not been gauged, but in no case could observations with regard to climatic conditions be dispensed with. He agreed with Mr. Latham, that the question of the quantity of water per acre necessary for efficient irrigation was a difficult one, and had never been, and probably could not be, definitively settled; because different soils, as well as different crops, required a greater or less supply of water, according to the peculiar circumstances of the case. Rice required more water than any other crop. The result of the experiments made by the Madras Government was to fix the quantity at 2 cubic yards per hour per acre, or  $66\frac{2}{3}$  acres per cubic foot per second. That corresponded to 5,000 cubic yards per acre per crop, and was calculated to be the quantity required for rice; while more valuable crops, which would bear a higher water rate than rice, took less water to irrigate them. Colonel Smith objected to the quantity of 5,000 cubic yards per acre, and thought

that at least 8,000 cubic yards should be allowed ; but a few years ago, Colonel Smith, in reporting on a project of his, had assumed 8,600 cubic yards as the quantity required for the second crop, which was the one a reservoir had to supply. He mentioned this to show the quantity had not been agreed upon or calculated with certainty for different districts ; but in estimating, it was necessary to take some standard ; and that of the Madras Government, of 2 cubic yards per hour per acre, was what he had adopted. With respect to the objection that he had neglected the fact that half the produce of the land was taken by the Government, and therefore could not be reckoned in the receipts for land assessment ; that was the principle, he believed, on which the dry lands were assessed, and he only proposed in his Paper that the same principle should be applied to wet lands. The latter, of course, yielded crops of greater value, and if half the crop were taken it would be fair to credit works, whether constructed by the Government or a company, with that amount. He did not advocate any particular agency for constructing these works—either the Government, a company, or private individuals. As commercial speculations the results would be the same whoever undertook them. His object was merely to give, as far as his information enabled him to do so, the results of such works as commercial undertakings, whether undertaken by Government or private companies. As Colonel Smith remarked, the result depended upon, first, what the water cost to get it ; and, secondly, what it could be sold for. But it seemed to him that Colonel Smith abandoned the commercial view altogether, when he said a fixed rate of 12s. per acre must be adopted as the water rate, and not one in proportion to the cost of the works, or the value of the water to the consumer. The Madras ryots had as good an idea of the value of a rupee as any people in the world, and they were willing to pay what the water was worth, if they were allowed to do so ; and they would not take the water unless they liked ; but the Government said, “ You shall not pay Rs. 10, although you may be willing ; but you shall pay Rs. 6 ; and if the water cannot be supplied for Rs. 6, you shall not have it at all.” Speaking of the cost of the water, Colonel Smith was mistaken in saying he had taken an imaginary average reservoir. It was a reservoir carefully surveyed and estimated, and was, out of several so estimated, the one least favourably constructed for the storage of water. It was not the favourable one proposed to be constructed by the Madras Irrigation Company—favourable with reference to the number of cubic yards of water per rupee stored. The case of the proposed restoration of the Mudduk tank was an



extremely favourable one, and he had never met with any other instance where so much water was stored at so small an expense. But Colonel Smith objected to that estimate, because, he said, the supply was uncertain, and he compared it with the Maury Conva tank, of which the supply had been proved to be uncertain. Colonel Smith seemed to think these tanks were in the same neighbourhood, whereas they were nearly 100 miles apart, and the characters of the two districts were totally different. The one was on the inside slope of the Western Ghâts, and the other on the table-land of Mysore, where the rainfall was very precarious. They were no more comparable than were the Rivington Pike District and the east coast of England. The capacity of the tank was not quite equal to the maximum discharge of the river. No doubt, in that instance, it would be better if the tank were capable of containing rather more than the average discharge; but that could be effected, not at double the cost as Colonel Smith supposed, but by the usual expedient of putting in planking on the waste weir to a height of 5 feet. The rivers rising in the Ghâts fluctuated much less than those in the table-land. The usual way was to put planks between posts on the waste weir, and to take them down in case of heavy floods.

The evaporation had been calculated from observations taken in the neighbourhood, the monthly evaporation being multiplied into the mean area exposed every month. The tank was just filled at the end of the monsoon season, and the small surplus of water now discharged by the weir after that was not taken into the calculation, although it was sufficient to make up for a great part of the loss by evaporation. The tank was full only at the end of the season; then the water was gradually drawn off, and the tank was supposed to be emptied in four months. For each of these months he had estimated the quantity carried off by evaporation over the exposed area of the tank, and the total amounted to 5 per cent., instead of  $6\frac{3}{4}$  per cent. as Colonel Smith calculated by a rougher method.<sup>1</sup> Multiplying that by the four months, Colonel Smith calculated the total evaporation to be 20 per cent. of the contents of the tank. That would bring up the evaporation to 120 inches per annum, an amount never yet registered to his knowledge. Colonel Smith had mentioned a tank in which  $\frac{1}{4}$ ths of the water was wasted by evaporation, and only  $\frac{3}{4}$ ths was put upon the land; but that tank was a very shallow one. If the tank had a depth of

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<sup>1</sup> The months March and April, when the evaporation was greatest, were those when the area of water in the tank was least.



water of only 60 or 70 inches, with an evaporation of 80 inches, more than half would pass away by evaporation; but the case was very different in a tank 60 or 70 feet deep. Even in the dry season there was always a small stream running into the tank, which was filled by the monsoon supply alone. The loss from the canal which Colonel Smith referred to was not much, and the water quickly deposited a layer of fine mud on the bottom and sides, as happened in filtering beds. A case was known where a channel in sandy ground had to be widened, and it had been so well lined with natural puddle, that the enlargement was carried on without stopping the supply; the excavation close to the old channel was quite dry even below the level of its bed. The evaporation of the water of the canal was not ascertained, because it was included in the 2 cubic yards per hour per acre; in which, too, the evaporation in the passage of the water from the reservoir down the river to the canal was also included. He was obliged to Colonel Smith for correcting a clerical error in the statement of the cost of stored water. He had stated it, after all deductions were made, to be £1 9s. 5d.; it should have been £1 13s. 8d., in the least favourable case he had estimated. The bed of the river was rocky, with here and there layers of sand left by the floods; lower down, about Kurnool, there was more sand. Even after the streams ceased running, the drainage of the country into the river, which was the main drain of a very large district, was more than sufficient to make up for the loss by evaporation. It had been gauged in the hot weather, and the discharge was found to be less in the upper than in the lower part; in 1868 it was only one-eighth. This differed from Mr. Jacob's experience in the Bombay Presidency, where he found that though a good deal of water flowed in, the evaporation made up for it, and the river discharge at the lower end was more than it was at the upper end. The objection that the reservoir did not hold the whole supply did not apply to the other reservoirs estimated for, which were more favourably situated; because, there the difficulty was not how to fill the reservoirs, but how to get rid of the surplus water. The largest reservoirs he found took little more than half the monsoon supply of the river; and then the water required to be embanked, to prevent it running over a watershed into another river. The difficulty was to get sites where the floods could be impounded. The Mudduk Masoor tank was capable of impounding the whole flood water. He could not accept Colonel Smith's conclusions, that only half the water stored was used on the fields. Colonel Smith gave no figures in support of that conclusion; and

he believed 15 per cent. would be the full amount of waste, assuming the Government rate of supply of 2 cubic yards of water per hour per acre in the main canal.

Mr. Aitken had stated that canals which cost only Rs. 7,000 per mile gave returns of from 40 to 60 per cent., and that, therefore, others costing Rs. 70,000 would yield only 4 to 6 per cent.; but the quantity of water carried must be reckoned, not the cost per mile. He admitted that the different measures used, viz, the cubic yard per hour in Madras, and the cubic foot per second in Bengal, and in some cases gallons, were very inconvenient; but the difficulty would not be remedied by the introduction of a fourth measure, the cubic metre. He thought the reckoning by cubic feet per second was the most handy.

From time immemorial it had been the custom to dispense with puddle in native works, and in the parts of India he was best acquainted with, there was no clay to make puddle with; in fact, there was a district 250 miles long and 100 miles broad where no stiff clay was to be found. There was at first a little leakage in a new bank, but it soon got puddled by the deposit from the muddy water, the banks became impervious, and this was effected by the silt existing in the river. In some cases the slope of the reservoir banks was protected by large stones built in the form of steps, and in others they were laid on the flatter slopes. Breaches often occurred in small tanks; they were generally repaired by forming a ring-dam in front, and sometimes the bank was cut to relieve the pressure of the water. That was done, when it was possible to do it, where the bank was on rocky ground, so as to cause as little damage as possible.

A great part of the water was evaporated after it was turned on the fields. The evaporation in places exposed to the hot winds was  $\frac{1}{8}$  of an inch per day, and a crop of rice was under water about a hundred days; so that about 33 inches would pass away by evaporation, which left only 5 or 6 inches to be disposed of by infiltration and drainage. The evaporation was perhaps reduced in the last months of the crop, by the water being sheltered by the grain, and, he believed, might amount to 30 inches altogether.

In experiments made by Colonel Meadows Taylor on the wells of the Deccan, it was found that 6,000 cubic yards was the quantity per acre used for the two crops of the year. The first crop consisted of turmeric, chillies, ginger, plantains, and other valuable garden produce; the second crop was wheat or cereals. For those two crops rather less than 6,000 cubic yards of water per acre were sufficient, and in the use of wells there was very

little water wasted, as the water was raised at a cost to the ryots of Rs.  $27\frac{1}{2}$  per acre, exclusive of interest upon the cost of the wells.

The reservoir mentioned by Mr. Conybeare was a comparatively small one, and he agreed that a small quantity of water could not be stored economically in India for the purposes of rice irrigation.

As to the revenue to be derived from irrigation works, if the Government fixed the rate so low that it was not remunerative, it was likely to give them a bad name. It was said they were not constructed because they were not remunerative; but they were not so only because the Government would not allow a charge which the people were ready to pay.

He thought the plan adopted by Colonel Dyas for breaking the force of the water in the falls of the Baree Doab canals an admirable one. The effect of the gratings was to break up the falling water and distribute it over a larger area, but he thought the plan was less applicable to weirs in rivers, to which the remarks about water cushions in the Paper referred, as all the length that could be got for a clear overfall was needed, and the introduction of gratings would require a greater length, or else the level of the water must be inconveniently raised. He thought them excellent for canal falls, and they seemed to have answered their purpose perfectly. The well irrigation, which seemed to please the people in the part of India described by Major Browne, would never be extensively practised in the South. In the Deccan,  $4\frac{1}{2}$ , and in Bellary, 3 acres, were the most one well would irrigate; the water was slightly brackish generally, and the cost of raising it by the cheapest method, if animal power was employed, was too high—55s. per acre in the Deccan, probably 80s. in Bellary, and 60s. at the experimental farm at Sydapott, Madras.

Mr. A. A. West supplied, through the Secretary, a table of the evaporation at Bombay, during the dry season, from a surface of 100 square inches of water in a cistern, open to the air, but shaded from sunshine:

|                      | Days. | Inches. | Inch                |
|----------------------|-------|---------|---------------------|
| 1814 October . . . . | 31    | 4.80    | Average .155 a day. |
| „ November . . . .   | 30    | 4.60    | „ .153 „            |
| „ December . . . .   | 31    | 4.45    | „ .148 „            |
| 1815 January . . . . | 31    | 4.15    | „ .131 „            |
| „ February . . . .   | 28    | 3.85    | „ .137 „            |
| „ March . . . .      | 31    | 4.65    | „ .155 „            |
| „ April . . . .      | 30    | 5.55    | „ .185 „            |
| „ May . . . .        | 31    | 5.30    | „ .174 „            |
| Total . . . .        | 243   | 87.35   | „ .154 „            |



The rains of 1814 ended on the 14th of October. Those of 1815 began on the 5th of June. The greatest evaporation in a day was 0·20 inch in the middle of April and latter part of May. The least was 0·12 inch in December and early in January.

During the month of May the thermometer varied from 90° to 102° Fahr. in the open air shaded from the sun; and from 87° to 90° in the house from 8 A.M. to 11 P.M.

The evaporation at Bombay during the rainy season, under the same conditions as the preceding, was:

|                       | Days | Inches |         | Inch,       |
|-----------------------|------|--------|---------|-------------|
| 1815 June . . . . .   | 30   | 3·05   | Average | ·102 a day. |
| „ July . . . . .      | 31   | 3·10   | „       | ·100 „      |
| „ August . . . . .    | 31   | 4·60   | „       | ·118 „      |
| „ September . . . . . | 30   | 4·45   | „       | ·148 „      |
| Total . . . . .       | 122  | 15·20  | „       | ·124 „      |

The rains of 1815 began on the 5th of June, and ended on the 16th of October. The evaporation in August was high; it was 2·35 inches in 1814, and 2·45 inches in 1816. The greatest evaporation in a day was 0·18 inch in clear weather in July and August, and 0·19 inch in October. On wet days it was 0·10 inch. The least was 0·05 inch during continual rains in June and July.

Mr. F. D. CAMPBELL said he did not agree with the Author as to the financial results of irrigation works in India, taking the country as a whole. The cases he gave were correct, but they had only to do with small works, which had been undertaken, and put in repair because of their peculiar advantages. The large and altogether new works now being constructed in Madras had very different prospects before them, as he knew from what he heard officially when he visited them three years ago. Excepting in the case of delta irrigation, there were no large works of the storage class, which had been working for some time, from which to draw any practical conclusions. He believed that the best works now being made would not yield more than 5 per cent., and they might be expected to do so about ten years after completion.



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AND CHURCH LANE.



# STORAGE OF WATER IN SOUTHERN INDIA.

PLATE 7

Fig: 1.

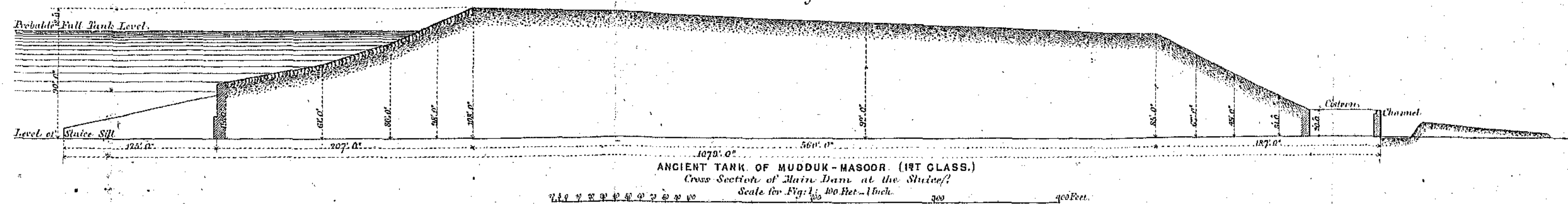


Fig: 2.

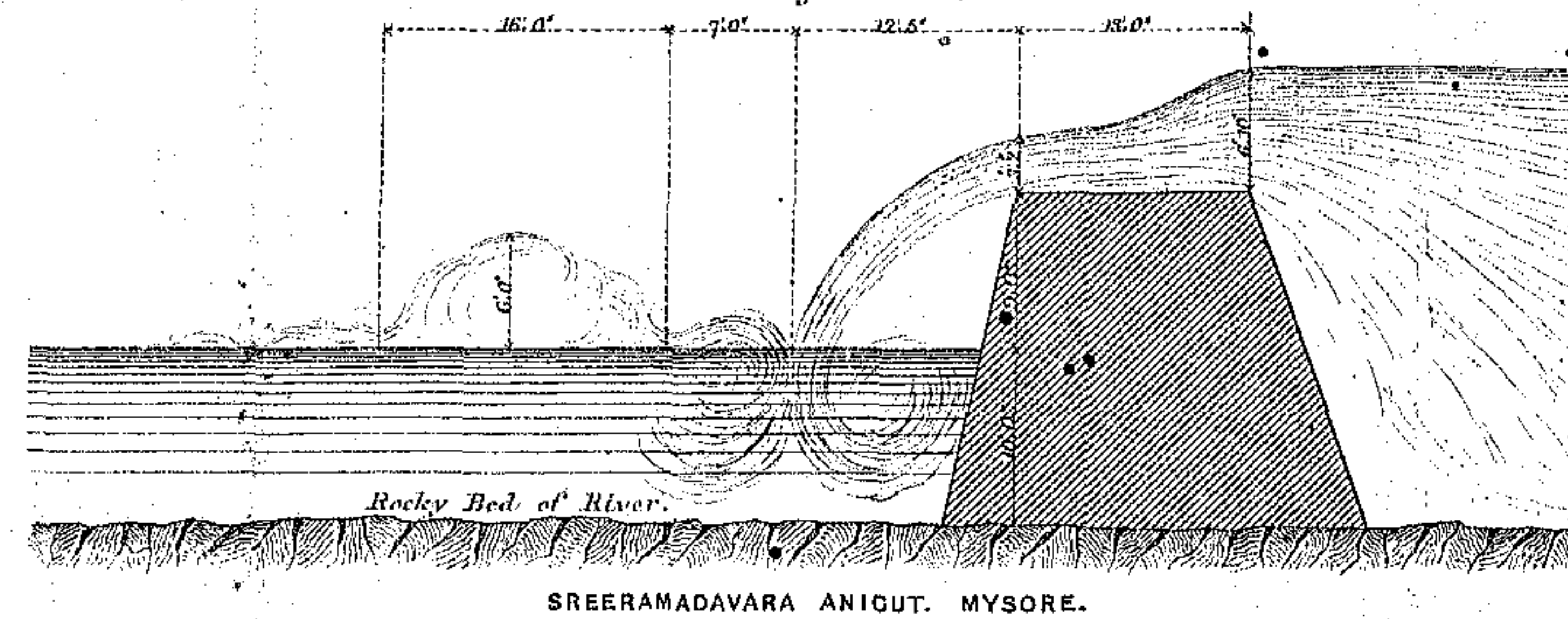


Fig: 3.

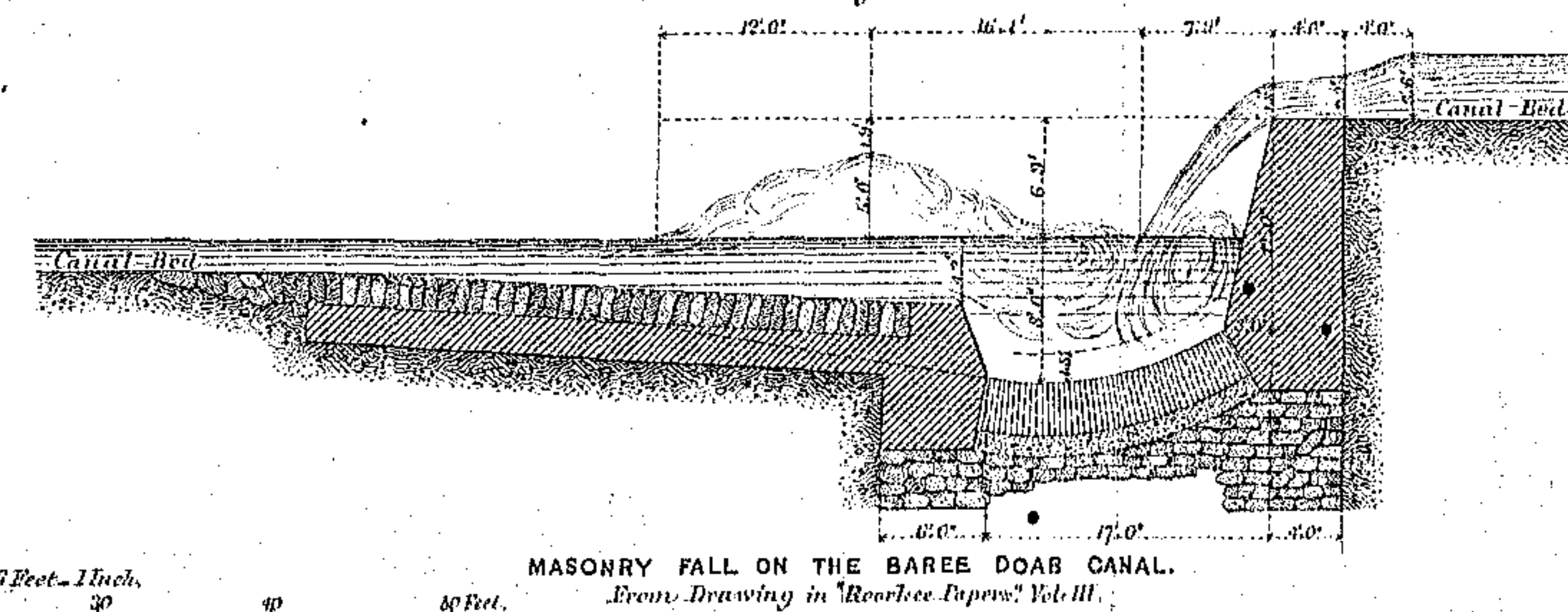


Fig: 5.

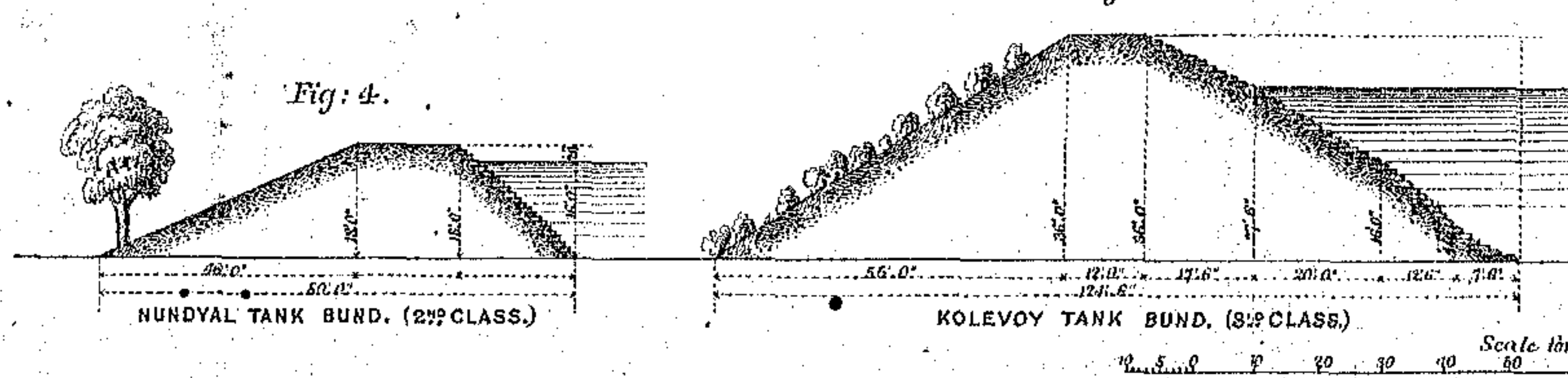


Fig: 6.

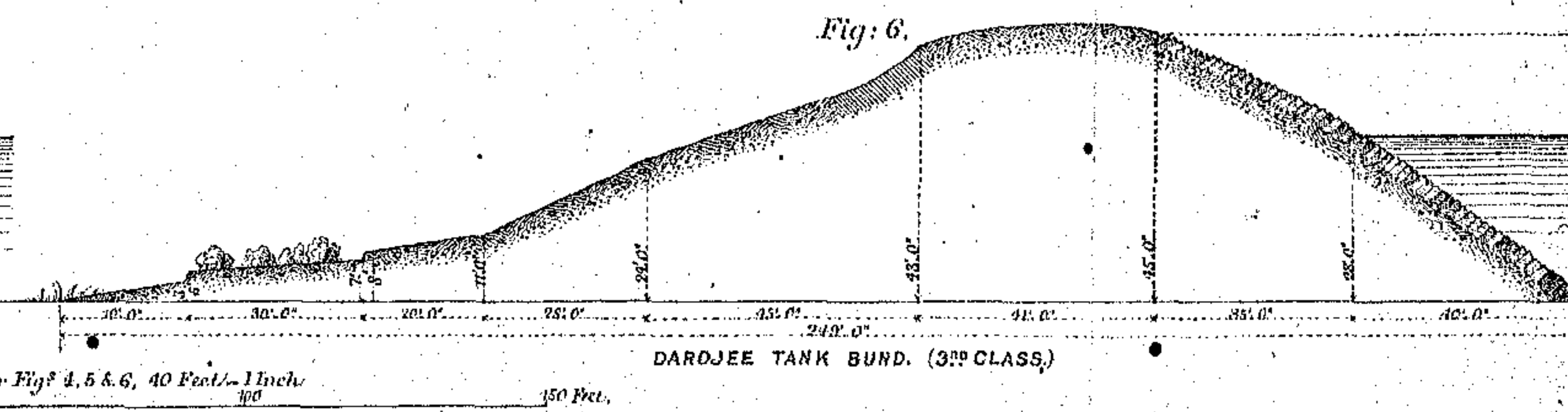
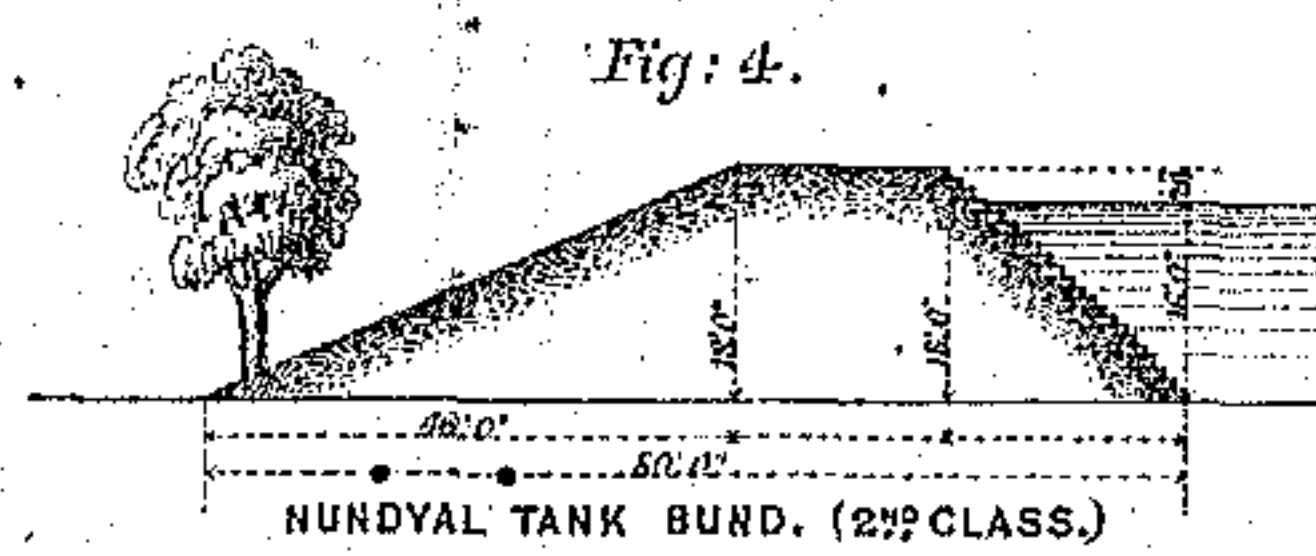


Fig: 4.



Scale for Figs 4, 5 & 6, 40 Feet = 1 Inch.

GEORGE GORDON, DELT.

Minutes of Proceedings of The Institution of Civil Engineers, Vol. XXXIII, Session 1871-72.

RELIABROU LIEPTE CASTIN ET ROLE





# IRRIGATION IN INDIA

IN CONNECTION WITH

## INDIAN DEFICITS.

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BY A MEMBER OF THE BENGAL CIVIL SERVICE.

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SECOND EDITION.

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(1).

# OUR IRRIGATION POLICY IN INDIA

AND ITS CONNECTION WITH

## INDIAN DEFICITS.

THE finances of India are again in great embarrassment. The fall in the value of silver has converted a possible surplus into a certain deficit; and the expenditure demanded by Imperial calls which cannot be denied still continues unabated. On the 31st July 1876, the Government of India was compelled to publish the following Financial Resolution:—

The unsatisfactory state of the Indian finances in July 1876.

RESOLUTION.—The embarrassment occasioned to the finances of this empire by the present disturbance in the relative values of gold and silver has, for some time past, been under the anxious consideration of the Viceroy and Governor-General in Council, and His Excellency has been led by such consideration to the conclusion that it is now advisable to notify to the Local Governments the wishes of the Government of India in regard to those preliminary measures of retrenchment and economy which are necessitated by the immediate exigencies of the financial situation.

2. It was a part of the budget arrangements of this year that the Secretary of State in Council should borrow in England £2,640,000 for the construction of Extraordinary Public Works. An incidental effect of that arrangement was to reduce, by the abovementioned sum, the amount that must, otherwise, have been raised by bills for the supply of the Home Treasury, and, according to the rate of exchange assumed in the estimates, viz., Rs. 1 = 1s. 8½d., to diminish the entry under *Loss by Exchange*, and improve the nominal balance of the year, by Rs. 45,00,000. Notwithstanding this and other advantages, the surplus revenue of the year was estimated at only Rs. 14,40,000.

3. It was calculated, at that time, that the supply of £13,660,000 to the Home Treasury by bills would cost Rs. 15,99,20,000; and, accordingly, the sum of Rs. 2,33,20,000 was provided under the adjusting head *Loss by Exchange*. Subsequently, however, to the publication of the estimates, the Secretary of State found it convenient to increase the amount borrowed in England to £4,000,000. The incidental relief to the estimates of the year from this source would thus be, if the

rate of exchange could be calculated as before, Rs. 68,80,000. The relief obtained may now be estimated at a much larger sum. In judging of the financial position and future prospects of the Government of India, it is necessary to bear this fact in mind.

4. The sum to be raised in England having been thus increased, the amount to be supplied to the Home Treasury, by bills, during the year is now reduced to £12,800,000. of which £3,844,134 has been obtained to date, by the sale of bills for Rs. 4,06,10,000. the adjustment entered under *Loss by Exchange* being, already, Rs. 71,68,660.

5. It is at present impossible to frame any approximate estimate of the cost, in rupees, of supplying to the Home Treasury the sum of £8,956,446, which still remains to be raised by bills : but the Government of India cannot now expect that the whole entry under *Loss by Exchange* will not be largely in excess of the grant.

6. Moreover, the prospects of the customs revenue are, by reason of the adverse exchange, unfavorable ; the charge for interest will be increased for the increased amount borrowed in England ; and the cost of the unprecedentedly large opium crop in Bengal is expected to cause the expenditure under *Opium* to exceed the grant by about Rs. 50,00,000 ; although there will, of course, be a corresponding addition to the opium in reserve.

7. Altogether, the financial prospects give cause for such grave anxiety that the Governor-General in Council deems it necessary to invite the earnest co-operation of the Local Governments and Heads of Departments in reducing, by every possible means, the threatened deficit.

8. The authorities at the Head of each Department, whether administered by the Imperial or Local Governments, should, therefore, take prompt measures to stop all outlay of public money which is not absolutely necessary ; or to which the Government is not committed ; or the discontinuance of which will not cause disproportionate loss and waste. An early report should be made to the Government of India in the Financial Department of the measures adopted for giving effect to these instructions, and of the saving which may be expected under each Government and in each Department. The Governor-General in Council will be unable to sanction any new expenditure that is not indispensable.

9. The financial disorder which demands these measures is exclusively due to the recent rapid fall of the value of silver in relation to gold, and the consequent enhancement of the cost in silver of all payments in gold. The Governor-General in Council is not prepared, at present, to say what measures the Government of India may be compelled to take, in order to permanently restore the financial equilibrium ; but, pending the adoption of such measures, it is incumbent on His Excellency in Council to warn all Local Governments that he may be reluctantly compelled to call upon them for sacrifices which, if requisite for the public welfare, those Governments will, he feels assured, be ready to accept in the loyal and generous spirit evinced by them on previous occasions of great financial pressure.



10. The Governor-General in Council has resolved, for the present, largely to reduce the expenditure on Extraordinary Public Works, and, in regard to many of the measures which may be necessary to effect that object, he confides in the valuable assistance of the Local Governments.

11. Moreover, the means at the disposal of the Government of India for granting loans to Municipal and other Corporations, and to Native States or private persons are, so long as the present state of things lasts, likely to be limited; and, therefore, no application for such loans should be made or forwarded by any Government officer, except for purposes which admit of no postponement.

Immense sums are annually expended in India for the maintenance of the army necessary to the support of our rule, and the consequent enforced peace and order among the heterogeneous peoples of India. Our administration of justice is scarcely less expensive, but it is necessary as a suppressor of crime and as the very foundation-stone of the edifice of prosperity. It is with the evil of famine and its antidote, irrigation, that we have never yet dealt adequately. We have indeed made roads and railroads by which food can be conveyed from tracts where it is plentiful to where it is scarce, but the whole system on which famine and famine finance, as irrigation expenditure may be styled, have yet been treated, is so insufficient and so impoverishing to the Imperial Treasury that, though it is clear that canals must be multiplied, it is equally clear that first of all the financial arrangements in connection with them must be thoroughly revised. It is no less incumbent that, with budgets ever impinging upon deficit, the present heavy annual charge borne by the Public Treasury on account of charges for unpaying irrigation works already constructed should, if possible, be met from other sources. These annual charges, at present amounting to about £300,000, will otherwise very shortly reach and exceed half a million sterling. As matters at present stand, the first step on the occurrence of a deficit is sure to be a stoppage of work, in whole or in part, on irrigation canals already commenced and urgently required. Progress is temporarily at a dead lock, and every such postponement exposes India to fresh risks from famine, while it adds largely to the interest charge on the capital already sunk in the works.

This is in a great measure due to an enormous irrigation policy.



But irrigation works must be multiplied & extended in order to secure safety from famine, yet this cannot be done under the present voluntary rate policy.

It is not too much to say that, until our irrigation policy in India is thoroughly recast, so as to enable irrigation works to be self-supporting and so as consequently to enable the Government to extend those works to all such parts of India as may require them, all the vast labour and toil which generations of Englishmen have expended in maturing a just and prosperous rule in India have been not fully fruitful. We have laid our foundations strongly, the walls are well advanced, the pleasure-grounds of art and science look goodly to the eye; but the building is still roofless, and, if the whirlwind of famine swoop down, its fairest chambers may become ruined and tenantless.

Twice in a decade we have seen the most fertile provinces of India devastated by famine, its lands laid waste, its waving plains of full-eared crops destroyed, its people in tens of thousands slain, its treasure squandered. A sadder fate could scarcely befall the poorest and most barren country ruled by the worst and most improvident of Governments. Let us glance back for a moment at the horrors of Europe's bitterest, bloodiest, costliest war which six years ago stirred to the deepest depth the hearts of all men, and lay them side by side with the horrors of the Indian province of Orissa in the famine of 1866, with the vast misery of the North-West Provinces in the famine of 1861, or with the enormous cost and prodigious exertions of an empire which alone prevented the Behar distress of 1874 from gathering into a calamity which might have dwarfed to insignificance the thought of the million famine deaths in Orissa. It will be found that in the suffering undergone, in the numbers of the slain, in the anguish of the death, in the sad rents and gaps that deserted hearths disclosed, in the broken health and hopeless future of a multitude who survived, although reckoning pound by pound the money cost be not so great, these sad epochs in India's history do, in the unsurpassable intensity of their misery, draw the scale against the woes which Germany or France have suffered. The latter were so near to English doors that the very air which England breathed rang with the cries of the dying; the conquered even in the gasp of death struggled so bravely against the conqueror that throughout all England's length and breadth the

hardest heart was touched, and a generous sympathy poured forth without grudge a prompt and powerful relief. But India is so far removed, its daily life is so little entered into by the English public, that, although, on the sad occasions alluded to, it was no stranger's land that bled, and no stranger's rule that was tried, the English people could with difficulty realize the full extent of India's need or their own responsibility. On the latest occasion the English press did indeed bestir itself vigorously, but the subject never sank down deep into the English heart. A general election was suddenly precipitated on the constituencies while the resources of the Indian Empire were being strained to the utmost in efforts to ward off an impending famine, yet so extraneous and uninteresting an object did India then appear that scarcely in one of the thousands of speeches which candidates addressed to the electors was any allusion made thereto. Domestic topics displaced the interest which, however faint, might otherwise have been felt in an Imperial, but distant, disaster.

Clever cynics have written that it is well that these things should be. It is God's will, say they, exemplified in Nature's laws. Our rule in India has quelled the constant war her chiefs and barons were wont to wage among themselves; our sanitary measures have prolonged life; our courts of justice have checked infanticide and murder. Thus life has been prolonged, while a stable rule has brought prosperity and more numerous births; were famine never to lay desolate, a teeming population would overstock the soil, and widespread poverty and want would be the result. Famine swoops down and carries off the number for whom pestilence, murder, and war had, in former days, accounted, and thus relieves the land. Such theories are fallacious, because the danger apprehended is not real, and because, if real, no ultimate consideration could warrant the absence of any possible effort by the State to ward off a present disaster of such appalling magnitude as a widespread famine. It is scarcely necessary to point to the vast uncultivated areas in many provinces in India to show that for very many years no fear of overpopulation of the soil need be entertained. No argu-

ment based on that theory need affect our present policy. There is every reason to believe that more frequent emigration, together with new and more extended manufactures and trades, will be found efficient for the relief of an otherwise too numerous agricultural population.

A new irrigation policy must therefore be inaugurated.

No means should be left untried by the Indian Government in order to avert the possibility of famine. This is now an accepted axiom. But financial necessities interfere lamentably with this recognized truth being put into practice, and every financial crisis results in a postponement of works so necessary to the welfare of India as irrigation canals. In this respect the recent resolution by the Government of India is abundantly ominous, and renders the present a convenient occasion for discussing the great and growing difficulties which beset the present irrigation policy, and for a consideration of how, without repudiating the guiding principle of justice, Government may adopt an irrigation policy consistent with financial equilibrium.

Famines in India are occasioned by drought or flood. There are many and large rivers carrying wastefully to the sea a supply of water which, if adequately utilized, would render impossible any widespread famine from drought. The same rivers are in the rainy season sometimes so overfull, that their waters sweep over the adjacent plains and lay waste the land. Canals which, while conveying water from those rivers for irrigation, would, by their embankments, protect the land from risk of inundation are required to effect the desired object. No one denies that were such in existence, leaving out of sight for a moment the wonderful facilities for intercourse and trade which they would afford, a serious famine would no longer be an ever-impending danger. The subject has been long before the Governments both at Home and in India, and the insuperable and ever-recurrent difficulty has always been the financial one. It would appear that, in such a vitally important matter, and autocratic rule, like that of the English in India, should not accept that difficulty as insurmountable. It is occasioned solely by the inability of these irrigation works to meet,



under the present system, the annual charge for interest on the money borrowed and invested in them. It is impossible to resist a conclusion that a policy must be framed which will no longer leave insoluble the difficulty with which we are thus brought face to face.

It appears from the report of the Government of Bengal that, at the end of the year 1871-72, the main irrigation schemes in that province were two: the Orissa scheme and the Behar scheme. The former had been entered on several years prior to the latter; it had reached a state of progress in which, though in no part perfectly complete, navigation and effective irrigation were available throughout large portions of the important districts of Midnapore and Cuttack. Its object, in its full completion, is a through navigable and irrigating canal running from the Hooghly at Calcutta to the Chilka Lake on the western coast at the southern extremity of Orissa. This tract of land extends for upwards of 300 miles along the Bay of Bengal, by which it is bounded on the east; on the west it is shut off from the rest of India by ranges of almost impassable mountains inhabited by semi-barbarous tribes. The canal draws its waters from the rivers across which, as they debouch into the plain, it passes and makes them available for the irrigation of this important province. The canal is intended to pass through the districts of Howrah, Midnapore, Balasore, Cuttack, and Pooree. In the two first districts it is estimated that the completed scheme will be able to irrigate 150,000 acres, and in the other three districts, which are, strictly speaking, the Orissa districts, probably 800,000 acres. The area that will be protected from flood by the embankments will be still greater. Since 1872 these canals have been steadily worked at, but the financial difficulty is so great that progress has not been so rapid as it should have been.

Refers to the existing irrigation works, and points out how heavy an annual burden they impose on the State

The canals in Orissa

During the Orissa famine of 1865-67 these works were not sufficiently advanced to be of any service in the way of irrigation.

The estimated cost of the Orissa scheme was £700,000 for the smaller portion in Midnapore, and £2,750,000 for the larger portion in Orissa Proper. But these estimates will certainly be largely exceed-



ed as (exclusive of interest), up to the close of the year 1874-75, the capital outlay had been £613,000 and £1,552,000 respectively. The works are still very far from completion. An approximate estimate of the cost, inclusive of accumulated unpaid interest, would probably be five millions sterling for the Orissa scheme, and one million for the Midnapore scheme. Out of the estimated area of 150,000 acres in Midnapore, probably 120,000 acres are now irrigable; while in Orissa probably 300,000 acres are irrigable.

The other large scheme, namely, the Behar scheme, is meant to intercept the waters of the river Sone and divert them to the irrigation of an estimated area of 2,000,000 acres. It is quite a new work and has only advanced to a stage at which its water can be utilized for the irrigation of a small area. Had this work been completed before the famine of 1873-74, it would have rendered inestimable service. The total estimated cost of 2½ millions is less than one-half of the expenditure incurred by Government on that famine. Exclusive of interest, £1,262,000 had been expended on this work up to the close of the year 1874-75.

The canals in Orissa and Midnapore, with a total capital of £2,062,000, show an annual charge on Government of £150,000 on account of interest and maintenance, and under the present system there is not much hope of an improvement.

As regards the financial results of the revenue-paying canals in Midnapore and Orissa, the official report for 1874-75 shows—

|                      | Capital invested exclusive of interest |
|----------------------|----------------------------------------|
| Orissa Canals ...    | £1,552,000                             |
| Midnapore Canals ... | 613,000                                |

To this must be added the unpaid interest and excess of working expenses over revenue which, up to the close of 1874-75, showed £360,000 against the Orissa Canals, and £137,000 against those of Midnapore, making up the total capital respectively to £1,912,000 and £750,000.

The Orissa Canals in 1874-75 yielded a revenue as follows:—

|                   |               |
|-------------------|---------------|
| Irrigation ...    | £2,038        |
| Navigation ...    | 2,141         |
| Miscellaneous ... | 669           |
| Total ...         | <u>£4,848</u> |

which was a slight advance on the revenue of the previous year. Under the present system there appears to be no immediate probability of any considerable increase in the revenue. The annual cost of maintenance and repairs is about £20,000; so that at present these works, far from paying interest on the capital outlay, do not pay more than one quarter of the annual outlay on their maintenance.

Taking the interest at 5 per cent. the annual loss to Government is £95,600 (interest) + £15,000 (maintenance), or a total of £110,600.

The Midnapore Canals show a slightly more hopeful aspect.

In 1874-75 they yielded a revenue as follows:—

|               |     |     |         |
|---------------|-----|-----|---------|
| Irrigation    | ... | ... | £6,701  |
| Navigation    | ... | ... | 4,488   |
| Miscellaneous | ... | ... | 481     |
| Total         |     |     | £11,620 |

This was an advance on the revenue of the previous year, but this income does not yet pay the annual charge for maintenance which is about £13,000.

Taking 5 per cent. on the capital of £750,000, we have an annual loss to Government from these canals of £37,500 (interest) + £1,500 (maintenance), or a total of £39,000.

The causes alleged for these financial failures are the apathy of the natives, the ordinarily abundant rainfall, the unfinished state of the works. These causes do in some degree exist, but are wholly insufficient to account for the extremely unfavourable results. Irrigation on the voluntary system is here exhibited under its worst aspects; but results similar in nature, though less glaringly disastrous, are apparent in the Northern Provinces of India where the canals are completed, where there is no general apathy, where the rainfall is scanty and where, from long experience, the revenue management has arrived at as great perfection as is possible under the present system of a "voluntary irrigation rate."

In the opinion of the present writer the cause of all this failure is the fact of the irrigation rate being voluntary.

Canals in the North-West Provinces. Turning now to the irrigation reports of the Governments for the North-West Provinces and the Punjab, and taking first of all those for the year 1871-72, let us examine whether the financial results are satisfactory.

The following is the Official Irrigation Financial Statement of the North-West Provinces for that year :—

| NAME OF WORK.        | Total outlay on construction to end of 1870-71. | Total income realized during 1871-72. | DEDUCT CHARGES FOR 1871-72.                  |                                  |          | Net surplus or deficit. |
|----------------------|-------------------------------------------------|---------------------------------------|----------------------------------------------|----------------------------------|----------|-------------------------|
|                      |                                                 |                                       | Cost of maintenance including establishment. | Interest charges at 4½ per cent. | Total.   |                         |
| Ganges Canal ..      | £2,418,531                                      | £182,007                              | £91,860                                      | £100,339                         | £200,699 | -£17,192                |
| Eastern Jumna Canal  | 197,332                                         | 51,026                                | 10,880                                       | 8,015                            | 28,795   | +22,231                 |
| Doon Canals ..       | 64,098                                          | 4,714                                 | 2,628                                        | 2,479                            | 5,107    | -393                    |
| Rohilkund Canals ... | 49,362                                          | 8,254                                 | 7,698                                        | 2,351                            | 9,959    | -8,705                  |

Net—£2,659.

This shows that on these four schemes, which were then the only complete ones in the North-West Provinces, there had, up to the end of 1870-71, been expended nearly 2½ millions, that the interest and maintenance charges against revenue for 1871-72 were £244,560, and that these charges were covered by the revenue, with the exception of £2,659.

At first sight this result looks tolerably favourable. It looks as if in ordinary years the irrigation works in those provinces were paying their way without forming a burden on the State.

But scrutinizing the figures more closely we see that, without the Eastern Jumna Canal, the deficit for the year would have been just £25,000, an uncomfortably high figure. In the consideration of facts on which to base an irrigation policy, we are bound to discard altogether from our calculation the results



obtained on the Eastern Jumna Canal; for it was in existence before we took possession of the country, and the only expenditure incurred on it by our Indian Government has been in here and there effecting a realignment. Its capital cost and interest charge are therefore unknown quantities. The table I have given shows the entire revenue from every source, derivable from the canals; of this five-sixths is water rate, and the remaining one-sixth miscellaneous receipts from mill-rents, navigation tolls, and other sources. Taking the figures for the Ganges Canal we find that in the year 1871-72. it irrigated 606,555 acres, and produced a net revenue of £91,547 (after paying annual charges, except interest), and gave an interest of 3·78 per cent. on the capital outlay, whereas Government had to pay 4½ per cent. for the money borrowed for its construction, while 5 per cent. is the least amount which should be estimated to cover interest and deterioration of the works. The loss for the year at 1·22 per cent., on £2,418,000 (the capital) was £29,500. Similarly, the Doon Canals irrigated 11,039 acres and yielded interest at only 3·18 per cent. on the invested capital.

The six years ending 1871-72 show the following results for the finished irrigation works in the North-West Provinces :—

| 1866-67, net revenue after paying maintenance charges 4·94 per cent. on capital outlay. |     |     |     |          |
|-----------------------------------------------------------------------------------------|-----|-----|-----|----------|
| 1867-68                                                                                 | ... | ... | ... | 8·44 do. |
| 1868-69                                                                                 | ... | ... | ... | 8·21 do. |
| 1869-70                                                                                 | ... | ... | ... | 5·31 do. |
| 1870-71                                                                                 | ... | ... | ... | 5·10 do. |
| 1871-72                                                                                 | ... | ... | ... | 3·46 do. |

or an average for the six years of just over 5 per cent. ; —a very satisfactory result were it not that, without the Eastern Jumna Canal, which, for reasons already given, should be excluded, the return is only 3 per cent.

The areas irrigated during these six years fluctuated much; the lowest being 761,460 acres in 1867-68 and the highest 1,441,898 acres in 1868-69. The variation is officially attributed to the rains being plentiful or scarce, inopportune or felicitously distributed.

It cannot be said that even standing by themselves these results for the North-West Provinces are satisfactory.



They of themselves exhibiting an annual deficit and a fluctuating revenue are in no way able to cover the greatly larger deficit of other provinces. Yet it is here that the people are most alive to the advantages of irrigation, and that the revenue management is regarded as almost perfect. Even the amount of revenue shown is only obtained by making the irrigators pay a high average rate of 5 shillings per acre for six months, or 10 shillings per acre per annum if crops are grown and irrigated throughout the year.

The reports for subsequent years show much the same result; in 1872-73 the entire works in the North-West Provinces paid 3.46 per cent. on the capital invested; in 1873-74 they paid 4.73 per cent. This latter year was however one of extensive drought, and the area irrigated was 1,049,334 acres against 940,586 acres in the preceding year. Even in the favourable year of 1873-74 receipts were £5,000 less than the charges inclusive of interest. In both year it is needless to say that, if the favourable results of the Eastern Jumna Canal are excluded, the percentage would be diminished by about one-half.

This is most clearly demonstrated by the following figures, showing comparatively the interest paid by the Ganges and Eastern Jumna Canals year by year:—

| Percentage paid<br>by Ganges Canal<br>on capital. |          | Percentage paid<br>by Eastern Jumna<br>Canal on capital. |       | These figures are exclu-<br>sive of what is called the<br>"indirect" revenue, name-<br>ly, revenue derivable from<br>the increased value of land<br>as brought about by the<br>canals. |
|---------------------------------------------------|----------|----------------------------------------------------------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1870-71                                           | ... 4.30 | ...                                                      | 10.75 |                                                                                                                                                                                        |
| 1871-72                                           | ... 2.74 | ...                                                      | 16.66 |                                                                                                                                                                                        |
| 1872-73                                           | ... 2.74 | ...                                                      | 15.01 |                                                                                                                                                                                        |
| 1873-74                                           | ... 4.14 | ...                                                      | 18.46 |                                                                                                                                                                                        |

In the year 1874-75 the canal revenue is said to have yielded 4.55 per cent. on the capital outlay on works in operation. The area irrigated had risen to 1,142,452 acres which was in excess of any year since 1868-69. The water rate still continued to average 5 shillings per acre for six months, and rose to above 6 shillings on the Eastern Jumna Canal. Excluding the Eastern Jumna Canal which paid upwards of 19 per cent., the interest paid by the other revenue-paying canals was 3.35 per cent. on a capital of £3,616,000; or, estimating that 5 per cent. is the lowest amount of interest which will ensure

Government from loss, these canals were worked at a loss of £59,664. If to this we add interest on their accumulated deficits in past years, which deficits amount to  $1\frac{1}{4}$  million, we have, on the year, a loss of £122,000.

Up to the close of the year 1874-75  $4\frac{1}{2}$  million sterling had been sunk in canals in the North-West Provinces. The average amount paid by the Ganges Canal during 1872-73, 1873-74, and 1874-75 was 3·8 per cent. on a capital, at last amounting to £2,645,000. To this capital, even after giving the canal credit for the  $\frac{1}{4}$  million which it claims as increased land revenue due to its works, must be added  $1\frac{1}{4}$  million accumulated unpaid interest, and the percentage paid is thus reduced to 2·58. Estimating that 5 per cent. is the interest really required, we must put down the annual loss on that canal at 2·42 per cent. on £3,895,000, or £94,250. The results on the Ganges Canal are more favourable than those on the other canals, except the Eastern Jumna, are likely to be, and we may safely take an average of 3 per cent. as the utmost they are likely to pay. Excluding the Eastern Jumna Canal, the capital expenditure on canals in the North-West Provinces up to the end of the year 1874-75, was  $4\frac{1}{4}$  millions; to which, after giving the canals credit for £300,000, claimed by them as the aggregate increment of land revenue due to them since they have been in operation, there must be added  $1\frac{1}{4}$  million as the accumulated unpaid interest of past years.

If we now refer to the Punjab Irrigation Report for the year 1871-72, we find a state of things in no way more satisfactory. We must omit from any calculation the Western Jumna Canal, which is an old Mahomedan work reopened and in some places realigned by Government. This canal shows a net surplus revenue of £60,710, after payment of 5 per cent. interest on its capital and maintenance charges, which is simply owing to the fact that our Government found it ready made, and consequently had to incur a comparatively small capital outlay on it. It yielded in that year a percentage of 27·04 on its capital. The Punjab Canals.

The other canals show :—

| NAME OF WORK                                     | Total outlay on construction up to end of 1870-71. | Total income realized during 1871-72. | DEDUCT CHARGES IN 1871-72.                  |                                    |          | Deficit. |
|--------------------------------------------------|----------------------------------------------------|---------------------------------------|---------------------------------------------|------------------------------------|----------|----------|
|                                                  |                                                    |                                       | Cost of maintenance including establishment | Interest on capital at 5 per cent. | Total.   |          |
| Bari Doab Canal ...                              | £ 1,259,522                                        | £ 71,540                              | £ 31,884                                    | £ 62,976                           | £ 94,860 | £ 23,370 |
| Lower Sutlej and Chenab (Inundation Canals) ..   | 11,290                                             | 553                                   | 3,687                                       | 564                                | 4,251    | 3,698    |
| Upper Sutlej and Chenab (Inundation) Canals. ... | 56,454                                             | 5,548                                 | 10,747                                      | 2,823                              | 13,570   | 8,022    |
| Indus (Inundation) Canals                        | 38,514                                             | 9,612                                 | 14,837                                      | 1,926                              | 16,763   | 7,151    |
| Minor irrigation works ...                       | 18,443                                             | 807                                   | 1,474                                       | 923                                | 2,397    | 6,439    |
| Total ...                                        | 1,384,228                                          | 88,162                                | .....                                       | .....                              | 131,890  | 43,738   |

The result as demonstrating an annual loss of £43,738 cannot be deemed satisfactory.

The only completed work in the Punjab which can help the present enquiry is the Bari Doab Canal. The Inundation Canals are rather reconstructed every year for the purpose of inundating certain lands which would otherwise be unculturable. Their effect is confined to bringing such lands under cultivation. In 1871-72 the interest on capital outlay furnished by the Bari Doab Canal was only 3·15 per cent., and this result was only obtained by the levy of a rate similar in magnitude to that obtaining in the North-West Provinces.

The canal had then cost  $1\frac{1}{4}$  million. In 1872-73 the net percentage yielded by the Bari Doab Canal was 2·36 on its capital of £1,320,000; or, including the owners' rate, 3·83.\* The Western Jumna Canal on the other hand yielded a percentage of 18·44 on its capital of £298,000. In 1873-74 the Western Jumna Canal on a capital of £312,000 yielded a percentage of 15·36; and the Bari Doab 2·37 on a capital of £1,345,000; or, including the owners' rate 3·77.

In 1874-75 the Western Jumna yielded 20·29 per cent. on a capital of £334,000, and the Bari Doab 3·07

\* *Vide* page 30.—The owners' rate averages 2 shillings per acre for 6 months on each acre irrigated and is in addition to the occupiers' rate of 5 shillings per acre, making a total of 7 shillings per acre for 6 months.



on a capital of £1,375,000; or, including the owners' rate, 4·64. But to the capital of the Bari Doab Canal has to be added accumulated unpaid interest amounting to  $\frac{1}{2}$  million sterling, including which in the total capital the interest yielded, inclusive of the owners' rate, is only 3 per cent. Taking 5 per cent. as the rate required, there is on a capital of £2,125,000 an annual loss of £42,500.

Taking the Orissa, Midnapore, Ganges, and Bari Doab Canals, we have the following results:—

An estimate of the annual deficit which may be expected from irrigation works.

|               | Capital expended up to 1874-75 inclusive of accumulated unpaid interest. | Annual Interest charges at 5 per cent. | Canal yields after defraying maintenance charges. | Deficit. |
|---------------|--------------------------------------------------------------------------|----------------------------------------|---------------------------------------------------|----------|
|               | £                                                                        | £                                      | £                                                 | £        |
| Orissa ...    | 1,912,000                                                                | 95,600                                 | —15,000                                           | 110,600  |
| Midnapore ... | 750,000                                                                  | 37,500                                 | —1,500                                            | 39,000   |
| Ganges ...    | 3,895,000                                                                | 194,750                                | 100,510                                           | 94,240   |
| Bari Doab ... | 2,125,000                                                                | 106,250                                | 63,750                                            | 42,500   |
| Total ...     | 8,682,000                                                                | 434,100                                | 147,760                                           | 286,340  |

Thus the present annual loss on these works which ought to be paying their way is £286,340; a total to which other works of a similar nature in full operation in the North-West Provinces, with a million sterling as their capital, add £28,000, making in round numbers an aggregate annual loss of £314,000.

Up to the close of the year 1874-75 just three millions sterling had been sunk in canals in the Punjab, to which must be added one million unpaid interest.

Up to the end of the same year 4 millions, inclusive of  $\frac{1}{2}$  a million unpaid interest, had been expended on canals in Bengal. I have also stated that 5½ millions, inclusive of unpaid interest, had been expended in the North-West Provinces. Omitting the Bombay and Madras works there is thus, up to the close of the year 1874-75, a total expenditure of 13½ millions on canals. Inclusive of the expenditure already incurred, the irrigation projects in hand or in immediate contemplation represent a capital of not less than 25 millions sterling. Of this about 9 millions are in Bengal, 7 millions in the North-West Provinces (excluding the Eastern Jumna Canal), 8 millions in the



Punjab (excluding the Western Jumna and Inundation Canals), and one million in other provinces, omitting Madras and Bombay.\*

The schemes at present on foot will, under the present voluntary system with a capital of 25 millions, cause a minimum annual deficit of £620,000, and a probable one of £750,000.

It has been demonstrated that it is only occasionally, even under favourable circumstances, that the voluntary system will produce a larger average annual return than 3 per cent. on the invested capital; while 6 millions of the capital expended in Bengal will probably, under that system, never return more than 1 per cent. On this capital of 25 millions we have thus, as a probable minimum average, an annual deficit (estimating the necessary interest at 5 per cent.) of a sum of £620,000, and, judging from the actual deficit already resulting, a probable average annual deficit of £750,000. This is a large sum to squander annually in abortive efforts to prop up a system of defective administration.

We may admire the virtue which would conscientiously make this sacrifice to a sentiment of justice; but believing the sentiment to be mistaken, we may be none the less eager to challenge the policy for which it is responsible. Looking to the actual results obtained by that policy, it cannot be difficult to forecast a total and disastrous defeat as its immediate future. In the face of those results the most enthusiastic advocate of the present system must long since have surrendered all hope of surplus or equilibrium.

The consideration of any course by which this failure might be avoided cannot be regarded as an unimportant matter.

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\* On August 10th, 1876, Lord George Hamilton, Under-Secretary of State for India, in his speech on the Indian Budget, stated that 17 millions sterling had been invested in irrigation works, and that those works yielded a return of £708,000 on that capital. In the Punjab 3 millions of this capital had been expended, and the return on that capital was 4½ per cent.; this was a somewhat severe test to apply, as the capital included all the money expended on works that were not yet in operation, and of course it was only those in operation which paid any interest. In the North-West Provinces there was a similar return of 4½ per cent. In Bengal which included the Orissa works, and some not yet in operation, the irrigation works involved a loss of 2½ per cent. It would be found that the expenditure on irrigation paid where there was little or no rain; and only where there was much rain in the course of the year were the results unsatisfactory.

On this the present writer would remark that, as already shown, the works in Bengal at present yield absolutely no interest, being worked at a loss of the entire interest paid by the State for capital sunk in them; in addition to which the State has to bear a charge of 1 per cent. for their maintenance.

The localities which stand in need of irrigation canals, and which, under the voluntary system, exhibit a probability of paying some interest, should evidently be selected for operations prior to those localities where, though irrigation may be an equal necessity, the nature of the ground renders the construction of a canal more costly, or the condition of the land tenure, or the ordinarily ample rainfall renders improbable the return of an adequate revenue. But, although this test may ordinarily be a safe one as to what work should be undertaken, Government cannot under all circumstances limit its action within those bounds. The Orissa famine demonstrated the necessity of taking measures for the safety of that province, and the present irrigation scheme was unavoidable. Yet, under the voluntary system, an annual loss of a hundred thousand pounds is the lowest which that scheme can be expected to entail.

Even with this outlay our famine defences in the shape of canals will be very inadequate, and a further loan will have to be borne.

Famine is to our rule in India an enemy far more powerful, more subtle, and more ready to attack us in our weakest parts than any human enemy we need fear. Its ravages are more ruinous in effect and less easy to repair. Yet up to the present it is an enemy against which our defences are but few and far between. Here and there a canal stands forth as a fortress against the enemy,—able indeed to save the surrounding country, but not efficient to protect the vast plains which lie beyond and out of its reach. Our famine defences require thorough revision and speedy completion. The first step towards this is to overcome the financial difficulty of swelling deficits which at present renders impossible any persistent measures in that direction.

No further annual charge on account of interest on these unpaying investments can be borne by the Indian revenues, and it is most necessary that the Government should rid itself of the present heavy annual charge it has to bear on that account. There would appear no recognized means of taxation, save the odious income tax, to which resort could be made for the purpose. The difficulty is indeed insoluble without a change of policy. Such a policy should lie well within the controlling influence of justice and, by the equitable incidence of the burdens it may im-

The Indian revenues are quite unable to bear the annual charge thus thrown on them.

pose, should be calculated to remove much that is oppressive, and a source of discontent in the realization of the present revenue from canals. Such a policy should place the attitude of Government towards irrigation on a sound and intelligible footing. The plains of India might then be speedily protected from both famine and flood by a net-work of canals, while the State, far from being called upon to meet any extra calls on its revenues, would find itself relieved of all the charges which it is now bearing as the result of its present ineffectual, irresolute and detrimental action respecting irrigation. If, as the present writer believes, such a policy as has been referred to is to be found in the imposition of a compulsory rate on all lands irrigable from or protected by a canal, whether that land takes water or not, provided that there is water to give it, or protection is afforded to it, it would be well to weigh carefully how far the imposition of such a rate would be sound in principle and calculated to work in practice.

A compulsory canal rate the only course open, being a just and political course as well as financially sound, it should be adopted.

Act XXX of 1871 (Indian Council), dealing with the canals in the Punjab, made provisions in this direction, but they were not sufficiently thorough and, such as they were, they were disallowed by the Secretary of State. It provided (Section 44) that, if the Local Government was satisfied that the owners or occupiers of cultivated lands irrigable from a canal had not made reasonable use of the canal for the purposes of irrigation, the owners of such lands were to be charged with a special rate—an insurance rate as it were—not exceeding 2 rupees or 4 shillings per acre per annum. If the land used the water regularly for irrigation, it would have to pay about 10 shillings per annum under ordinary arrangements.

The legislative attempt which has been made in this direction.

This attempt to meet the difficulty which has been referred to was in the right direction, but it did not deal with that difficulty in a manner sufficiently thorough. There are at least two points wherein it was palpably weak.

First of all, the difference between the voluntary rate and the special insurance rate, amounting to about 6 shillings per acre per annum, was sufficient still to deter the majority of those who from laziness, apathy or ad-



herence to the traditions of their fathers refuse to use the water, or those multitudes who are wont, until it is too late, to trust for the safety of their withering crops to the rain that will not come. The object should be not to have the few paying the high voluntary rate, and the majority the low insurance rate, while the water, which, if used, would yield golden results to the community at large, is allowed to find its way unused to the sea, but to have all using the water, and paying a moderate rate for this benefit. This object would be obtained by making the voluntary rate and the insurance rate as nearly similar as possible, thus doing away with the reason which all now feel for holding back from taking the water, if they can possibly do so. If the rates were actually the same, whether water was taken or not, there would be no one who would not gladly take the water and use it;—all with profit, and some with very great profit, to themselves. It should be indispensable that a complete system of drainage works for the whole of any area commanded by an irrigating canal should go hand in hand with the canal works, should form part and parcel of the complete scheme, and should be constructed from funds provided in the same manner.

The second weak point in this legislative attempt to master the difficulty was the method proposed for the assessment of this special, or insurance, rate. The enquiries which would have been necessitated would have been vexatious to a degree scarcely possible to contemplate. Whether land is really irrigable from a canal or not is often a matter which nothing except the careful and intelligent irrigation of the land would settle satisfactorily; but it was only when this was not done that Act XXX of 1871 proposed to enforce a special, or insurance, rate. Assessments based on any other data, however satisfactory they may be to the mind of the official adjudicating, would often leave the ryot or zemindar regarding himself as an oppressed and deeply-wronged individual. The amount of hostility stirred up by the method of assessing the special rate would have been of such a magnitude as to form a bar to the possibility of the general use of the compulsory provisions of that Act.



The views embodied in Act XXX of 1871 appeared a move in the right direction, though the possibility of applying them practically on a large scale might have been prevented by a mistaken procedure. The Secretary of State, however, negatived that measure.

After the disallowance of Act XXX of 1871, no further attempts have been made to introduce a compulsory canal rate.

Discussions regarding a compulsory rate.

Evils incident to the voluntary rate, apart from its financial failure.

No move in the direction of a compulsory rate has since been made. There have however been important discussions on the subject. In the Annual Administration Report of the Bengal Government for the year 1871-72 it is stated (page 127):—"High rates are gladly paid for water supplied at a season when there is little rain; the deltas of the southern rivers of Madras receive a full supply from the Western Ghats at a time when there is little monsoon on the Madras Coast and the North-West Provinces, and the Punjab Canals derive their chief revenue from the irrigation of the cold weather and spring crops where there is little rain. On the other hand, the Orissa rivers have an extremely scanty flow of water at that season, and we must chiefly depend on the irrigation of the rice and other rainy season crops for a revenue from the canals. It is principally at the end of the season in October, when rain may or may not fall, while the rivers still hold a considerable flow of water, that the benefit is felt. Probably, it will turn out that a uniform supply of water, well managed by a skilful system, will give better crops than an irregular though heavy rain supply. But at present the people look on a water rate merely as a sort of insurance against a possible failure of the rains, especially a failure at the end of the season, and they are very unwilling to pay heavy rates till at least the failure is actually on them. If the year is a good or ordinary one, and there is no special failure of the rains, they think they can do very well without irrigation." Too much weight cannot be laid on the few words "and they are very unwilling to pay heavy rates till at least the failure is actually on them." Universal experience supports the truth of this remark which could scarcely be said to suffer if the adjective "heavy" had been omitted. The fact is that ordinarily, in Bengal, a ryot, when allowed to pay a voluntary rate for water, taking it or not as he likes, taking it and escaping payment for it if he can, waits on and

on for the rain which does not come. To this course he is directly tempted by the present well-meant, but illusory, policy. He says to himself in the morning, "Rain will come to-day. If it does not come to-day, I will agree to take canal water to-morrow;"—and so, while every day's delay does much damage to the crop, he waits and waits until at last it is but the wretched remnant of a half-ruined crop which he can save; thus making the water rate an odious and overpowering burden which, bad enough were it to fall in a year of good yield, becomes unspeakably hateful when its incidence is only accompanied by the half crop it has managed to save. The ryot then has no surplus from which to pay the water rate, and, forgetful that what crop he has is due to the water, he with heavy heart goes forth to the money-lender, contracts a new loan, and sinks deeper than ever into debt. He attributes this new evil to the water rate and hates it bitterly. The small benefit received is in his mind totally eclipsed by the hardship experienced. This recurring dissatisfaction and exasperation on the part of those for whom Government is bearing such heavy financial losses is one of the most disheartening features of the present system. This fact alone, it is believed, is an argument of the greatest weight in favor of a compulsory water rate, as the only means of avoiding a delay ruinous to the general prosperity of the cultivators, the country, and the finances of Government. That the same causes, in a modified form, are at work in the North-West Provinces and the Punjab is manifest from the following extracts from the Reports of those Governments:—

In the Resolution by the Government of the North-West Provinces on the Irrigation Revenue for the year 1872-73, it is written:—"With  $5\frac{1}{2}$  inches of rainfall less than in the previous year, it might have been expected that the increase in the area irrigated would have been greater; but it was only in the lower districts of the Doab that the winter rains failed at the critical time: in the upper districts, though not very copious, they fell just when they were required for the wheat crop." Again in the Resolution for 1873-74:—"With a higher average rainfall than that of last year, there was an increase in irrigated area of

110,000 acres. This fact shows how dependent the country is upon seasonable rather than upon copious rains. The increase this year is due partly to the failure of early kharif rains, partly to the failure of winter rains in the Lower Doab."

The Resolution of the Punjab Government on Irrigation Revenue for 1872-73 states:—"The fall of rain during the year was more generally abundant than for many years previously—a state of things which, however favorable to agricultural prosperity, has just the reverse effect on the finances of the permanent canals, on which much the largest proportion of the irrigation is dependent." The report of the same Government for 1873-74 states:—"A plentiful rainfall is a rival of the canals, though not a completely successful one in any portion of the plains of the Punjab."

It is no wonder then if, notwithstanding the fate of Act XXX of 1871, a discussion concerning the necessity for a compulsory canal rate still continued.

At page 180 of its Annual Administration Report for 1871-72, the Government of Bengal has written:—"The Government of India much inclined to the system of making the payment for irrigation compulsory, and if there ever could be a case in which a light compulsory rate by way of insurance (like a rate to keep up a fire-engine) might be accepted as the means of cutting the knot of the tangled skein of difficulties, it was the case of Orissa. The Commissioner of Orissa was in favor of a compulsory rate;—the Collector of Cuttack against it, thinking that a voluntary system had not yet had a fair trial. A compulsory insurance rate might be possible if we could be sure of its being kept down, but in the hands of a special department, bent on showing a large canal revenue, it would be most dangerous, and it is understood that it is no longer pressed by the Government of India."

Opinion of  
the Govern-  
ment of  
Bengal re-  
garding a  
compulsory  
rate

In Bengal it was resolved to continue the voluntary system for at least five years, with what success as regards Orissa and Midnapore has been already demonstrated. The annual loss on these canals is now just £150,000; the receipts are less than £16,000.



The reasons for the decision in favor of the voluntary system are thus given at page 265 of the same Report :—

“It was apparent that a compulsory rate in any form could not be at once imposed, as in no part of the irrigable tract had the works reached such a stage of completeness as would be a preliminary essential to the introduction of such a rate, nor were they likely to be in such a condition for some years. Nothing therefore remained but to give the voluntary system a further trial.”

These were sound grounds for a postponement of the general introduction of a compulsory rate on those canals, but they may be extended too far. It is not necessary that the works of an entire canal should be complete before a compulsory rate is introduced on a portion of the land covered by the canal. It is sufficient if the works of any length or section of such a canal are complete to warrant the introduction of a compulsory rate, so far as that section is concerned.

The above quotation however shows that Sir George Campbell, the then Lieutenant-Governor of Bengal, probably viewed the compulsory rate, as the inevitable policy of the future. Without this the Orissa works appeared to him a certain and heavy charge on the general revenues of the State for many years to come. It is indeed now still more patent that, though these works were absolutely necessary for the safety of the province, the inhabitants of Orissa who reap the benefits will not, under the voluntary system, pay one-twentieth of the annual charges. It appears to the present writer the acme of injustice to make these canals which are of mere provincial application and utility a charge on the general revenues. There can be no equity in a policy which requires the ryot of Oude whose lands lie open to drought and flood to contribute by taxation in paying for the safety and wealth of the ryot of Orissa. He is in no conceivable way interested. The provinces lie almost a thousand miles apart, and if he knows that on the far distant shore of Orissa sits in majesty the image of the great Juggernath, he is probably wiser than the rest of his fellow villagers. The injustice also not



unfrequently takes the form of actually depreciating the value of the property of persons thus compelled to contribute. Backergunge is a fertile district at the north-east of the Bay of Bengal where famine and drought are unknown and can scarcely be conceived to be a possibility. It annually exports a large amount of rice which, were other districts not artificially protected from scarcity, would frequently command largely enhanced prices. The people of that district are not only prevented from thus increasing their wealth, but are actually required to subscribe towards paying for the means taken to effect that prevention.

The plea of most of those who argue against a compulsory water rate is its injustice. This is a vague prejudice of which the present writer declares himself a strenuous antagonist. He believes that under the influence of a compulsory rate, present discontent would turn into appreciation, apathy into energy, and suspicion into confidence.

Pointing to the conclusion that, financially unsuccessful in Upper India, the voluntary system of water rate is still infinitely more unsuited to Bengal is the following quotation from the same Report by the Government of Bengal.

At page 255 is the following :—

“The water rates are looked to as the main source of revenue, but up to the present time they have never reached an amount much in excess of the receipts from navigation, and, in fact, have scarcely paid the expenses of collection. This fact” (which still remains unaltered) “sufficiently indicates the low degree of development which irrigation has yet obtained in Bengal, and this is mainly owing to a want of appreciation of the value of water on the part of the cultivators, the available supply even in the present condition of the canals being out of all proportion to the demand. Other causes tend to produce the same effect, such as the mode of collection by the zemindars of Midnapore, where the permanent settlement prevails, and the fears entertained by the ryots both there and in Cuttack (which is under 30 years’ settlement) of an enhancement of the land rent by the zemindars on

the ground of increased productiveness due to irrigation; but upon the whole, the main cause of the backwardness of the people to avail themselves of the advantages of irrigation is a doubt as to its value at the price charged for it, and a disposition to resort to it only to save their crops when the rains fail, rather than as a means of increasing the productiveness of the soil."

The argument concerning the voluntary and compulsory system is thus referred to in the same Report:—

*The opinion of the Commissioner of Orissa on a compulsory rate.*

"The Commissioner of Orissa, Mr. Ravenshaw, who had previously held this view" (in favour of a compulsory water rate) "brought it again before the Government and urged it with much force. He maintained that the imposition of a light water rate upon all *bond fide* irrigable land to be collected and paid by the zemindars would be more generally acceptable to the people, and more profitable to the State, than any system based on the voluntary system could be; that it would involve less interference and less harassment of the cultivators by the revenue officials, and would be much less costly to work, while the Uriya ryot, finding the payment of the water rate inevitable, would resign himself to his fate, take the canal water, and having in the course of a few years learnt by experience its value, would willingly pay for what he had previously so obstinately refused. Mr. Ravenshaw proposed to begin with a rate of 1 rupee to be fixed for five years, to be afterwards raised to rupee 1-4, and so to rise by gradual increments to a maximum of rupees (2) two which was not to be exceeded during the currency of the present settlement.

Mr. Schaleh, ~~Senior~~ Member of the Board of Revenue, supported Mr. Ravenshaw's views. He argued that there were in the case of Orissa special reasons for the introduction of such a compulsory rate. The necessity for the works which would afford protection to the Orissa deltas from the alternate droughts and inundation from which they have so long suffered, had been amply demonstrated. The cost, however, would be great, not less than three millions sterling, and it would be unfair to cast the burden of payment of the interest upon the tax-payers of all India, who

*The opinion of Mr. Schaleh, Senior Member of the Board of Revenue, on a compulsory rate.*

had already borne a heavy annual loss in remission of revenue in past years, besides the enormous expense of the famine of 1866. If, therefore, the Uriya ryots were too ignorant and prejudiced to avail themselves of the irrigation offered to them, it was only just that they should be made to contribute, by means of compulsory assessment, the cost of works constructed for their exclusive benefit, nor would such a measure be unpopular.

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Mr. Schaleh would, however, with the Commissioner, make it an imperative condition antecedent to the imposition of a compulsory rate that complete arrangements should be made for the supply with water of the entire area, that its drainage should be thorough, and that no charge should be made for any portion of the area for which the water supply might prove, from any cause, insufficient.

\* \* \* \* \*

The Chief Engineer's opinion on a compulsory rate.

The Chief Engineer advocated the imposition, not of a water rate to be paid whether water was taken or not, but of a rate which would represent the actual *bonâ fide* benefits conferred upon the people by the works, irrespective of habitual irrigation, namely, protection from inundation, security against famine or scarcity, drainage, cheap carriage to good markets, a complete system of internal water communication, and an unfailing supply of good water.

The ryot who refused canal water in ordinary years, and only resorted to it in seasons of exceptional drought to save his crop, was, nevertheless, it was urged, in enjoyment of all ~~these~~ other collateral advantages. To let him go untaxed, and to throw the whole charge upon his more intelligent neighbours who made a regular practice of irrigating, would be inequitable. Advantages enjoyed by all, should be paid for by all: common justice required that the whole burden should not be thrown on one particular class.

The charge for interest and maintenance ought, the Chief Engineer considered, to be met from two sources: one a general rate upon the land proportioned



to the increased value conferred upon it by security from inundation and from all extraordinary risks of season, by drainage, and by increased value of produce, and the other a special rate to be levied only on the lands for which water is taken regularly from year to year. All the benefits of both the compulsory and voluntary systems would in this way be obtained. The general and compulsory rate would represent only value actually received, and the sale of water for regular irrigation, that is, for the purpose not merely of ensuring the safety of the crops, not for increasing their yield, would be a matter of perfectly free contract. "This plan was proposed as the only method of securing to the State its just dues without a risk of individual injustice."

It would be well here to point to the weight which should attach to the opinions set forth in the above quotation. Mr. Schaleh is a Bengal Civilian of very great and prolonged experience, who occupies the highest post in the service, except that of Lieutenant-Governor of a province. No officer throughout the whole of Bengal is more respected by members of his service and by the entire European and Native community. He is accredited with justice, integrity, sterling ability and common sense. He can boast perhaps of a more intimate acquaintance with the sentiments, wants, virtues and failings of the Bengal peasantry than any other officer, and Orissa is peculiarly the field where his experience may be said to be of the most perfect and matured nature. Mr. Ravenshaw has been resident in Orissa as its Commissioner ever since the year 1865. His failing (if it exist on either side) has certainly been to lend too ready and fostering an ear to the complaints of the people. Both these officers, calculated in an eminent degree to have a just appreciation of the case, have emphatically declared for a compulsory rate.

Mr. Ravenshaw's opinion as to the *amount* of rate seems to the present writer to be framed on an erroneous basis; while, in his statement of lands which should be assessed with a compulsory canal rate, he has omitted unirrigable but culturable areas benefited by the embankment and drainage works of the canal. No canal

The present writer's opinion on the amount of the compulsory rate and the lands to be assessed.



should be made to pay for aught more than for itself : not one penny more or one penny less. If a canal is capable of easy and cheap construction, the people who should benefit by that fact are those whose lands are to be benefited by the canal, and whose lands happened to lie in a locality where water is easily procurable. If a canal is peculiarly costly, it is rendered costly by the fact that the lands benefited by it are situated in a locality where water is with difficulty procurable. In such a case the water is more precious to them, and they, and no one else, should pay for it.

The present writer's theory as to the lands on which the rate should be imposed and the amount of rate to be levied is that it should be a fixed annual rate on every acre of culturable land which may be irrigable from the canals, and also on every acre of culturable and non-irrigable land protected by the embankment works, or benefited by the drainage works connected with the canal. The rate on each acre would vary in accordance with the benefits relatively conferred on it ; the total assessment should be such that every section of a canal should, after paying what may be estimated as an average annual charge for maintenance, repairs and establishments (probably 2 per cent. under the compulsory system), be able to pay interest at 5 per cent. per annum on the capital outlay incurred on it. This makes a total of 7 per cent. per annum.

A canal should for this purpose be divided into sections of not over 50, and seldom less than 30 miles in length, with all the distributary channels branching therefrom. The capital cost of that section should be—(1) the cost of all the ~~irrigating~~ protective and drainage works in that section ; (2) a fair apportionment of the cost of all the headworks (such as weirs, &c.) and main non-revenue-paying works connected with the canal ; (3) all accumulated interest on such expenditure up to the time of the assessment of the compulsory rate. If it is deemed advisable to irrigate from a section of a canal before the section is completed, such irrigation should be entirely free of charge. The people would in this way get accustomed to the use of the water before having to pay

for it, and there would be an absence of the bitter feelings which any attempt to levy a voluntary rate would, in such a case, produce with financial results altogether inadequate. Further details are for the present postponed, as the principle of the policy is now the point under discussion.

The opinion of Col. Haig, R.E., the Chief Engineer in Bengal, on the subject of a compulsory canal cess, has already been quoted. He advocates the imposition of a compulsory rate. His arguments on that point are cogent. The present writer regrets that he cannot concur with him in the manner in which he would try to unite the compulsory and voluntary systems. It appears to provide a machinery too complex for practical use and calculated to give rise to much avoidable annoyance, for it would maintain the harassment which under the voluntary system the cultivators annually undergo at the hands of an army of corrupt subordinates who frequently invade their lands for the purpose of examining the extent of the irrigation and measuring the irrigated lands. This annoyance, which is so inseparable from the working of the voluntary system, is one which is very real, very costly, and very intense in its nature. The proposals of Colonel Haig are indeed open to all the objections which have already been urged against the measures propounded in Act XXX of 1871.

A consideration of the Chief Engineer's opinion.

Reference must now be made to Act VIII of 1873, entitled "The Northern India Canals and Drainage Act," which is at present the law on the subject of irrigation revenue. Bengal has as yet no complete law on the subject; a bill is now before the Bengal Council, \* but it stops far short of the provisions of Act VIII above referred to.

Refers to Act VIII of 1873, the present law on the subject of Canal Revenue.

Act VIII of 1873 provides the following sources of irrigation revenue:—

(1). A rate on occupiers of lands using the canal water for irrigation.

(2). In addition to the above, a rate on the owners of canal-irrigated lands in respect of the benefit which they derive from such irrigation; lands permanently

\* This bill has recently become law.

settled or held free of revenue being liable to this rate in the same way as temporarily settled lands. This owner's rate may not exceed the difference between the land revenue which would have been assessed before the lands were irrigated, and that which might be assessed were the lands resettled after becoming canal-irrigated.

(3). A rate not exceeding 6 per cent. per annum on the cost of all drainage works, *plus* the annual cost of maintenance and supervision. This rate to be levied on all lands which are benefited thereby; of these a schedule must be drawn up under the sanction of the Local Government and published.

A consi-  
deration of  
its provi-  
sions.

The first provision leaves it still quite optional with the occupier of land whether he will take water and pay the rate, whatever it may be. It thus in no way improves the previous state of things.

The second provision renders it possible to assess owners of *canal-irrigated* land with an owner's rate on account of the benefit the lands derive therefrom. Now as the land which irrigates from a canal is constantly varying with every season, it is hard to see how this clause could be made of practical effect, for the owner's rate and the consequent sub-arrangements which he may make with his tenants could not be allowed so to vary. In the Punjab, where it is in force, it would appear to have been assessed, in a rough and ready manner, at  $\frac{1}{3}$ rd of the occupier's rate; it being simply an increment of about 2 shillings per acre to the previous voluntary irrigation rate, raising that rate from 5 to 7 shillings per acre for six months' irrigation.

If the words had been *canal-irrigable* instead of *canal-irrigated*, this provision might have been of real use, without adding to the already very high actual irrigation rate.

It would then have assimilated to the proposals of the present writer. But there should be no additional voluntary rate on occupiers for actual irrigation, such only acting as a deterrent from the use of the water, to the diminution of the wealth which would otherwise result to the community in general from its universal use.



The third and last provision, concerning drainage, is the compulsory system, pure and simple, and it is that system which, in almost precisely the wording of that provision, should, in the opinion of the present writer, be extended to irrigation. The principle has been introduced into Bengal in the Road Cess Act, under which the roads of that province are maintained by a special tax on the lands of the province. It has in Act VIII of 1873 been adopted as regards the drainage of lands in Northern India. The only preliminary proceedings which that Act makes necessary are as follows (Section 57):—"Whenever it appears to the Local Government that any drainage works are necessary for the improvement of any lands, or for the proper cultivation or irrigation thereof, or that protection from floods or other accumulations of water, or from erosion by a river, is required for any lands, the Local Government may cause a scheme for such drainage works to be drawn up and published, together with an estimate of its cost and statement of the proportion of such cost which the Government proposes to defray, and a schedule of the lands which it is proposed to make chargeable in respect of the scheme."

The present writer's proposals differ from the procedure laid down in that Section in the following points:—

1. That the original estimate for the canal, including all works necessary for irrigation and drainage, should be sanctioned by the Government of India before the work is begun.

2. That the assessment of the compulsory rate should be made after the actual cost of the works has been ascertained.

3. That the rate should be assessed so as to yield 7 per cent. per annum on that cost, the lands paying in proportion to the benefit accruing to them. Provided that, if the canal is also a navigation canal, such a proportion of the original cost as can be fairly chargeable to navigation shall be deducted from the original cost of the works, and on the balance only shall the lands assessed be required to pay 7 per cent.

The Government would, by means of tolls levy the interest on the capital chargeable to navigation.



The illogi-  
cal nature of  
the provi-  
sions of Act  
VIII of  
1873.

The principles on which a canal revenue is to be obtained are as embodied in Act VIII of 1873, threefold. There is the perfectly voluntary occupier's irrigation rate, the half-compulsory owner's irrigation rate, and the altogether-compulsory drainage rate. It is not clear why these divergences of principle should be embodied in one and the same law. A compulsory rate, if just in the case of drainage, is also just in the case of irrigation. The emphatic expression of opinion by high officials in Bengal, peculiarly competent to speak on the subject, demonstrates that the imposition of such a rate would not be unjust. It is a principle already embodied in the Bengal Road Cess Act, which has worked successfully. In the north of India it is a principle already embodied in the drainage provisions of Act VIII of 1873. The extra yield of the crops irrigated early and regularly, and the absence of anything like entire loss of crops, would leave the irrigating cultivator in a condition better than at present; while the safety of the non-irrigator would be paid for by himself, and his delinquencies and want of intelligence would no longer render necessary the spoliation of a remote province.

Opinion  
on the prin-  
ciple of a  
compulsory  
rate express-  
ed by Sir  
Geo. Camp-  
bell when  
Lieutenant-  
Governor of  
Bengal.

While still dealing with the principle of a compulsory rate reference must, for a moment, again be made to the opinion held by no less an authority than Sir George Campbell. He (himself the author of the Road Cess Act) in 1872 when Lieutenant-Governor of Bengal wrote on the subject of a compulsory canal rate as follows: "I must guard myself against any supposition that I can for a moment concur in the doctrine that it is fair to charge the interest of capital expended on the locality for whose benefit it was intended, that people who have no voice in the matter should be made to pay for engineering and financial failures, not because they are benefited, but because the projectors intended to benefit them. The most that I can bring myself to consider is whether the principle that a compulsory charge may be made for actual benefits might be applied to Orissa.

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If we could be sure that a compulsory water assessment would never be raised above a very low rate, any higher rates at any time imposed being voluntary, I

am not sure that I should not be willing to accept it as a solution of many difficulties, but I very much dread a compulsory rate to be arbitrarily fixed from time to time."

Later, in 1873, the same authority wrote in a tone still more favourable to a compulsory rate:—"It is Sir George Campbell's belief that almost all other canals (than the Sone) which can be devised in these Provinces will practically be of the nature of an insurance against bad years rather than a profitable speculation. Can we impose an insurance rate on those who are benefited? or is Government justified in spending great sums from the General Revenues not for profit but to save life in years of failure? These are very perplexing questions."

These opinions resolve themselves into a verdict in favour of the compulsory rate, provided that it is low, not changeable, and is imposed on lands which receive some benefit, the rate not being greater than the benefit received. This conclusion, at first looked at askance, appears to have been gradually pressed on Sir George Campbell by an increased practical acquaintance with the subject.

If, as the present writer urges, a fair compulsory rate be at first imposed, and be not liable to change much of the danger apprehended by Sir George Campbell would be avoided. The lands on which it is imposed should undoubtedly be those—and those only—which either do or are able to receive some benefit from the works; but the extent of the benefit received by the whole area should not regulate the total amount of the rate raised from that area, though the amount of each contribution towards that total should be regulated, once for all, by the relative benefit each acre may receive. The total amount of the rate raised must be the total amount required for the interest on the capital expended and for the maintenance of the works.

His objections considered.

Although it may, at first sight, appear from the above quotation that Sir George Campbell was of opinion that the people of India should not pay taxes except when they had a voice in the matter of their



imposition, this conclusion is in evident opposition to the tenor of some of the most important measures passed during the period of Sir George Campbell's administration of Bengal.

Indeed, nothing more instantaneously dispels any doubts on this head than the provisions of his own Road Cess Act, passed in the teeth of severe opposition from the landed interest of Bengal; and nothing more than the same Act, which is now universally submitted to without objection and is conferring immense benefits on the whole of Bengal, and which would most certainly have remained absolutely inoperative had the payment of the cess been in any way optional, demonstrates how just and wise a policy it often is for Government to decide on what is required for the welfare of a district, and, having decided, to make that district, or such part as is benefited, pay for the benefit conferred. If the law embodying this policy has been found to be practically as great a success as any measure ever passed by the Bengal Council, remaining sufficient of itself to illumine the reign of the administrator who produced it, it would assuredly be wise to extend the principle from the comparative luxury of roads to the imperative necessity of canals. The benefits conferred by a canal are even more local than those conferred by a road.

The compulsory principle, which has not been excluded by the Government of India from Act VIII of 1873, to which reference has already been made, is adopted openly and fearlessly in the following clauses of the Bengal Council Act X of 1871, commonly known as "the District Road Cess Act":—

(1).—All lands in any district to which the Act is extended shall be liable to pay a rate not exceeding 3 per cent. on their annual value, and the amount so realized shall be expended on roads and communications within that district.

(2).—The cultivating ryot shall pay to the holder of an estate, or rent receiver intermediate between himself and the holder, half of the cess. The holder shall then pay to Government the full amount of the cess less a certain amount (about 20 per cent.) for collection

expenses. If there is an intermediate rent receiver, he shall pay to the holder the whole amount of the cess (who shall then pay it into Government) less a certain amount for collection expenses.

(3.)—The Government may within three years recover any arrears from the holder of an estate by attaching rents, &c., and the holder may recover the amount due to him from others by the same process as he would recover an arrear of rent.

Such provisions are apparently irreconcilable with any idea of consulting the popular wish as to the payment of a tax and with any doubt as to the position which Government should in such a matter assume.

All persons who have written on the subject may be said to have admitted the immense difficulties, administrative as well as financial, with which the voluntary system has to contend. The nature of these difficulties and the ruinous results of the voluntary system are forcibly sketched by Sir George Campbell in the Bengal Administration Report for 1872-73 :—

The consensus of opinion as to the practical difficulty attending the voluntary system.

“In all our rainy season irrigation the great difficulty is the indisposition of the people to take water except in case of failure of the rains. They like to have the canal as an assurance in case of necessity, but most of them will not pay for water, or engage to take it till the necessity actually arises. We have tried to check this tendency by demanding penalty rates and cash payments from, besides strictly enforcing the rules against, people who only come for water at the last moment. But the fear is that in practice this cannot be carried out when a crisis comes. Already this year, in October, there has been a great alarm of failure of the rains and a rush for water. With an imminent risk of famine staring us in the face, we have felt that we could not insist on cash from those who have no cash, or enforce strict rules regarding measurement, &c., when the delay would be ruinous, and a crowd of applicants all coming together at the same moment once in several years cannot be so served. We have felt that under such circumstances we must



relax the rules. The people are ready enough to profit by such experience; they may well believe that when the worst comes to the worst, we cannot and will not let them perish, while we have the water; they know they will get it in extremity, and they wait. The subject is no doubt one of extreme difficulty."

All admit that these difficulties would be in a great measure dissipated by the compulsory system. But while some then at once reason the matter out and come to a conclusion that not only has the compulsory rate these advantages, but also those of fairness and justice, others find in its unfairness and injustice the only argument, but an insuperable one, against such a rate.

These latter opinions are recorded somewhat thus:—Government might impose now a light rate to which no violent outcry would be raised, but it assumes the responsibility of raising this rate from time to time in a compulsory way, till it reaches a standard which is thought sufficient. This is no light responsibility. Instead of letting water, like anything else, find its own value, Government would commit itself now to decide the question ever afterwards.

*The ground-  
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the prejudice  
against a  
compulsory  
rate.*

But surely this responsibility is one ever present to a Government in its every action, and if not equal to undertaking like responsibilities, it loses the reason for its existence. A constant change in the rate is no part of the scheme of compulsory assessment. Such an argument as the above cannot survive investigation. Take, for instance, the proposal of the present writer as regards a fair rate. It has the merits of being simple, fixed and certain; it asks the people benefited to pay the interest of a sum invested for their benefit,—a sum borrowed for them at a rate of interest at which no company or agency other than the Governments of Great Britain and India could obtain money; it refuses to take more, and will not take less; it is calculated to insure the food supply of the country, to inflict hardship on few or none, and to remove hardship from many. If such a tax is not a fair tax, the entire schedule of the taxes which fill the coffers of any Government in the world may be in vain searched for one deserving of that designation.

The real gravity of the responsibility which Government would undertake would lie in the decision as to where canals were wanted. Are canals, let it be asked, required in India or not? If so, who but Government should be responsible for a selection of the localities in which they should be constructed? May it not be supposed that Government, deriving no gain, but much toil and worry from such works, would not undertake their construction without being convinced of their necessity? Certainly at no time has the Government of India shown itself incompetent to undertake a responsibility which so unavoidably accrues to it. The decision in such a matter is as much an unavoidable attribute of Government as is a decision whether a garrison shall be retained at Peshawar, a resident at Indore, or a university at Calcutta.

The nature of the responsibility which Government would assume under a compulsory system.

The present footing of the irrigation policy of the Indian Government may be stated as follows:—

A resumé of the nature of the present irrigation policy. Its financial, economic, and sentimental failure.

Canals are constructed by the Government, after a careful consideration of their utility in the proposed locality, with funds borrowed for the purpose. The original outlay in purchase of land, salaries of officers, purchase of material and construction of works is all charged to Capital Account. The canal once ready for use, the revenues derivable therefrom should be able to return 5 per cent. on the capital expended after paying all charges for maintenance, repairs, and collection. These revenues are at present attempted to be raised by what is called the "voluntary system"; that is to say, when a canal is completed no revenue is derivable from it until the cultivator offers to take water and to pay for it, and then only to the extent that he does so offer. If the revenues so collected suffice to pay the above charges and interest, the Government, though not a gainer, is not a loser by the undertaking. If they yield a higher percentage Government is probably a gainer.

It has been shown that of the canals existing in India the only ones that may be expected with any degree of certainty to yield this necessary amount of revenue are the Eastern and Western Jumna Canals; and it has been shown that, owing to the British Gov-



ernment having received these canals ready made, it is impossible to base any argument on them. In making this statement certain of the Madras works are not taken into consideration, for there irrigation receipts and land revenue have become so intermixed as to render it impossible to separate them; this is no doubt the shape that irrigation revenue may assume with much immediate advantage to the finances of the State, but the existence of zemindaries and the system of land revenue do not allow of it in most of the rest of India.\*

The result of this voluntary system has been shown to be a large and constantly swelling annual deficit which must shortly reach and exceed half a million a year. This is a most tangible evil. There are other evils of a more sentimental nature in origin, but with a no less lamentable result. The cultivator at present feels towards the Government, as regards irrigation, as a customer feels towards a tradesman. He feels that what he pays is a loss to himself and a gain to others. He will try to beat down the figure asked, to haggle for the commodity, and to postpone the evil day when he must conclude the bargain. He has also a strong position in his dealings with Government. There are great facilities at his command for a dishonest taking of the water; he knows that if the water is not taken and paid for Government will suffer a severe loss; and he looks for a propitious rainfall. The position of Government is thus alike devoid of power and dignity, while the cess, which it seeks to levy, has from its very nature all the worst evils of directness and avoidability.

The voluntary system does not even guarantee to Government, beyond risk of loss, the land revenue of the area covered by the canal; for the cultivator will often see his crop daily drying up, and will allow his hopes of an ample out-turn to fade, and not till then will he begin to *think* of taking water, while by the time he has applied for and obtained water probably, but a wretched remnant of his crop remains to be saved. Government

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\* Under such an arrangement there is, however, a constant danger that the mingling of land revenue with a canal cess may, in course of time, lead Government to forget the responsibility it has undertaken, and that those who in this manner pay for certain advantages may not always receive them with regularity.

will often find itself unable to extract its revenue from such a crop. As to the cultivator, his feelings are then of anything but gratitude. He feels that he would have been in no worse plight if the canal had not been there. If the long-looked-for rain does fall just after he receives canal water, how doubly afflicted does he consider himself; his knowing neighbours who still waited for the rain save just as much as of their crops as he, and point at him the finger of derision for his folly in having voluntarily added to his burdens the burden of a water rate. A cordial hate of the canal ensues.

If the rain does not come, every one will have waited; every one will be similarly circumstanced; and at the last moment every one will rush for water to save their half-ruined crops and will expect that a week's irrigation should be accomplished in a day. No canals ever constructed are capable of flooding the whole area commanded in two or three days, especially when the soil is dry and cracking, and when no man will be content until he has half a foot's depth of water on his land. Much confusion ensues; and, when the time for payment arrives, endless will be the representations that, when every hour was of consequence to the crop, days elapsed after the application for water was made before water was supplied. Much dissatisfaction and much unwillingness to pay will be the result, whereas if the water had been taken in time, every one would have been provided with an ample supply and the entire crops saved. All this happens far too frequently for it to be classed in the category of exceptional occurrences. It is described as follows in the Bengal Administration Report for 1872-73:—"In Orissa there seemed to be a serious failure of the rains in September, and many cultivators rushed to the canals for water. A few of them did, in fact, pay for water (about 1,500 acres) at rates higher than those of the early season, but just then rain fell and all the applicants who had not completed their bargain disappeared. There has since been abundant rain and no need for canal water; the unfortunates, who paid for 1,500 acres, are laughed at by their fellows, and irrigation prospects are again discouraged."



Government has spent large sums on irrigation canals, and it is of course very lamentable that, while in a year of good rainfall it is rare, even under favourable circumstances, to have the canal water taken and utilized with zeal, in a year of short or inopportune rainfall the crops are not preserved to anything like the extent which the canals are capable of effecting. The result is that the Government land revenue is not altogether removed from peril; payment of the water rate is endeavoured to be avoided by every possible means; and Government appears in the light of an oppressor and tax gatherer instead of as a benefactor. The results are equally unsatisfactory to Government and to the cultivator. This voluntary system moreover checks by higher taxation any attempt on the part of the cultivator by industry and enterprise to raise more valuable crops. The cultivator has also to undergo many petty annoyances which are inseparable from the voluntary system. The officers employed in patrolling the canal banks, watching the irrigation, and marking out the area which has received water are necessarily, owing to the wages paid and the nature of the work to be done, drawn from the lower classes. They not unfrequently make themselves very offensive both to the irrigating and non-irrigating cultivator unless they receive a fitting douceur.

It thus appears to the present writer that no portion of the community receives any commensurate satisfaction from all the vast expenditure of money, skill and labour demanded in the construction of large irrigation works. Yet all the factors necessary for producing a large amount of good and satisfaction to all exist. It is probably only from the manner of putting those factors together that confusion and failure have hitherto resulted. The only recompense obtained by the supporters of the voluntary system is some visionary idea of justice done. As often as an effort is made to scrutinize the causes of the disastrous results, it is the *ogis* of justice which is invoked to cover the multitude of misfortunes, the serious dangers and the intensifying difficulties begotten of that system. Even if the delusion is as strong as it is hollow, it must speedily yield to the force of such commentaries as its consequences, and to the careful moderation of the prudent, but

vigorous, policy which should now be substituted for the tottering system which it has so long supported.

Irrigation canals are *capable* of being of the greatest benefit to all by increasing the yield of the land in ordinary years and by the prevention of famine in years of drought. This no one will deny. Evidently then in the abstract it would be very desirable to have these works constructed as universally as possible. Therefore, if only funds can be obtained for the purpose, canals must be constructed. The works would be of an imperial nature in magnitude, in costliness, in the interests which they would affect and in the results which they would produce; it would therefore appear impolitic for the Government to make over to any independent agency the construction of these works, except on agreements clearly defining and limiting the rights and obligations of such an agency and reserving to the Government the power to intervene whenever it may desire.

The course  
that should  
be adopted.

Still more improper would it be for the Government to make over to an independent agency the right to the revenue derivable from such works. For such an agency would then, to the cultivator, assume the power and authority of the Government, and yet would at the same time be devoid of responsibility for acts whereby the Government may become gravely compromised.

The conclusion arrived at is that the Government should (as now) be the constructing and maintaining agency for irrigation works, and that the funds necessary for the original outlay on such works should (as now) be raised on loan by it.

The Government having then after due deliberation decided that in a certain locality irrigation works are necessary for the welfare of that locality and its preservation from famine enters on their construction.

When they are completed, to whom is the Government to look for the annual and regular payment of a sum which shall cover the annual interest on the original outlay incurred (say 5 per cent.) and all annual charges for maintenance, repairs and collections (say, under the compulsory system, 2 per cent.)? Should it, as now, lump together the results of all its irrigation

works, take the net profit, if profit is within the range of the possibilities of the most distant future, and by extra taxes make the general public, as now, responsible for the payment of a deficit which is an annual certainty? This is the present "voluntary system," and to it the present writer is uncompromisingly opposed. The general public are thus taxed for a benefit in which they participate only exceptionally and remotely in years of a severe and general drought, and in no other manner. It would seem the height of injustice to require that public by a Salt tax, Income tax, Customs duties, or other expedients to provide for any deficit in the Imperial budget which may be caused by these canals. The same course of reasoning continued downwards naturally resolves itself into this, namely:—Every canal must stand or fall by itself; its immediate benefits as a means of irrigation or protection (not of navigation) are confined to a certain well-defined area, and that area must alone be responsible that the State does not suffer loss by the undertaking.

All loss to be avoided

All idea of gain to be abandoned. But, on the other hand, there must be a total absence of any idea of gain to the State. This idea of gain and loss is unfortunately inseparable from the present policy, which invariably estimates that such and such an undertaking will pay so much per cent. and is therefore calculated to leave so much clear profit in the hands of the State, which it can apply to meet demands utterly foreign to the locality whence the surplus is raised. The present writer is not aware that the Government has ever yet had to congratulate itself on being the recipient of such a surplus on any but the most insignificant scale, but nevertheless it publicly and professedly works to that end. Were any such surplus profit to exist on any irrigation canal, it must be the result either of the intelligent use of the water by appreciative cultivators and so be a tax on intelligence, industry and enterprise; or it must be derived from the misfortune of a deficient or untimely rainfall and so be a tax exacted when it can least well be met. By the "surplus profit" is meant the net profit after all charges for maintenance and interest have been met, such as the Government has on rare occasions been able to grasp, and, despite its insignificant proportions, has, eagerly and almost triumphantly, embraced, as a set-off against



the huge deficits elsewhere occasioned by sullen apathy or propitious seasons.

Again, as long as Government enters the arena as a seller of wares of which it justly has a high appreciation, but of which the disposal rests with its customers and subjects,—though in this case they more resemble masters,—so long will there be a haggling as to price, a dissatisfaction on the part of the seller, if owing to circumstances he cannot sell, and on the part of the buyer, if circumstances compel him after much wavering and much haggling to yield to the terms offered.

This bartering and bargaining is moreover calculated to disturb the relations of the ruled and the ruler, at all times a dangerous affair to tamper with.

It is the first imperative condition of a sound irrigation and famine policy that the Government should for ever discard the idea of looking upon one canal as a paying speculation, and upon another as a losing one. So long as it assumes this mercantile language its policy deserves only that fate which would inevitably attend the undertakings were they mere mercantile speculations. But let the Government, as concerns the construction of these works, once for all, declare that it takes its stand on the position it holds as the ruler whose first duty it is to provide for the safety of the lives of its subjects and the maintenance of internal prosperity. Let it not descend from that position to barter and elbow in the crowded market-place. Let it kick aside a policy so feeble and incomprehensible, so certain to end in humiliation and disastrous defeat, while giving birth to no feelings of gratitude amongst those for ~~whose~~ benefit this policy is intended, but rather to discontent, resentment, and contempt.

The position which Government should assume

Power and pre-eminence, such as the Indian Government possesses, are the sole reasons for its existence. When, dropping the imperial robe, it yields to some vague prejudice and seeks to deal in bargains as the only measure of its righteous dues, it assumes an anomalous position which pleases no one; while, for the recovery of its revenue, it embroils itself in mean squabbles with petty cultivators throughout the length and



breadth of the land. The actual results of this policy, —discontent and deficit,—form the best commentary that can be offered on it.

Let the Government plainly declare that it alone can decide where canals are required; that where they are required it will have them constructed; that its object in having them constructed will be the fulfilment of the weighty responsibilities attaching to its position by preserving the lives and property of its subjects from flood and famine, by stimulating superior cultivation, and by rendering secure its own annual claim for land revenue. Let it then go on to declare that those for whom the canal is constructed shall alone pay for it; that not one penny less or one penny more shall be taken from them; that it will no longer recognize any justice in one canal paying the State 10 per cent. on the original outlay, while another does not pay 2 per cent.; that it will not leave this important branch of revenue to the chance disturbances of season or of temperament.

Any prolongation of the period of the voluntary system disastrous.

Any prolongation of the voluntary system period appears an evil devoid of a single substantial advantage; it would merely tend to nourish discontent, to encourage hopes doomed to disappointment, to postpone the date of a resolute resistance to the fears and reasonless murmurings of people who would wish to shirk their necessary share of the burden of taxation, and to defer indefinitely a considerable increment to the prosperity of India. The distressing predicament of the present position, with an annual deficit approaching and likely shortly to exceed half a million sterling, cannot but induce the Governments both at home and in India to discard theories intrinsically feeble, to assume higher and clearer ground, and there to adopt the course which, while avoiding sentimentalism and deficit, will enable it to furnish India with such a net work of canals as shall keep its population and its rulers free from ever-recurrent fears of famine.

Manner in which the compulsory system should be worked.

Having thus brought down the discussion to the conclusion that, while the system of a voluntary canal rate is unjust, impolitic and impoverishing both to the people and the exchequer,—unsound in principle and unsatisfactory in practice,—the compulsory rate, dis-

sipating plausible sophistries and bewildering contradictions, founded on a wise and intelligible policy, would be the reverse of all this, it remains to consider the manner in which the compulsory rate, in the aggregate not exceeding 7 per cent. on the capital outlay, should be assessed.

Most canals are now constructed for the double purpose of irrigation and navigation. The additional original cost in providing for the latter is not large. It would be advisable that whatever the amount may be it should be kept entirely distinct in the accounts; the capital accounts and revenue results of navigation should be shown separately from those of irrigation, drainage, and protection.

Navigation expenditure, and receipts excluded from consideration.

The public, who are the persons benefited by the navigation, should be left to pay for that benefit by means of tolls. The consideration of the navigation revenue will therefore not fall within the scope of the present argument. When the capital outlay on a canal is referred to, it must be understood to mean that portion of the capital which has been expended for irrigation, drainage and protective purposes,—in other words, for all purposes except navigation.

The portion of the capital which would be debited to navigation would be comparatively small; but, whatever its amount, it is not included in this discussion. The 7 per cent. spoken of is a percentage on the remaining portion of the capital expenditure.

The people who are in a position to be benefited by an irrigation canal and its companion drainage works are the landlords and cultivators of the area irrigable from the canal and its distributary channels, and those whose lands are not irrigable but are protected by the works from inundation, or improved by drainage.

The landlords and occupiers of the area irrigable from a canal or protected by its works from inundation, or improved by the drainage facilities afforded should be assessed.

These then are the people who should pay the 7 per cent. on the capital outlay, which may be said to be generally sufficient to enable the canal to pay its way. By the word "landlord" it is here meant to denote the first rent receiver,—the person who collects rent from the actual cultivator and who pays either to the Government direct or to some person intermediate between himself and the Government, a sum fixed either for ever or during the term of a settlement.

average rate paid by him would be very much less. If the landlord has to contribute one-fourth, the burden would, *pro tanto*, be still lighter for the cultivator.

On the  
Orissa Can-  
nals the  
average rate  
on cultur-  
able lands  
which may  
be irrigable  
would be  
about 6  
shillings per  
acre per  
annum.

The Orissa Canals are probably as expensive works as have been constructed. At 7 per cent. on a capital of £1,912,000 they at present annually require a revenue of £133,840; of this total, probably £5,840 may be set aside as the charges which should be met from navigation and miscellaneous revenue, leaving £128,000 as the charge to be met annually by the proposed compulsory cesses. It is estimated that the irrigable area of culturable land is, or very shortly will be, 300,000 acres, while a further 200,000 acres have been protected from inundation. The capital expended in affording this protection amounts, it is officially estimated, to about one-sixth of the total capital, and should therefore bear one-sixth of the charges, or (say) £21,000. On this point I find Sir George Campbell in the Bengal Administration Report for the year 1872-73 writing:—"There can be no doubt that even if the canals had not been made, a large expenditure must have been incurred by Government for protective works, as before the works were commenced the main stream of the Mahanuddy was rapidly making its way into the Katjoree which passes into the Pooree District, where the channels are insufficient to carry even the ordinary supply." At a little over two shillings per acre of the 200,000 acres thus protected we have £21,000, leaving £107,000 to be met from irrigation revenue. This would give an average of 7 shillings per acre per annum. But the whole capital expended on headworks and workshops cannot be charged to the existing irrigable area, for they are calculated for the wants of distributary channels commanding a much larger area, and therefore, probably, an average of 6 shillings per annum per acre would be a just and proper rate. The area irrigated in 1873-74 was 12,600 acres; and in 1874-75 22,800 acres. The charge was mostly 2 shillings per acre.

If we exclude from capital the £360,000 accumulated unpaid interest, the balance of capital will be £1,552,000; 7 per cent. on this would be £108,640. Deducting £4,640 as charges to be met by navigation and miscellaneous revenue, and £17,000 for protected lands, we



have a balance of £87,000 to be met by irrigation revenue. This on 300,000 acres of irrigable land would be about  $5\frac{1}{4}$  shillings per acre, or deducting the fair proportion of this charge due to head works not yet fully utilized, the average acreage charge would be 5 shillings. Neither in the case of these canals nor in that of any others are the non-irrigable areas which are improved by the canal drainage works taken into consideration, because there is no data on this subject; but it is quite possible that the tax which it is proposed to levy on such areas may reduce the rate payable by the irrigable areas by one-eighth.

The Midnapore Canal at 7 per cent. on a capital of £750,000 has an annual charge amounting to £52,500. These works are not far from completion, and therefore almost the whole annual charge should be met from the works as they stand at present.

On the Midnapore Canal the average rate on culturable lands which may be irrigable would be about 6 shillings per acre per annum.

Setting aside £7,500 as the charges which should be met by navigation (for which this canal is largely intended), and miscellaneous revenue, together with a further sum of £8,000, which should be contributed by lands protected from inundation, but not irrigable, there is a balance of £37,000, which should be met from irrigation revenue. The irrigable area being estimated at 120,000 acres, the average acreage rate would therefore have to be about 6 shillings.

But if the accumulated unpaid interest amounting to £137,000 is deducted from the capital, the total annual revenue would have to be £9,600 less, or £42,900. Setting aside for navigation and miscellaneous revenue £6,805, and for protection £6,600, we have a balance of £30,000 to be met from irrigation revenue. This on 120,000 acres would be an average of 5 shillings per acre.

The Ganges Canal, with an estimated irrigable area of 800,000 acres (where a greater area has been shown as irrigated from this canal in any year, the figures are arrived at by adding together the areas for each six months of the year, thus in many cases shewing the same acre twice) has a capital of  $2\frac{3}{4}$  millions to which should be added  $1\frac{1}{4}$  million accumulated unpaid interest. This at 7 per cent. requires an annual revenue of £280,000. Setting aside £45,000 as the charges

On the Ganges Canal the average rate on culturable lands which may be irrigable would be about 6 shillings per acre per annum.



to be probably met from other sources, there is a balance of £240,000, or, if the arrears of interest are omitted from the capital, of £170,000, to be met from irrigation revenue. This would require an annual average acreage rate of 6 shillings, or of 4½ shillings respectively. The present gross revenue is £208,000; the voluntary irrigation rate averages 5 shillings per acre for six months.

On the Bari Doab Canal the average rate on culturable lands which may be irrigable would be about 6½ shillings per acre per annum.

The Bari Doab Canal has an irrigable area of about 400,000 acres, and a capital of £1,400,000, but it has also £750,000 accumulated unpaid interest. This capital at 7 per cent. gives £150,500 or £98,000, according as that arrear interest is included in or omitted from the capital. Excluding charges to be met from other sources, this would probably be diminished to £125,000 or £80,000 as due from irrigation, which is an annual charge of 6½ or 4 shillings per acre respectively.\* The present gross revenue is £90,700; the voluntary irrigation rate averages about 7 shillings per acre for six months; of which 2 shillings are payable by the owner.

The foregoing results may be summarized in the following table:—

| Names of Canals. | REQUISITE ANNUAL IRRIGATION RATE PER ACRE OF IRRIGABLE LAND       |                                                                    | Deduct, as tax leviable on unirrigable lands benefited by the drainage works of the canal, one-eighth of the foregoing. The balance then is— |               |
|------------------|-------------------------------------------------------------------|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|---------------|
|                  | (A)<br>If accumulated unpaid interest is included in the capital. | (B)<br>If accumulated unpaid interest is omitted from the capital. |                                                                                                                                              |               |
| Orissa ...       | 6 shillings                                                       | 5 shillings.                                                       | 5½ shillings.                                                                                                                                | 4½ shillings. |
| Midnapore ...    | 6 "                                                               | 5 "                                                                | 5½ "                                                                                                                                         | 4½ "          |
| Ganges ..        | 6 "                                                               | 4½ "                                                               | 5½ "                                                                                                                                         | 3½ "          |
| Bari Doab ...    | 6½ "                                                              | 4 "                                                                | 5½ "                                                                                                                                         | 3½ "          |

N.B.—Throughout this pamphlet a rupee has been taken as representing two shillings

It would appear to the present writer necessary that, in introducing a compulsory rate, the Government should capitalize all arrears of interest which have accrued on

\* The areas shown as irrigable from the Ganges and Bari Doab Canals are believed to be approximate.

these works, adding the amount to their respective capital accounts. On new works, it is believed that not more than 15 per cent. on the capital invested need, under the compulsory system, ever accrue while the works are under construction; that amount may be unavoidable.

Looking to the figures shown in the last column of the table just given and adding 15 per cent. thereto, it may be concluded that, on new works where large arrears of interest have not been allowed to accumulate, the average irrigation annual charge would be from 4 to 5 shillings per acre for culturable and irrigable land. One-fourth of this has been suggested as the share justly payable by the landlord, while the cultivator would have to pay the remaining three-fourths, or from 3 to 3½ shillings per acre per annum.

Thus under the compulsory system the average annual rate per acre of culturable land which may be irrigable would run from 4 shillings to 5 shillings.

It should be remembered that, at present in Upper India on the Ganges and Bari Doab Canals, the voluntary rate payable by cultivators varies from 5 to 6 shillings per acre for six months' irrigation. The conclusion is that all those who are habitual irrigators will be benefited, and that under this compulsory system they would have every inducement to improve cultivation, as they would find their intelligence and industry no longer made the subject of heavy taxation; while the "owner," who now on the Bari Doab Canal pays 2 shillings per acre for six months, would likewise be largely benefited, having only to pay about half that rate for an entire year.

The present average rate to irrigators on the Ganges and Bari Doab Canals under the voluntary system is 5 to 6 shillings per acre per half year.

It is necessary to allude to the manner in which the Eastern and Western Jumna Canals and other Canals which have come ready-made into the hands of Government should be treated. There is no reason why those who are benefited by them should be required to pay only 7 per cent. on a capital which represents but the cost of extraordinary improvements and realignments. Those persons who may be benefited should be required to pay the 7 per cent. on such a sum as may be fairly estimated as the cost of the works, as they now stand, if they had been constructed by Government instead of having been acquired by it through conquest. The surplus interest thus falling into the hands of

How, for the Canal Cess, the capital of the Eastern and Western Jumna Canals should be estimated.

Government is a legitimate due of the State. The amount would probably be about £60,000 per annum from the Eastern and Western Jumna Canals, each of them contributing a moiety.

Lands to be divided into 3 classes according to the benefit received and to be assessed accordingly.

It would appear that in making the assessment at first on each field, the land should be divided into three classes according to the benefit that irrigation is likely to confer on them; the first class probably paying 30 per cent. per acre more than the average rate, the second class the average rate, and the third class 30 per cent. less than the average rate.

Canals should be subdivided into sections and each section should have a separate capital account.

For the purpose of the canal cess it would be more equitable to split up a large work, where the main canal is (say) over 50 miles in length, into sections of somewhere about 30 miles each. Each section would bear its own expenses and a proportionate share of the deadweight that every canal must carry in the shape of interest and maintenance charges for the costly but of themselves, unremunerative headworks. Such a section of a canal having been completed, all the distributary channels leading from it should be put in complete readiness and furnished with all the apparatus necessary for regulating the supply of water to the fields; minor field channels leading on to the separate fields situated on the slope which falls from the distributary channel should also be constructed. These latter diminutive channels hold a very important position in the machinery for irrigation, as they aid greatly the regularity and rapidity of the distribution of the water, while checking what must otherwise be a wasteful consumption; their construction is not costly, but they require in the first place to be laid out on scientific principles, and cannot well be left to the cultivators, who should, however, each man in his own field, be required to keep them in thorough repair when they have been once constructed at the cost of Government.

On completion of a section of a canal, the course to be taken in order to assess the cess.

When all this has been done, the Local Government should cause its Engineer Officers to draw up charts of the land which they may deem irrigable from the canal and its channels, distinguishing between the area which is culturable and that which is unculturable. They should thus map out the tracts commanded by



the canal, showing each field and its area in detail. Similar charts should be made by them of lands not irrigable which they may deem chargeable with some contribution either as being protected from inundation, or as being benefited by the drainage works which have accompanied the canal.

These charts should be sent to the District Revenue Authorities for most careful study and revision. The charts should also show the acreage rate which should be imposed on each portion of the area concerned.

The charts, when revised and corrected, should, together with a report from the Revenue Authorities, be forwarded to the Local Government for approval. That approval having been obtained, a notification should appear in the *Gazette*, that, such a section of a canal being with all its distributaries and drainage works complete, the lands benefited thereby would be forthwith assessed with a canal rate, such as to yield 7 per cent. per annum on the total capital chargeable to that section. It should add the precise amount of that capital.

The Act authorising the imposition of a compulsory canal rate should contain clauses laying down the following necessary provisions, as also those which have just above been set forth.

It should state distinctly the share of the assessment to be borne by the cultivator and the rent receiver respectively, and should declare that where the cultivator himself has a permanent right to hold his land at a permanently fixed rental he shall be deemed both rent receiver and cultivator. It should also declare that the zemindars, as shown in the Collectorate Revenue-roll, will be held responsible for the punctual payment and collection of this cess from the parties by whom it is payable, they receiving a commission of 5 per cent. on the amount, and having power, in the case of arrears, to sue as for rent due; while the Government will have power to recover arrears from the zemindars themselves precisely as in the case of arrears of land revenue.

Provisions which should be contained in the Act authorizing the imposition of a compulsory canal rate.

It should declare that on the publication of the notification in the *Gazette* the Local Authorities should



issue notices of demand on each person chargeable with any acreage rate, showing the amount assessed together with the area for which and the rate at which the assessment is made. Any objections should be filed within one month from the service of this notice, and these should be decided with much care. In this way the slight alterations desirable may be gradually effected and injustices remedied within the first two years of the imposition of the cess, after which time the claim against each acre should remain fixed and determinate.

The Act should provide that in one or two contingencies Government should grant an entire or partial remission of this canal rate; namely, when, owing to the breaching of the embankments, damage through inundation may accrue to the crops, or when, through any cause the prevention of which is in its power,—as through a defective condition of the works,—an insufficient supply of water may enter the canal. A right should be reserved to the Government of closing any canal or section of a canal for repairs during one period in any year not exceeding a month in duration, and for any short periods not exceeding three days at a time and one month in the year in the aggregate. Such closures may be necessary for improvements or repairs, and for such there should be no claim for remission of water-rate; provided that the long closure of a month is preceded by a notice issued fully three months prior to the commencement of the closure.

As regards the collection of this canal rate, it must be borne in mind that the zemindars have already rent-collecting establishments, with much spare time on their hands who might well be utilized for this work and would indeed form the fittest agency. The commission which it has been proposed to give the zemindars should be shown as a charge against the revenue and would fall under the 2 per cent. allowed for maintenance and collections.

Reduction of establishment charges possible under the compulsory system

One great advantage which the system of a compulsory canal rate can boast is that it would enormously reduce the charges under the head of both collecting and patrolling establishments. It may be remembered that 2 per cent. on the capital outlay has

been taken as representing the probable charge for maintenance, collections, &c. under the compulsory system. Under the voluntary system these charges are very much higher, being from  $2\frac{1}{2}$  to  $3\frac{1}{2}$  per cent. on the Ganges and Bari Doab Canals. The Orissa and Midnapore Canals show a charge of from 1 to 2 per cent. on this account; but these cases can form no guide, inasmuch as, the works being incomplete, a large portion of the establishment charges are debited to capital. With the great economy effected in establishments by the compulsory system, it is believed that the charges for maintenance, &c., may, on the Ganges and Bari Doab Canals and on all other canals, be reduced to 2 per cent. on the capital outlay.

Instead of the present hordes of collectors and peons who roam through the irrigating tracts searching for new irrigation and recording the extent of area irrigated, invading lands and annoying the people, often idle for months together, and then, on a sudden rush for water being made, unable to answer the call with sufficient promptitude, the compulsory rate, introducing regular and systematic irrigation and a fixed liability for payment, would enable the local revenue officials with the assistance of a small staff of cheaply paid subordinates, employed for the purpose of regulating the flow of water on the different days to the different lands, to manage the whole business of distribution of water and collection of revenue. In addition to this it may be well if, to every two or three districts where canals may be in existence, a young Civil Servant were appointed to be constantly on the canals, watching in the interests of the people, the condition of the canals and the proper and efficient distribution of the water. The staff of Engineer Officers required for the maintenance of the works would not be altered by the cess being voluntary or compulsory.

In introducing the compulsory canal rate there would at first doubtless be opposition to be overcome; but, after its introduction, the justice of the policy and the equity of the cess would be apparent to all, and the present writer doubts not but that it would give rise to contentment and obliterate many heart-burnings. In almost all legislation it is necessary to offend some one;

Such opposition as you at first meet the compulsory rate would soon die out,

the tax-payer of course at first thinks only of the burden of the tax and not of its necessity and propriety, which should with Government form the first considerations.

The relation of the compulsory canal rate to the land revenue.

Before concluding, a short reference must be made to the position this compulsory rate would occupy in relation to the land revenue. In India, the land revenue annually payable by the landlords to Government is fixed for various periods,—in some cases in perpetuity, in others for 30, 20, or 10 years. During the currency of the period of settlement Government cannot increase the assessment of the land revenue. At the end of the term of settlement Government can alter its assessment in any way it may choose, its demand being limited only by justice and the amount that people are willing to pay. Probably in many cases, where during the currency of a settlement a new canal has been opened, the land irrigable therefrom or protected from inundation by its works would, on account of the benefits, supposed to accrue to such land being on detailed enquiry found to be considerably in excess of the compulsory cess levied, be thought able at the time of re-settlement, to bear a higher land revenue assessment. This would be owing to the *existence* of the canal and apart from all other causes which may justify and increase in the land revenue assessment; such, for instance, as the falling purchasing power of money. Were the system of a compulsory rate introduced it would appear to the present writer that the revenue raised by means of it should, during the period of the settlement then current, be shown in the accounts distinct from the land revenue. It would further appear that on the termination of the settlement, the re-assessment of land revenue should be made entirely independently of this compulsory cess, and that not even the portion of the canal charges contributed by lands for protection and drainage should be merged into the land revenue. It is in the interest of the people most necessary that they should not in any such way part with the strongest safeguards they can have that, if they have to pay for the canals, Government must maintain them and the works connected with them in thorough repair, and that only so long as the



works are thus maintained in full efficiency shall they be made to pay. Were the cess or any portion of it merged into the land revenue, this most necessary condition would in the course of time be gradually lost sight of; the works would fall into dis-repair and inefficiency, but the people would have to pay all the same.

This discussion of the manner in which Irrigation Works must be made to pay their own way, and of the comparative capacity of the voluntary and compulsory systems of taxation for securing that end together with the thorough maintenance of the works, the contentment of the people taxed and an increase in the general prosperity of the Indian Empire, is now finished. The writer, without further apology, submits his ideas as to the policy which it is necessary to pursue in order to relieve the Government of India from the very heavy and permanent annual charge of at least half a million sterling which represents the annual deficit in the immediate future arising from its canals, as well as to enable that Government to multiply its canals, and to extract from them the greatest possible amount of good. Several opinions embracing a large variety of proposals have been reviewed, and amongst other conclusions therefrom, are the unavoidable ones that no person is satisfied with the present irrigation policy, and that "one of a more reliable nature must be substituted. The demoralizing tendency and economic fallacy of the policy, as also the inevitable injustice of the application of taxes levied from the general community to the purpose of meeting the heavy annual charge which it entails on the Indian revenues, have been discussed and deprecated. A theory has been set forth, and a practical method of giving effect to that theory has been pointed out. The adoption of the course advocated would, it is believed, convert discontent and deficit into content and financial equilibrium. The irrigation and famine policy of our Indian Government would be placed on a satisfactory footing as regards its sympathetic, its economic, and its financial aspects; a position never yet attained, but which, once attained, would go far towards rendering famine unknown in the land.

Conclud-  
ing remarks.



In the whole range of Indian questions this is a subject which in importance and pressing urgency can yield to none. The financial problems involved in speeding the day when irrigation canals shall cover the plains of India are, in the face of the enormous demands made on the exchequer by frequent droughts, of a nature which renders their early solution an imperative necessity, if British rule in India is to be maintained.

# ECONOMICAL RIVER TRAINING IN INDIA.

BY

CARLETON FOWELL TUFNELL, Assoc. M. Inst. C.E.

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## ADVERTISEMENT.

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# THE INSTITUTION OF CIVIL ENGINEERS.

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## SECT. II.—OTHER SELECTED PAPERS.

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(*Paper No. 1852.*)

### “Economical River Training in India.”

By CARLETON FOWELL TURNELL, Assoc. M. Inst. C.E.

ONE of the most striking natural features of Northern India is the condition of its rivers, or what during nine months of the year can only by courtesy be termed rivers. The traveller who suddenly finds himself face to face with a bridge  $\frac{1}{4}$  mile in length, carrying a road over an arid waste, studded here and there with small ponds and patches of rich vegetation, cannot but wonder at the unnecessarily lavish expenditure, as he would term it, of the Indian Public Works Department. Let the traveller, however, find himself at the same spot during the monsoon, when through every span a foaming torrent rushes, and the reason for the construction of the bridge is at once apparent. To the engineer, responsible for the safe keeping of the bridges and of the villages near the river banks, this characteristic is invaluable, enabling him to work dry-shod in making preparations to deal with the annually recurring floods. The regularity with which the monsoon visits India is another source of comfort to the custodian, who knows exactly when to have protective measures perfected.

The methods of training streams by force vary in different localities according to requirements and natural resources. Where the river-bed contains boulders, these are massed together, and spurs of immense strength are readily constructed. Such rivers, however, require but slight attention as compared with those whose beds are entirely of sand, and which change their course on the least provocation. When block kunkur is at hand, or easily obtainable, spurs of great solidity are easily formed. This method of protection obtains on the Scinde, Punjab, and Delhi Railway over the rivers discussed later in this Paper, which pass under the line a few miles above the actual points to be considered. The kunkur is brought in the company's trucks, and discharged near the abutments of the various bridges. Earth, or even sand with a

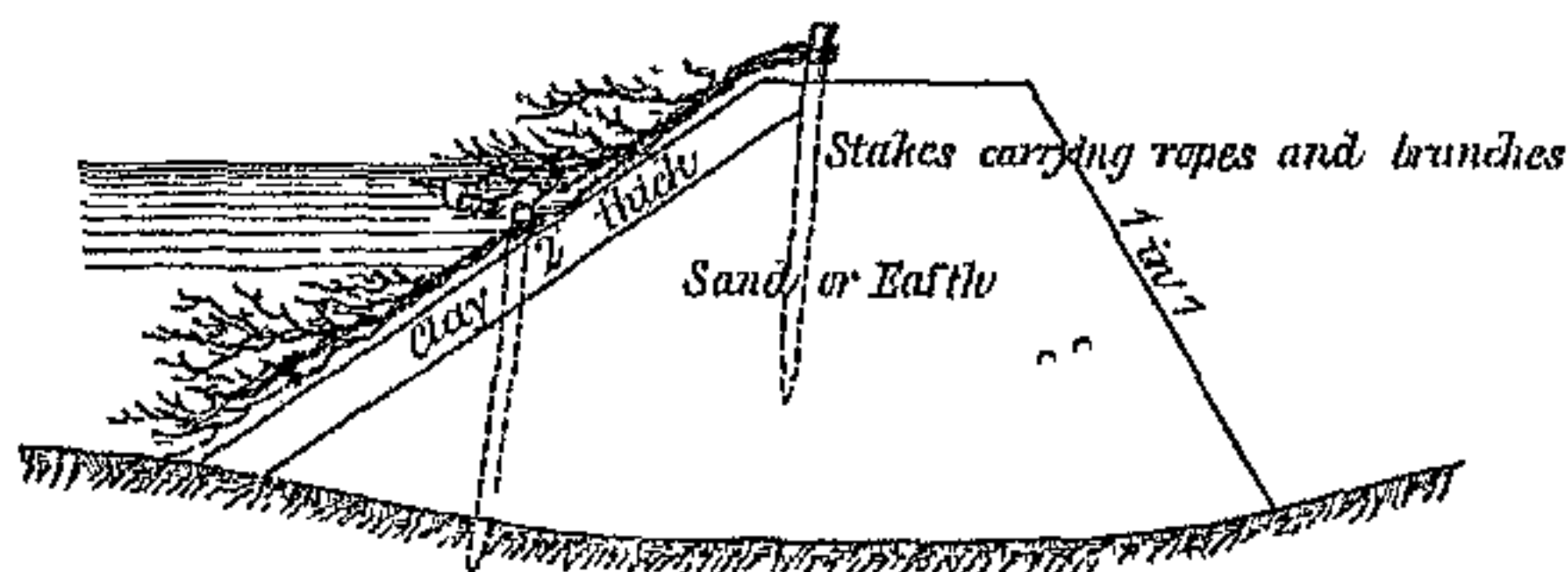


facing of tree branches (Fig. 1), has been found to act efficiently where the cost of carriage of boulders or kunkur has rendered the more solid spurs impracticable. Spurs of this description were, in fact, in almost universal use until of late years in Northern India, and are still from time to time adopted.

Artificial sandbanks of huge dimensions have also been tried without tree-facing; but labour, the sole item of expenditure in such works, has now become so expensive that the reduction in size rendered possible, when a facing of clay and tree branches was tried, has more than counteracted the extra cost of the facing. Only where trees are exceedingly scarce, therefore, is it wise to adopt this plan.

The object of this Paper is, however, mainly to consider the subject of river training where coaxing, as opposed to force, is the primary agent, an agent prompted in the first instance no doubt

FIG. 1.

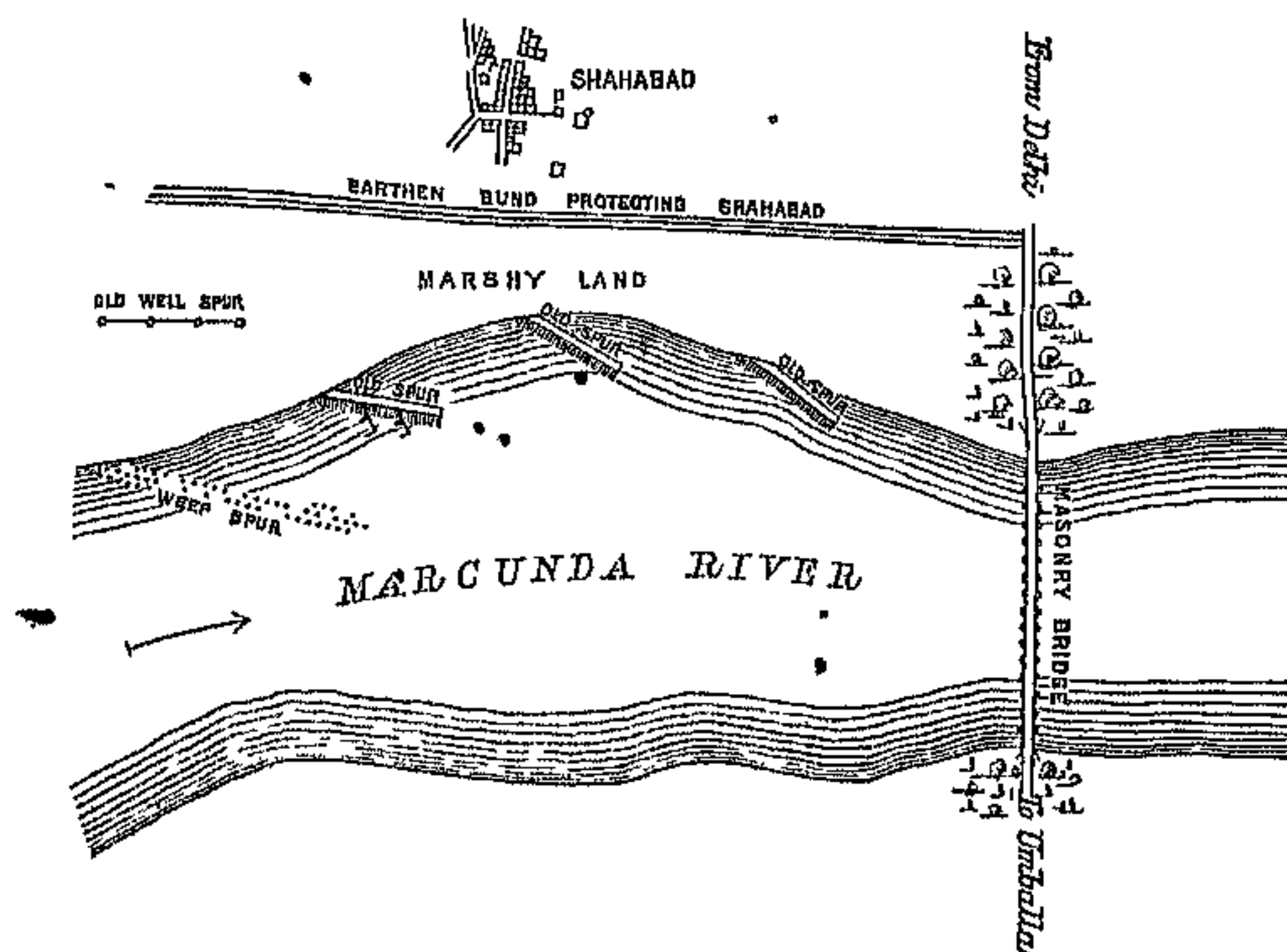


by economy. So vacillating are Indian rivers, so changeable their streams from day to day, that it is often absolutely necessary to prepare precautionary traps and stumbling-blocks in places comparatively remote from the river bank. The construction of strong spurs not only necessitates money but time, and, when complete, these cannot fail to produce a galling effect on the holder of the government purse strings; if, by chance, the spurs have no work to perform, and are left high and dry, a useless expenditure of labour and funds.

To better describe the use of floating spurs, Brownlow's woods, &c., it is thought advisable to take three actual examples of rivers lately under charge of the Author. The diagram annexed shows the three rivers at points where they cross the Grand Trunk Road. Over the Marcunda (Fig. 2) a brick bridge of twenty-seven spans of  $36\frac{1}{2}$  feet each carries the road, whilst, as regards the Tangri and Oomla, the construction of the Scinde, Punjab, and Delhi Railway has so reduced the traffic on the Grand Trunk Road in this part of late years, that funds have not been provided for

bridging these smaller rivers (Figs. 3 and 4). During the dry months a temporary road of serbunda grass (a coarse rush) is usually laid down and replenished from time to time; whilst in floods an elephant is kept at hand for the use of travellers, all cart traffic being for the time suspended. Another method of crossing is largely practised by the native drovers and others. Herds of cattle swim and reswim the torrents daily, starting upstream far above the intended place of landing. By clutching the tails of the fattor kine the natives effect a safe passage, a feat which would be impossible but for the aid thus afforded. The three rivers to be discussed run parallel to each other towards the

FIG. 2.



west, and all three cross the road within 12 miles of Umballa, and at a distance of about 30 miles from the lower Himalayan ranges.

The river Marcunda, at the point in question, is about 1,600 feet in breadth, and there is an entire absence of flowing water during the greater portion of the year. In the rains the depth which at times and in places reaches as much as 15 feet, varies hourly according to the volume of water and to the ever-changing form of channel bed. Till within the last few years, the full force of the stream was principally felt on the northern shore, but an entire

change has since come over the scene, and protective measures are now needed on the southern bank alone.

FIG. 3.

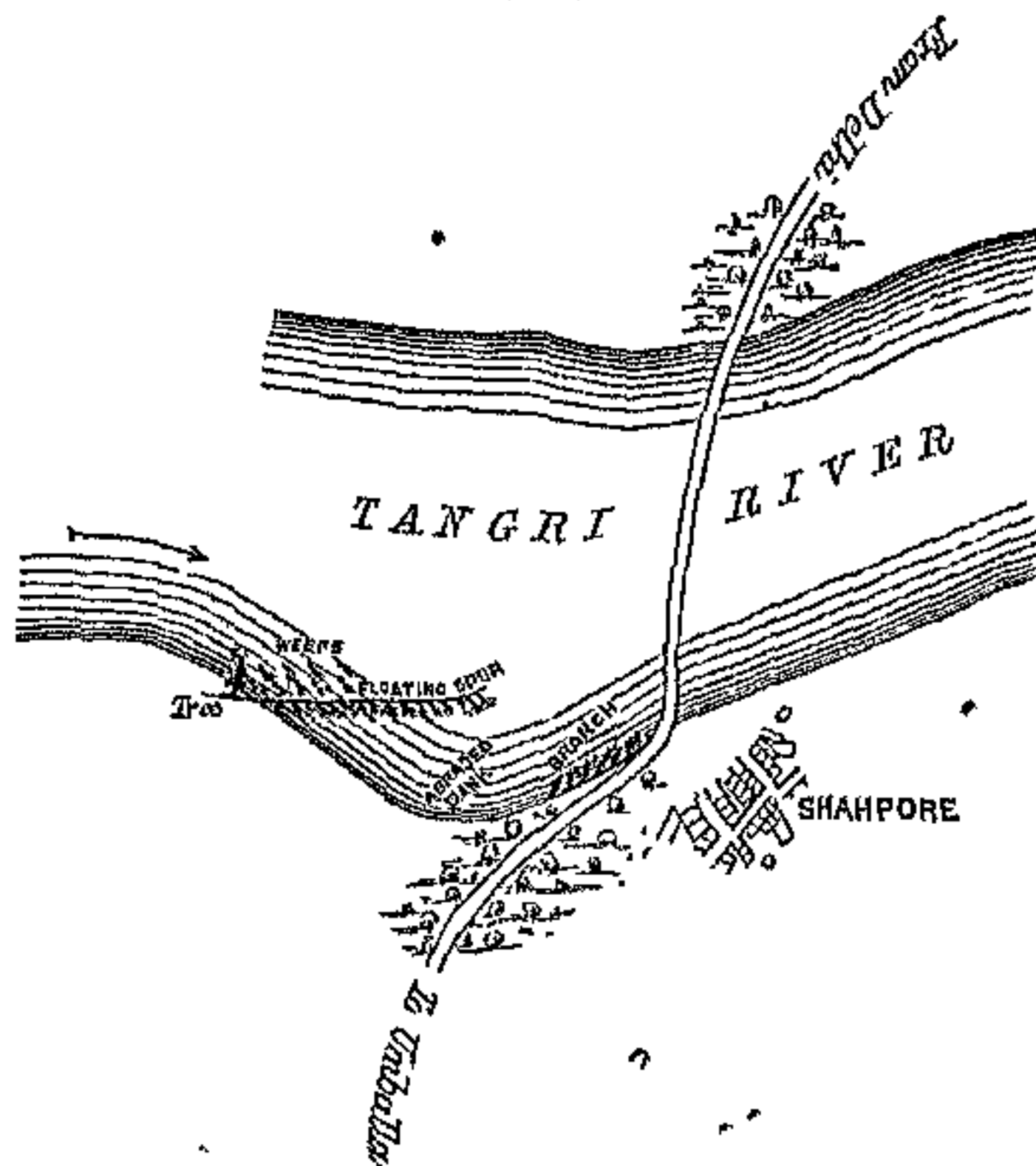
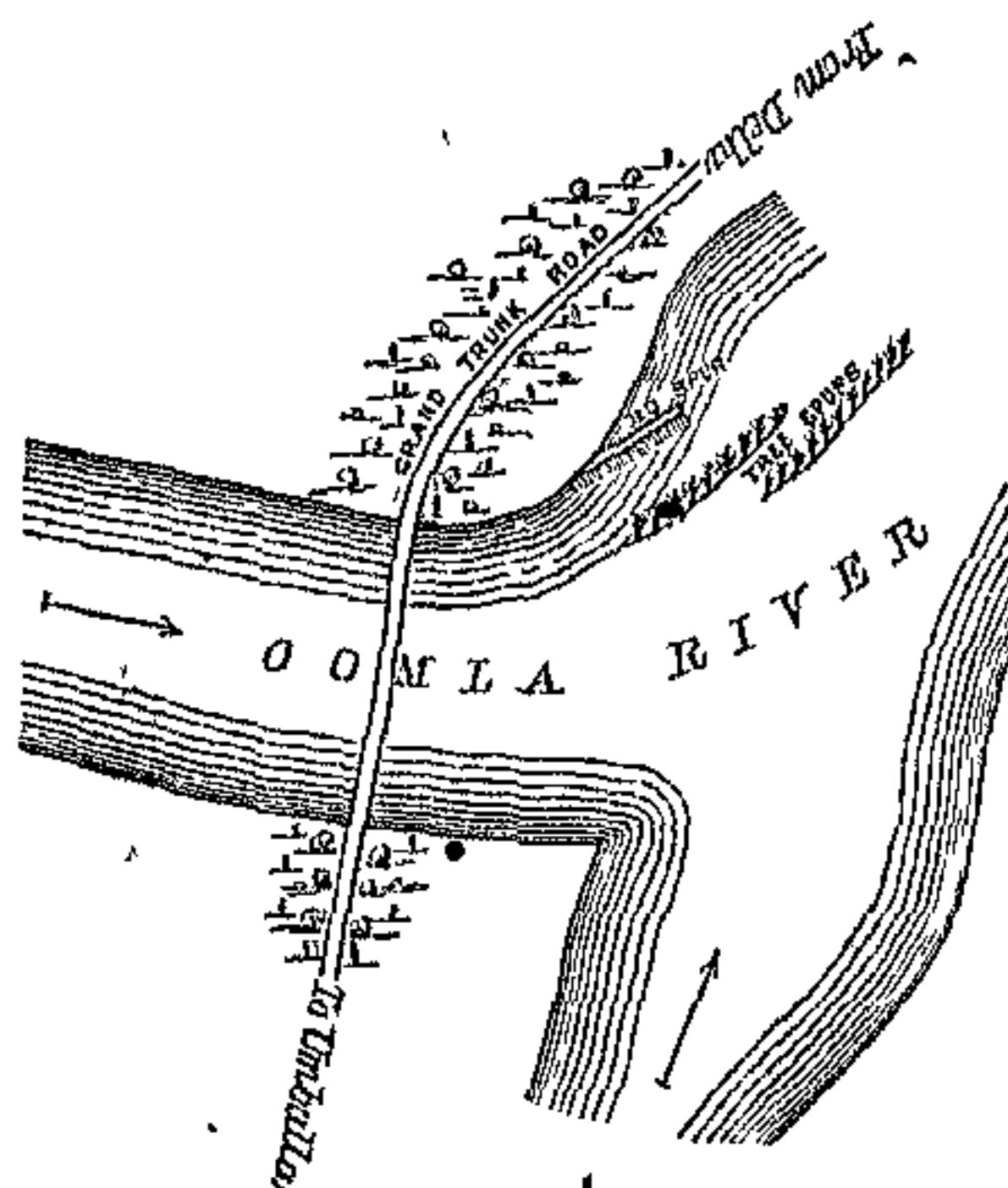


FIG. 1.



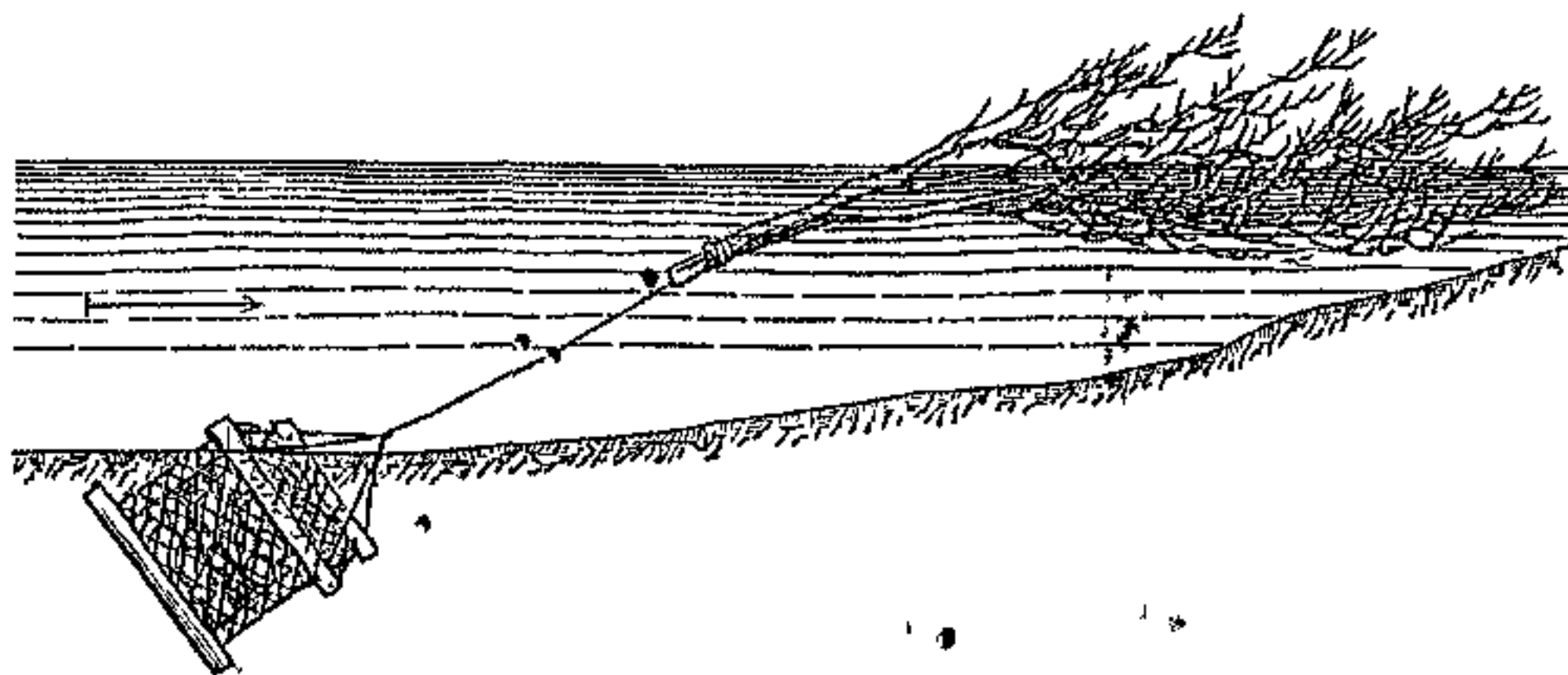
Beyond an immense earthen bund or spur, about 2 miles in length (Fig. 2), is situated the native city of Shahabad. The city



is practically protected by this bund; moreover, any considerable incursion of the river in that direction would be resisted, owing to the danger it would entail on the southern abutment of the Marounda bridge.

The commencement, then, of the monsoon of 1880 saw the main stream on the southern shore, where it was opposed by three strong earthen spurs faced with the branches, as described above, and shown in Fig. 1. These spurs had been severely injured during the previous year, and would have required a large expenditure to render them efficient. Instead of undertaking the extensive repairs of earthwork necessary, and replenishing the facing of branches, a plan was adopted to induce the stream to change its course, by causing a deposit of silt over the abraded face of the spur which was first exposed to the stream. This plan consisted in firmly attaching two long "monj" ropes, 5 inches in

FIG. 5.



diameter, to the top of the bund at selected spots, and anchoring the other ends in the river-bed by means of crates filled with bricks, and buried beneath the sand. To the ropes were attached, by means of ban string, and as close together as possible, large branches as bushy as procurable. This spur was covered, so to speak, by a second spur, composed entirely of Brownlow's weeds, situated a short distance up stream (Fig. 2). The weeds (Fig. 5) were placed at intervals of 20 feet in two rows, likewise 20 feet apart. Rough timbers about  $3\frac{1}{2}$  feet in length and 3 inches in average diameter, were first firmly nailed and lashed together to form a cubical crate; around these stout cords were intertwined, forming a network for containing brickbats. Old kilns, used in the construction of the bridge, afforded ample bricks. The crates were first sunk in position in the sand, care being taken to expose a flat surface at right angles to the force exerted by the tree when floated. The rope connecting the tree and the anchor



measured  $2\frac{1}{2}$  inches in diameter and about 12 feet in length, whilst the tree was selected of a large size, and thick, bushy nature. The entire spur contained one hundred of these weeds, and extended about 800 feet in the river-bed at an angle of  $30^\circ$  with the direction of the stream. Additional strength was given to the spur at both extremities by increasing the rows from two to three for short distances. The effect of this spur was satisfactory. At the close of the rainy season no vestige of the hindermost row of weeds was discernible, so well had the front row done its work. Sand, over the entire bed in rear of the spur, had accumulated to a height of several feet, and the main stream was diverted into the middle of the channel.

Before dismissing the subject of the Marounda defence-works, some mention should be made of a spur which now stands high and dry, far away from the present watercourse, and which affords an example of the application of force to river training. The position of this spur is shown in Fig. 2. A series of enormous brick wells, distant about 50 feet apart, and sunk, it is believed, 25 feet, are connected by a heavy iron chain, which is rigidly anchored within the wells. It is probable that earthen bunds extended from well to well, the iron chain carrying a facing of tree branches. No trace is left of the earthwork, and the chains and wells are scarcely perceptible, being almost entirely covered by sand and vegetation.

Yearly encroachments on the road, and increasing danger to the village of Shahpore by the Tangri (Fig. 3), rendered it a matter of the utmost importance to perfect defensive measures at this point before the rains of 1880. Earthen spurs, of the type shown in Fig. 1, with Brownlow's weeds at the toe, were first constructed; but an almost unprecedented flood early in the monsoon completely removed all vestige of the spurs and weeds. The following method was thereupon adopted. The perpendicular banks, cut away by the flood immediately on the upstream side of the road, were first sloped off; stakes were then firmly planted above, and the arrangement of "branch-facing" was tried, as though the natural bank were itself a spur. At the foot, crates of brickbats were loosely thrown. Advantage was taken of a large tree on the bank, Fig. 3, to throw out a floating spur. A 5-inch rope was attached to the tree and carried into the stream at an angle of about  $40^\circ$  to the bank for a distance of 200 feet, where it was finally anchored with great care by numerous crates, &c. To this rope branches were closely tied, and at intervals of 5 feet large barks of deodar wood (procured from an old bridge in the neigh-

bourhood) were attached in order to aid flotation. Brownlow's weeds were also distributed above the spur to help its action. A sudden subsidence of the water, after the flood alluded to, enabled this work to be effectually carried out, and the result was all that could be wished, the main stream being at once diverted into mid-channel.

The plan adopted in the case of the river Oomla is shown in Figs. 4, 6 and 7. Large trunks of trees, about 12 inches in

FIG. 6.

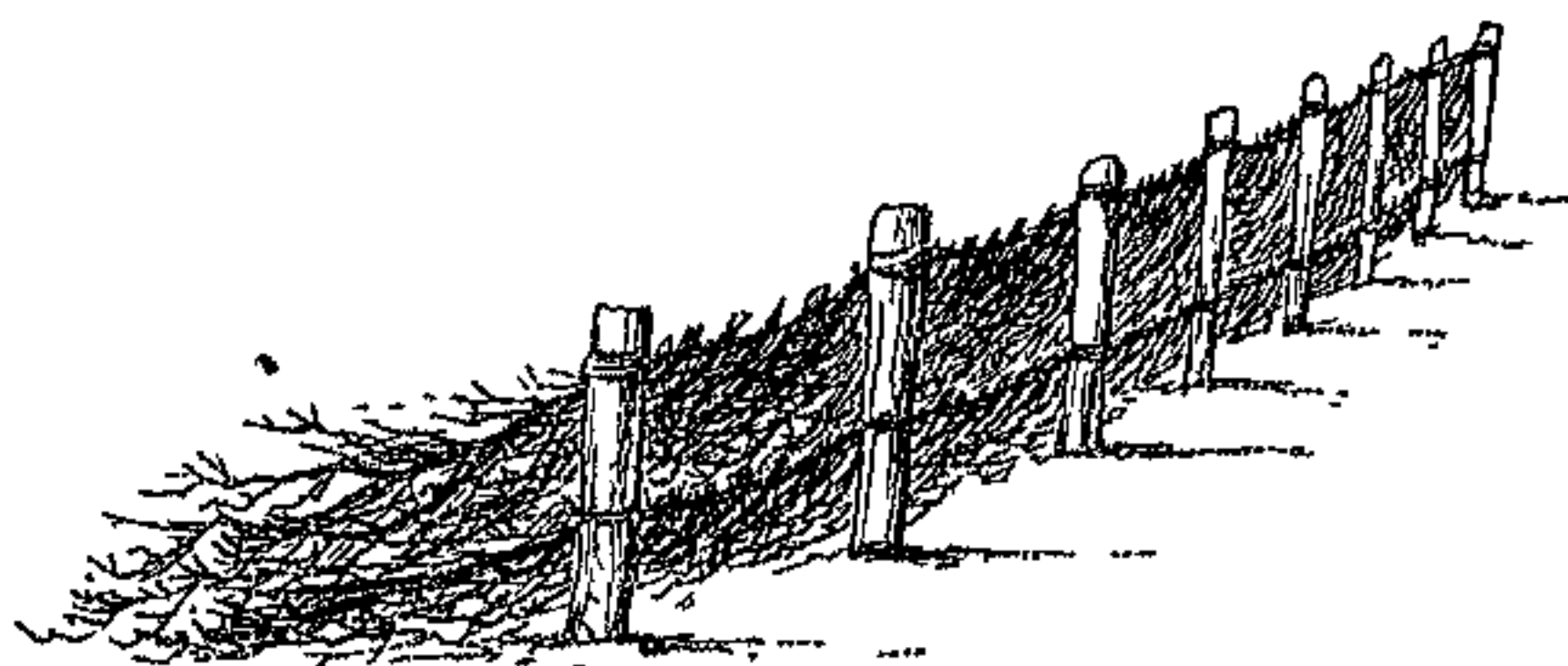
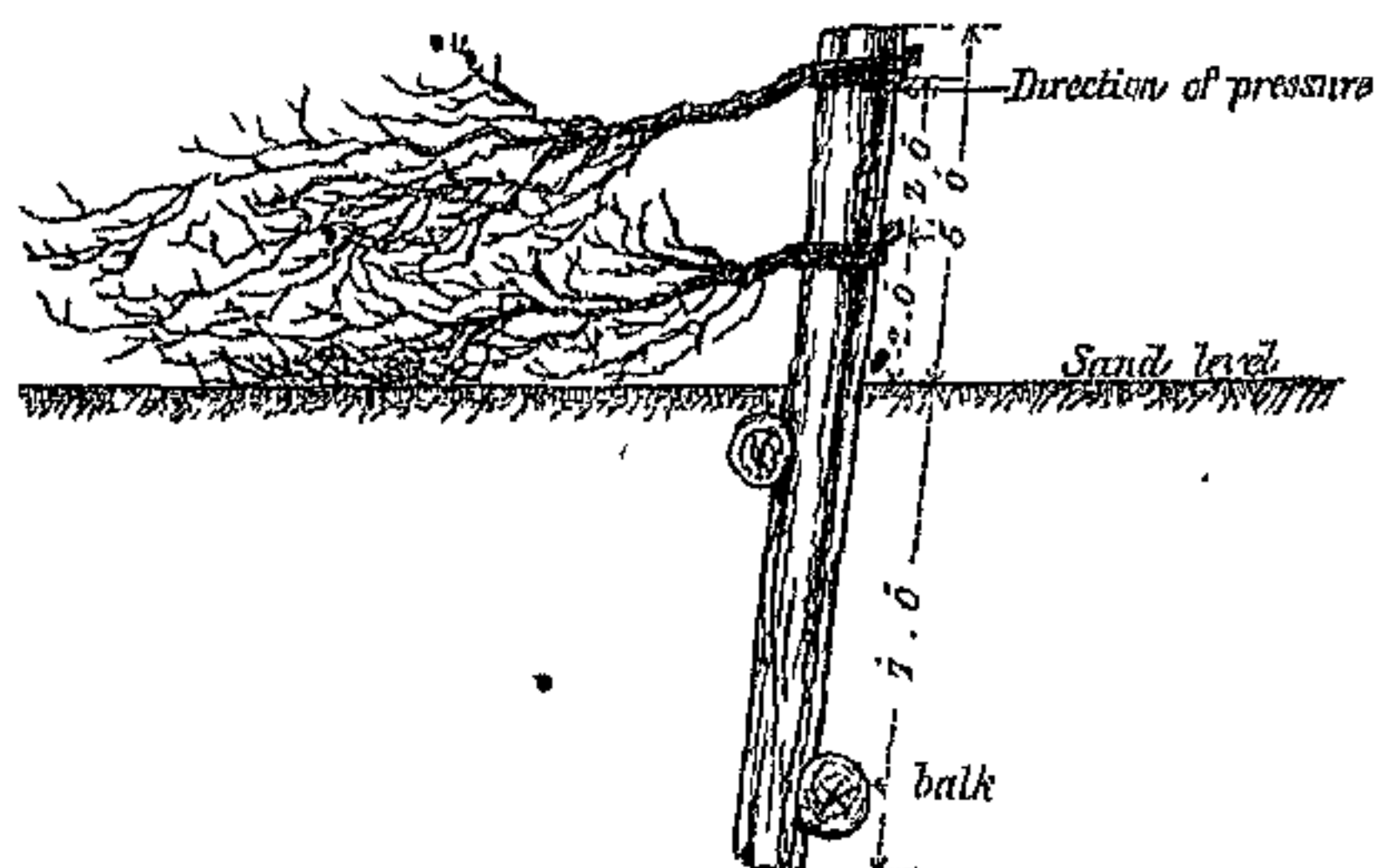


FIG. 7.



diameter and 12 feet in length, were sunk to a depth of 7 feet in the sand at distances of 12 feet apart. It was at first intended to sink them by sharpening the butt-end and "jumping" them, but it was found more expeditious to dig a deep hole and thus let them in. Extra resistance was opposed to the pressure of the stream by placing large barks 4 to 5 feet long, as shown in Fig. 7. From tree to tree were attached two 5-inch ropes, respectively 2 feet and 4 feet above the ground; to these were tied, as close together as possible, large bushy branches on the side

furthest from the stream. A few Brownlow's weeds were placed at the down-stream extremity of the spurs, as an extra incentive to the current to cause an accumulation of silt. The abnormally high flood, which so greatly damaged the Tangri banks, also sorely tried the tree spurs on the Oomla; at the close of the monsoon, however, a decided change in the river-bed was perceptible.

That the cost of spurs, as above described, is but trifling compared with that of kunkur or earthen embankments sufficiently massive to ensure safe resistance to heavy floods, will readily be allowed, unless indeed in the event of trees being almost unprocurable. In the cases under discussion the trees were obtained from plantations along the Grand Trunk Road, whilst the brick-bats were brought from abandoned Government kilns, which in each instance were close at hand. The cost of rope and nails was practically nothing, and the unskilled labour requisite amounted to a mere bagatelle compared with the carriage. Where carriage entails so large a proportion of expenditure, it is impossible to enter minutely into the question of rates, which practically vary for every spur. Suffice it to say that, under advantageous circumstances, a Brownlow's weed would cost from 2 rupees (4s.) to 3 rupees 8 annas complete, and in position, whilst for trees felled and fixed (as in the Oomla spur) 1 rupee each was sufficient. The cost of branches per lineal foot, including rope and string, was from 4 annas to 8 annas (6d. to 1s.).

The Paper is illustrated by several diagrams, from which the woodcuts in the text have been prepared.



LONDON ;  
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STAMFORD STREET AND CHARING CROSS.



To

The Commissioner of Orissa Division

Cuttack

Sir

I beg most respectfully to state that I am requested by the Balasore National Society to submit the accompanying report and petitions for your favourable consideration and pray that you would be pleased to forward them to the Governments of Bengal with your opinion thereon.

A few years ago reports reached the Balasore National Society from various quarters that the Irrigation Canals had become a source of oppression to the people. With a view to ascertain how far these reports were correct they deputed Babu Sashi Bhusan Mukerji to collect real facts and to submit a report thereon. This gentleman was told not to interfere with the works of the Government officials in connection with the canal—to make no common cause with the ryots—and not to instruct them to withhold paying their cess, but simply to collect facts.

Babu Sashi Bhusan went to make enquiries in March last. He travelled over nearly the whole tract of land through which the canals pass. He collected from nearly 846 mouzas 57 petitions to which more than 2100 signatures are affixed. Translations of the petitions are word by word embodied in this report which also contains translations of the report submitted by him.

The petitioners speak of

- I. The disadvantages from the canals.
- II. The oppression of the canal officers.
- III. The redress of greivances.

## [ B ]

I. As regards the disadvantages they show that the Canals cannot supply water to high lands which require irrigation water to grow crops, but they pour in an over-abundant supply of water to low lands which require no water from the irrigation canals and which are thus injured by their surface soil being washed away.

2ndly. The cultivators get at present very little benefit from rain water as the whole amount of it is taken to the canals by means of a network of drains scattered over the fields. Being thus deprived of an advantage which Nature provides, they are put under the necessity of paying heavily to meet this artificial want.

3rdly. The embankments stand in the way of the overflowing of rivers and thus prevent the deposits of silts which hitherto kept up the productive power of the soil.

4thly. The rates of cess are high. • •

5thly. The cess is realized in one instalment.

6thly. The cess is levied on all lands excepting home-steads whether they are irrigated or not.

7thly. The cattle are not allowed to graze on the embankments and their sides.

8thly. The canals are dried up in winter and dry seasons, when the ryots want water most urgently.

II. As regards the oppression of the officers the petitioners show that if they do not treat the under-officers connected with the canal they are harassed and oppressed in several ways:—

1stly. They do not get water in time.

2ndly. Water is let into their fields when there is no need for it to the great damage of the standing crops, and not satisfied with this, the fields are assessed for this water.

3rdly. Their cattle are impounded on the false plea of

having grazed on the embankment.

4thly. Notices are not served on them in time and very often not at all and warrants are at once issued to arrest them.

5thly. Such fields as do not require water, or have not taken water are assessed.

6thly. The subordinate officers of the canal pour in water to some fields unasked for and realize double cess *ie* Rs 6 per acre on the plea of the owners' having stolen water.

7thly. Those who fail to pay cess are harassed and oppressed very much at the time their property is attached. For instance, things that are found out-side their houses are not seized but the officials forcibly enter the houses of the defaulters and take away any and every thing which they can lay hands upon, and even go the length of snatching away ornaments from the persons of the women they happen to meet.

8thly. The *ijardars* tyrannise over the ryots in various ways:—( a ) They realize cess from the ryots, but at times enter it in their account books on other accounts than cess. ( b ) At other times they realized a portion of the cess and subsequently realize the whole amount, without making any deduction for the amount already paid ( c ) Again a portion of the cess is intentionally left unrealized with a view to enable the *ijardars* to have a hold on the ryots on some future occasion.

III. The petitioners pray :—

1stly. Government may exempt from assessment the lands which do not take or require water.

2ndly. That Government give compensation to the ryots whose crops are damaged or whose fields are made less fertile by running waste water over them

3rdly. A better system of issuing notice in the first instance upon defaulters be instituted.



[ D ]

- 4thly. That the watercess be collected in three instalments.
- 5thly. That a better class of *ijadars* be appointed.
- 6thly. That the rate of the cess be considerably reduced.
- 7thly. That lands which have been deprived of their natural supply of moisture by canal—drains be supplied with canal water *gratis*.

8thly. A better arrangement of Ferry boats.

7thly. Cattle should be permitted to graze on the slope of the embankments towards the sides of the paddy fields.

The Society think that there is a great deal of truth in the statements of the petitioners, although the petitioners may have exaggerated their complaints and greivances occasionally. So the Society pray that a Commission be appointed to inquire into the complaints of the petitioners consisting of three members representing Government, Zemindars and Ryots respectively.

I have the honor to be

Sir

Your most obdt Servt

Baikunthanath De

President

Balasore National  
Society.

— O —



THE FOLLOWING BENEFITS HAVE  
BEEN DERIVED FROM  
THE CANAL.

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Many fallow lands have been cultivated by the Canal waters. Generally the irrigation canals pass through lands situated on a high level. High lands, therefore on both sides of the Canal which remained uncultivated before for want of water, have been made arable owing to free water communication. Besides, some lands, where only *Asu*, *Biri* and *Beali* used to grow, have been turned into *Sharad* or water-paddy fields on account of a permanent water supply. And a comparatively large quantity of water-paddy can be had. Those lands therefore which had only one crop for the whole year, are producing two water-paddy crops annually, there being an abundant supply of water. Some places have also been made favorable to sugarcane cultivations. Those villages, where only 1 or 2 acres could be had for the sugarcane plantation have now 5 or 7 acres for the purpose. Cotton cultivation has much to do with the waters of the canal. Besides, to the cultivation of vegetables, such as—Brinjal, *Kachu* and also to the rearing of greens, plantains and other plants, the water of the canal has been of great use.

In villages on both sides of the canal the want of water felt is comparatively less. Villagers, who could not procure water even from a great distance are now supplied with fresh water near at hand. Domesticated animals had to suffer much

## [ II ]

from scarcity of water and sometimes in many places they used to be carried away in large numbers during the summer season. The villagers also had to suffer much from illness and to die an untimely death by using the muddy water for drinking and bathing purposes, but now these miseries have been removed by the waters of the canal. (II) The Embankments of the canal and its branches have done much in the way of improved communication. There is no public road in every village. The beaten paths through which they pass, are in a miserable state and especially during the rainy season these paths become almost impassable. Consequently many could not carry on their trade properly owing to difficulties of communication. But these obstacles have now been effectually removed by the embankments. Formerly the villagers knew nothing of the places lying 45 miles beyond the villages but now an old man of 80 years can give you informations of what is going on 40 miles off. Surely this is a great gain.

The people of this country know not before how to make money from contract works, but from the canal they have now learnt how to lay out money to their advantage. Many have also learnt various canal works. When the canal work was started many natives made fortune from contract works and now they have become so well versed in the profession that some are successfully seeking employments abroad. Formerly the condition of the industrious class in the interior was very bad, but when the canal work began they found ample work for themselves and got 2 annas daily for their labor. Thus they have been able to live in comparative ease, and by judicious use of their little earnings they have gradually succeeded in making some money to buy paddy seeds and ploughs for cultivation and to pay rents for the lands they cultivated. In some places lower class people are still working in the canal

### [ III ]

and so they are above want. The number of low class men is comparatively great and that they are deriving benefit from the canal is no doubt highly advantageous and promises a certain degree of improvement in the country at large. The canal also does good to those who seek to earn their livelihood in this place and do not like to go abroad by taking service under Government or Zemindars or others. The people work for them at home, they are not required to go any where for it. Their best wishes have thus been gratified. They are now finding work under government at home.

\* The ryots living near the rivers had to suffer a great deal when these rivers overflowed their banks. During the rainy season their cottages used to remain long under water and they had recourse to adjacent high lands and hills with all their moveables to save themselves. There they waited patiently until the waters subsided and then came down and repaired their habitations, thus experiencing a heavy loss. But the canal has now effectually put a stop to it, in as much as its high embankments stand as a barrier to prevent the overflow of the surrounding places.

The ryots of Madhupur have got rid of these disasters as the high level canal passes by their village.

All parts of the canal are not favorable to commerce. The three large canals Viz.—Patamundi, Taldanda, Machhgon and their branches are used solely for the purpose of watering the fields around and so they are not navigable. The steamers and boats laden with merchandize pass only through the High Level and KinduPatna canals. Besides this, these two canals and their branches also supply waters to the fields for cultivation;

KinduPatna canal is more serviceable for trade than the High Level canal. As it extends a long way into the interior,



## [ IV ]

the merchandize brought from Calcutta to Chandbally port, are carried easily through it to Cuttack and Kendrapara and thence to the Gujats, thus persons of those places get foreign articles of commerce at a comparatively low price. From Cuttack and other places also, things are being sent to Calcutta with little trouble ; only Bhudruck and Jajpur products are sent by steamers through the High level canal to Cuttack. Sometimes rice, paddy, tamarind and the like are sent from the interior to Cuttack by the High level canal; but the trade is not extensive.

In particular places the canal waters have been much useful to cultivation, but those that have the advantage of river waters or the water of fountains from adjacent hills do not derive a greater benefit from the canal waters than they otherwise would. When there was no rain-fall, the cultivation was stopped for sometime for want of water and then again after a heavy downpour it was all bustle and stir with the cultivators. This was a great disadvantage; but this has now been removed by the canal. If there is a drought during the time of cultivation no such inconveniences are now felt, and the paddies, which but for the canal waters would have been destroyed for want of a proper rainfall, are now growing afresh under its influence. Fields from which nothing could have been expected during a heavy drought now yeild at least 4 annas crop. But this cannot avert a famine in Orissa, because all its cultivated lands do not get canal waters. It is only the lands near the canal which always expect its waters during a season of drought. Its present system of water supply is in no way adapted for extensive cultivation ; and as the few acres of lands which despite the want of rain, would produce crops by the canal waters, do not give sufficient paddy for the consumption of the people of Orissa,



famine can not be warded off when it will make its appearance and thus the object for which the canal has been made could never be gained, should things go on in this way

### DISADVANTAGES DERIVED FROM THE CANAL.

1. The officers who were deputed to survey lands in such a way as the canals could pass through, without causing any inconvenience to the subjects holding them, obtained bribes from the people under false apprehension that the canals would run over their houses and by holding out that measures could be taken to divert them if bribes were to be offered. In this way Rs 80 was taken as bribe from one Sadanund Missra of Mukundapur in Pergunnah Gunsito. One Niladri Choudhuri of Kurunia-Changarpur in the same Pergunnah, having opposed to pay bribe, fell a victim to the anger of the Amins who, under pretence of making survey, forcibly broke into his house. There was a *marpit* between Niladri and the Amins and Niladri was originally prosecuted. His case ended in conviction in the Lower Court. Fortunate it was for him that on appeal to the Judge, Niladri was honorably acquitted. This sort of treatment was dealt out to the people of various places at the first stage of the canal work.

2. The officers of Land Acquisition Department who were afterwards deputed to look to losses caused by the canals to the people in connection with their houses, gardens, lands &c. and to report to government for their compensation, made private arrangements for bribes with the people of Mofussil and thereby caused, in some places, the government to suffer and in others the local people. Besides, a subject who lost his *oul* land and new house in the canals received back their values at the rate of the *duam* land and broken house for refusal to pay bribe.

whereas he who was able to satisfy the officers received more than his due for the loss of the latter, as he was paid at the rate of the former.

3. At the time the canals were being excavated, it was necessary to cover up low places in the canals and to make embankments where required by bringing mud from outside. The contractors being favored by the public servants threatened the people that they would take out mud from their gardens and houses and the people, as a matter of course, protected their own property and prevented the contractors from making use of their illegal force by payment of bribes. Those who agreed to the contractors' terms had to lose nothing but those who refused, had their out-houses, gardens and even their house-verandahs cut away with force, though there were heaps of mud accumulated at places nearer to the canals. Many persons fell victims to this mal-treatment.

4. After the completion of the canal-work, the Amins were deputed to fix water cess upon the cultivating lands. They stretched out their hands for money and, in cases where they received nothing, the house-compounds and the gardens were taken into account with the cultivating lands and water cess was levied upon the whole. The rate payers suffered continually for two or three years under this illegal taxation and at last for the proper consideration of the higher authorities they began to submit memorials one by one. The people however have not been as yet successful in obtaining redress.

5. Two years after the introduction of water-irrigating system up-country Amins, known in mofussil as *Bar handia*, were deputed to make a through survey of lands according to lists of Pergunnahs and Mouzas. As one portion of a pergunnah or a mouza could be easily misplaced within the jurisdiction of a different Pergunnah

## [ VII ]

or a different Mouza, the Amins were influenced by the offers of handsome money from the local Zemindars to make false demarcations of Purgunnah and Mouzas and to pass them as correct ones. This has materially injured many Zemindars and subjects and ther<sup>e</sup> ensued two or three criminal cases in Cuttack against these oppressive Amins, some of whom received condign punishment for their works. This fact is well known to the pleader Gopal Babu of Cuttack.

6. Within two or three years after the irrigating system, water cess from Rs 3 to 8 was levied upon each acre of land and the ~~exactions~~ were made from the people at the said rate. The rate payers were highly oppressed under this mismanagement and no heed was paid to their representations. Owing to this mismanagement, water cess on three acres was forcibly exacted from one who really held one acre and in cases where people were possessed of no lands at all, water-cess on some two or three acres was drawn from them. In cases of opposition to the payment of such illegal water-cess, it was realised by warrant, distraint and auction. The people had to suffer much under this irregularity.

7. At the time when the 5 years' settlement was promulgated, the officers called two or three principal residents of a village from whom full particulars of each resident as to what village he resided in and how much cultivating land he had, were received and each resident had to put in a *kabuliat* in which was stated the water-cess levied according to the list of his cultivating lands. From this it appears that there must have been great mistakes in the executing of the *kabuliats* owing to the absence of their real holders. Water-cess on three acres was imposed upon one who actually held one acre and he who was possessor of no lands was made to pay something. Thus, subjects who were, in some cases, holders

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## [ VIII ]

of *kabuliats* of others' lands and, in other cases, of *kabuliats* forcibly taken from, them were forced to pay illegal taxes for a period of 5 years. Nobody paid heed to their cries and remonstrances. Some mouzas were found to pay water cess, although they were not watered at all ; some mouzas had no necessity of being supplied with water in the low lands but water-cess was realised from their residents by supply of excess water which, in fact, caused ruin to the crops growing therein. In truth, the people lost their all during the course of these 5 years. Some villagers fled away from their parental lands; some respectable villagers paid water-cess by the sale of their *lakhraj* lands for the preservation of their family reputation and some had their houses levelled to the ground for want of repairs. A few villagers committed suicide in order to escape the iron grasp of the tyrants as the water-cess officers were called. These tax-harassed people represented their grievances to the Collector of Cuttack who, without giving any favorable consideration to the straitened circumstances of the people simply ordered that on the expiration of the *kabuliat's* time no one should be forcibly made to execute new *kabuliats* or no *zulum* be shewn to them. But before the expiration of the already granted *kabuliats*, the Collector was transferred and the oppression and *zulum* consequent upon the grant of *kabuliats* were much the same as before. A fresh requisition was again made to the new Collector but without avail. New *kabuliats* were again being taken from the people to their extreme reluctance under the repassing of the 5 years' settlement.

8. The people were over-oppressed with *kabuliats* executed by them in 1882 and after the expiration of their *kabuliats'* terms they were quite unwilling to execute new *kabuliats*. As there was drought in last *kartik*, some mouzas indispen- sibly required water for cultivation. This afforded the water-cess offi-



cers the best opportunity for renewing the 5 years' settlement with the subjects. The water requiring mouzas were supplied with water *gratis* by breaches in the embankments of the canals and the distributaries and their inhabitants were tempted to execute false *kabuliats* in order to show the way to the people that true *kabuliats* were granted by them. Besides those mouzas, all the adjoining mouzas were inundated by unusual supply of water to the utter unwillingness of the cultivators which, in fact, though it proved beneficial to some extent in a few villages damaged all the ripe corn to an alarming degree. Hence it is clear that the water-cess officers had no other object in letting out water of their own accord into the lands of the people than to compel them to give new *kabuliats* and their object was at last brought into effect without difficulty. The cultivators who had their lands overflowed with water against their will were threatened that they would have to pay twice or four times their water-cess if *kabuliats* were not executed at the usual rate. In the year 1883, watercess of Rs 1-8 was realised per acre of land from those who were made to consent to give new *kabuliats* but those who never agreed to give *kabuliats* had to pay twice or four times their watercess upon their lands. When opposition was raised to the payment of such illegal watercess, the defaulters had their house-furnitures sold off for non-payment by warrant, distraint and auction. In order to have mitigation of this illegal taxation, the people conjointly made a full representation to the Collector of Cuttack but to their misfortune their petition failed to attract the attention of that official. Thus the people were made to suffer silently all the troubles and hardships attending the grant of *kabuliats* against their will.

9. Among the cultivating lands, there are some which are so

high as not to allow the canal-water to run over them; water-cess of from Re 1 to Rs 1-8 was levied thereon and collections were drawn at the same rate for a period of 5 years although the canal-water did not water them during the full period of the 5 years' settlement. As those lands were with difficulty supplied with the canal-water in the last year owing to the fact that the canal-water was inaccessible to them, double the above charges were imposed upon them. The low lands which do not require the canal-water at all and where the crops are choked up with the excessive rains were largely supplied with the canal-water in spite of the existence of adequate water there at all times. The result of this unecessary supply of water was that it damaged all the ripe harvests and water-cess of Rs 1-8 was fixed upon them per acre of land. Last year there was no necessity of the canal-water, but it was profusely let in upon the lands to the utter reluctance of their owners and thereby were destroyed all the ripe harvest and twice or four times their water-cess was charged. The people were, in no little degree, harassed by this unjust imposition and irreparable loss was sustained by them. It is quite clear that the watercess officers had no other motive in forcing such an illegal imposition than to compel the people to execute new *kabuliats*.

10. The people can take the canal-water by means of mud-shoots. The watercess officers supply these shoots to the people at a higher price than they are purchased from the potters. The people are never allowed to purchase them at their own choice and convenience. Sometimes it happened that the watercess officers wilfully broke down the shoots purchased by the people without their knowledge for the purpose of supplying them with new shoots and thereby obtaining a profit. The canals which run through Taldanda and Machhgan offer the best proofs of this practice of the water-cess officers. The people

of that part of Orissa suffered a great deal by reason of this sort of oppression.

11. The manner in which watercess is realized from the subjects is not at all convenient to them. At the first stage of this system, watercess was realised at one time but fortunately for the people it is now drawn on two occasions from them. Under the rules the people are to personally present themselves before the local officers to pay their cess at the time when it is due. As more than legal due is charged upon almost all the villagers and false charges are made upon such lands as are never watered by the canal-water, the people do not go of their ~~own~~ accord and pay their taxes in time and as soon as the stated time expires, water-cess together with other charges is realised by the service of warrant, distraint and auction. The poor villagers have been bothered too much and have none to whom they can represent their complaints.

12. Notices are served somewhere by the water-cess officers themselves and somewhere by the *chowkidars* of the locality. In most cases, notices are neither sent to the houses of the people nor are their signatures obtained. Under the name of their being served, the notices are generally left at the lodgings of the officers or in the houses of the *chowkidars*. I personally witnessed plenty of the notices lying accumulated in the above places without being served though they were found to be ready for service. Owing to this great inconvenience the people remain fully unaware of the service of notices and after the stated period the defaulters have their property illegally distrainted for disobedience of orders as stated in the notices and thereby an excess amount of annas 6 (*i.e.* notice fee 2 annas and attachment fee-4 annas) is paid by the defaulters over and above their usual water-cess. It has come to my notice that notice fees were privately drawn by the officers and mis-



appropriated. An irregularity like this was also seen to be practised at the time of the distraint of the defaulter's property. It was also observed that the defaulters had their property at once distrained without any notices sent to them and excess fees of annas 6 chargeable on both the aforesaid accounts, were taken from them. In some particular cases, the watercess officers were found to pay water-cess from their own pockets on behalf of the cultivators and afterwards to take bribes from the interested parties. It was no little hardship and disturbance that their property should be distrained at once for non-payment of water-cess in time. Instead of touching anything lying outside the defaulters houses ~~that~~ can easily fetch their water-cess and its cost, the water-cess officers enter with force their houses and have their drinking and cooking vessels or any other utensils of the kind brought out from their cooksheds by low caste people, such as, *Pans Kandras* or Mahomedans who are permitted to lay their hands even upon *amani*-sort of porridge. After the departure of the invaders, as the water-cess officers are called, the people are obliged for the sake of their nationality to throw away their *handas*-cooking vessels, and have their houses cleansed and sanctified. Of the distrained things one of Rs 5 worth which is taken away for Re 1 could not be used again, if it could be taken back from the water cess officers by payment of their legal dues, for fear of being placed beyond the pale of society, by reason of its having been touched by low-caste people. It is either to be sold at half-price or exchanged. The use of this utensil in future time will be a source of degradation of the people in the eyes of others. Hence it will be needless to mention here the number of disadvantages the people have undergone under this injustice. It also happens that such things



## [ XIII ]

as are worth Rs 5 are sold off at Re 1 and the mofussil people understanding that they have been touched by low caste people, such as *Pan Kandra* &c. do not take them though sold cheap. Consequently water-cess officers take the advantage of keeping them at cheapest price for their own sake in the name of other men. In cases where the distrained things are purchased by the local chowkidars or the public officers, illegal charges such as cost of conveyance of the purchased things, diet allowance of the purchasers, cowshed hire of the purchased cattle &c. are unjustly taken from the people. It has also come to my notice that in many places things were distrained and auctioned in the absence of their real owners.

13. Where the watercess officers fail to obtain bribes from respectable men, they do not touch their property for non-payment of watercess but secretly endeavour to trouble them in some other way. The watercess officers do not send them notice at all for information of their being defaulters but at once arrest them on their way to market, *Bazâr* or anywhere else by the production of unexpected warrants. The respectable men could not say anything but feel greatly ashamed before the public and try to get out of the hands of the arresting officers by promising to pay their dues whether legal or illegal. The arresting officers who intend maliciously to dishonor them, do not leave them on the way but bind them with string and take them in custody to their home by making them take unnecessary journey and insulting them on other ways and do not release them until watercess is paid. It is highly discreditable that public officers should thus wilfully expose and insult well circumstanced people, many of whom left their parental lands and went away to some distant parts. The number of such

## [ XIV ]

persons will be easily found out on enquiry.

14. It has come to my notice that exactions are made by the watercess officers in some places and in others by the local *ijardars*. The latter receive as remuneration a commission of five per cent on the whole amount for which *ijara* is obtained. This is no doubt an inconsiderable and inadequate sum which can hardly enable them to make two ends meet. Besides this an *ijaradar* can not have his whole exactions realised from the rate-payers until 7 or 8 months are lapsed. According to the latter calculation, what an *ijaradar* receives as wages for his labour within the long period is almost nothing. Necessity has no law. He therefore keeps himself on the look-out for other resources. By other resources is meant oppression to the public. During the time when watercess is being realised, diet allowance is taken, *pautis* are not given to ignorant men for the purpose of realising a second exaction from them, half of the cost payable on the service of notices and warrants is on private measure charged on the actual watercess said to have been previously paid in behalf of ignorant rate-payers and bribes are obtained by adjourning the usual time of payment. With regard to the realisation of watercess, public officers are held in more respect than the *ijaradars* by the people who dislike the latter. In most places, petty Zemindars and *mahajans* are appointed as *ijardars*. These men have an easy time of it. They have everything in their own way. They are not required to bring suits against their tenants' debtors for the realization of their dues in the shape of rents, or paddy or money lent to them. When watercess is paid, instead of debiting it into the accounts as watercess, it is entered in behalf of rent, paddy or money. After the expiry of the usual time, notices and warrants are duly served upon the tenants and their

houses, utensils are auctioned in case of nonpayment of watercess.

15. The drains have become another source of trouble to the people. In the last year when the 5 years' settlement was over, the number of new executors of *kabuliat* was much decreased and with view to increase their number, drains were excavated and are still being dug. The office of the drains is that they take away all the rain-water from any land, be it high or low, and the cultivators are compelled to give in *kabuliat* for cultivating them. As soon as it rains, the whole rain water is taken off by these drains to the nearest reservoir or the nearest canals and what is sown on the ground at the expense of much labour and money and the manure consisting of putrid straw scattered over the ground for the sake of the fecundity of the soil are swept away to the great loss of the cultivators. All the hopes of the cultivators are thereby frustrated. The people do not receive any compensation for the loss of their lands through which the drains run and no action is taken against the complaints made by the people or the Zemindars. Over places where there are long-standing tanks and *jhills* which were more or less serviceable to the cultivation of lands, on the occasions of drought, the drains are purposely made to run, to prevent the cultivators from cultivating lands with the water of tanks *jhills* &c. and without executing *kabuliats* for the canal water and after the excavation of these drains, the cultivators are compelled to give in *kabuliats* in as much as all the water of tanks, *jhills* are taken away by the drains. Both People and Zemindars have been great losers by reason of the excavation of the drains. The disadvantages derived from them may be enumerated as follow:—(1) No cultivation could be safely made without executing *kabuliats* for the canal water. (2) The tanks and *jhills*



used to be filled up with water during the rains and thereby the nearest villages used to have good supply of water for bathing and drinking purposes and the nearest cattle used to ease themselves as they had free access to those tanks &c. during the cold and hot weather, but after the excavation of the drains to their great annoyance no sooner it rains than all the rain-water canals is taken off of the people as well as of the cattle. ( 3 ) The lands which remain fully overflowed with water during the rains can be payable in no other way than growing a large number of fish but since the excavation of the canals, no water could firmly stand thereon and consequently no fishes could grow and hence the loss is irreparable. As these lands have been tenanted from the time of the Settlement, the Zemindars are obliged to retain them and pay their rents from their own pocket.

16. The distributaries are made to prevent the rush of water from the rivers and water-falls of the hills which used to pour water upon the land for the benefit of cultivation. The lands finding no profuse supply of water from that source could not lend their produce in the same quantity as before. The distributaries are likewise made by the side of the hills. These distributaries being situated upon higher lands than the ordinary canals, are never filled up with water unless the heavy rains set in, so when scarcity of rain is felt, the lands are not properly supplied with water which tells seriously on cultivation. The supply of canal water may occasionally water them but that too is not available iff the watercess be not paid. But the flows of hill waters left sediments behind over the ground, fertilized it and allowed various harvests to grow in abundance. But since the existence of the distributaries, the lands have been gradually becoming more unfruitful day by day and not more than half of the produce



growing there could be had now, although much more labour and expence are required in buying manure and paying water-cess. This result is adding to the poverty of the people who are growing poorer day by day, and some are flying abroad. The obstruction to the course of natural water damages the crops in another way. The lands bordering on the rivers are generally sandy and at the time when the natural water was without any obstruction the sediments brought with the torrent of water and deposited over the lands caused them most fertile; consequently the yield was in abundance. But since the time this course of water began to be prevented, sands have been accumulating and the lands have been becoming barren. Some places have grown so sandy and barren that no vegetables can grow there. Consequently the tenants in whose possession these lands have been since the time of the Settlement find it next to impossible to pay rents to their Zemindars. Besides they have to pay water cess and as their lands were of the first class at the time of Settlement the rent on them ranges from Rs 4 to Rs 6 per acre.

12. The rate of watercess is much higher than it ought to be. In almost all places the ryots have to pay per acre of land Rs 3 for rent, Rs 1½ for watercess and annas 3 for P. W. and Road Cess, annas 6 for notice &c. fee. In addition to this what is payable to blacksmiths, *chowkidars*, *khundates* on an acre according to the custom of the village is about annas 3 in paddy. The cost of cultivating one acre of land comes to close upon Rs 3 and the crops gathered in, being not more than Rs 9 or Rs 10, very little is left to the cultivator to maintain himself and his family. It is very clear from this that the lands are deteriorating and the cultivator is involving himself over head and ears in debt to keep life and soul together. It has been seen by rough calculation that all the charges including rent payable on lands and all the expenses incurred for the

cultivation of paddy will amount to nearly twice the sum expended before, while the produce of lands has been less. Hence men's misery is daily on the increase. A comparison of the condition of the people of different places shows that the men of the villages in which the canal has been of longer date are more miserable than the men of the villages in which the canals have been of recent date. The condition of the subjects living near the High level and Patamundi canals is little better than those living along the Kendupatna, Taldanda and Machhagan canals.

18. People find it very difficult and inconvenient in crossing the canals at the Ferry-ghats. In places where ~~there are~~ bridges constructed over the canals, no inconvenience is met with, but where there are arrangements made by boats, both the villagers and their cattle are put to good many troubles and inconveniences while crossing the canals. There is no regular arrangement for making the boats available at all times in all the Ferry-ghats. It is beyond words to express the inconveniences arising to the people in places where the canal passes midway between a village if there be no ferry boats ready always to make them cross it. In these places, boats should be always ready at the Ferry-ghats for the purpose of crossing. The cultivators are daily required to take their paddy seed to the other side for sowing. The paddy, conveyed by bullocks, is unnecessarily detained for 2 or 3 days on account of the boats being not available on each occasion and thereby cause heavy loss to the cultivators. Similar inconvenience and loss are felt by the cultivators when the ripe corn is brought home from the fields. The ripe paddy which is most likely to get loose with the least stroke drops down from the ears on the way owing to the unnecessary detentions and

removals from place to place caused by the mismanagement of boats. Many cultivators were found to have been devoured up by alligators while attempting to cross the canals on account of boats being not always available. Many cattle were also seen to share the same fate. As lands are every where intersected by the canals, the cattle of one side have their pasture on the other side and many died of cow-diseases mainly caused by crossing the canals by swimming twice every day for the sake of grazing. Had there been proper arrangement for crossing the canals by boats, this would not have been the case and if this state of things be suffered to continue for a length of time, people will be great sufferers. The higher authorities ought to be requested to take immediate steps for the removal of these difficulties.

19. The canals and the distributaries are every where found to pass very close to the villages, and the villagers and their cattle have no other ways to go abroad and come home than to pass over the causeways, bridges, and embankments attached to the canal. The water-cess officers impound the cattle of the villagers whenever they are found grazing in those places and the villagers are required to pay annas 5 per head of cattle to the pound keepers to have their cattle released by way of fines and feeding charges. Before the canals were excavated, the cattle were set to graze wherever they liked and they were neither sent to the pounds, nor were any charges made upon them. Now-a-days, the cattle are always kept guarded and can not be let out without proper watch kept over them. Owing to the fact as already said that the canals run very close to the villages, it is very difficult for the villagers to prevent their cattle from going astray in spite of proper guards. Failing to keep their cattle properly watched,



the people are compelled to enter into a private arrangement with the watercess officers, so that they may not impound the cattle at any moment they like. With all their attempts at economy the cultivators are unable to keep their cattle at so enormous expenses, and finding no alternative, many of them have disposed of their cattle; hence the number of cattle in the villages by the side of the canals is much on the decrease. To ascertain the correctness of this information, one has simply to look into the pound registers, where an increase of income is clearly to be observed. It will be found that the number of cattle now taken by the Jugannath road to other countries for sale have greatly increased. Milk and *ghee* are scarcely available at present in these villages which are the principal food of the Hindoos. The number of cattle is rapidly decreasing and the cultivators cannot be expected to prosper. This requires being early enquired into by the authorities.

\* 20. There are villages surrounded on all sides by the distributaries and the villagers and their cattle have of necessity to cross these distributaries almost every day. If they are damaged a little, the water cess officers keep them closed for 2 or 3 days which cause great troubles to the villagers, who are at last compelled to get them repaired with their own money. The trouble which the people have to suffer in consequence knows no bounds.

21. The naturally low lands are kept under water almost all the year, sometimes by the continual-oozings out of water from the canals and the distributaries to which they adjoin, sometimes by the water supplied to the sugarcane plantations for which *ka buliats* have been executed and sometimes by the passing of water while the canals and the



sub-canals are partially kept dried for the purpose of deepening them further. These deep places are therefore ever left uncultivated, but their tenants are never exempted from paying rent, watercess &c. From my personal experience I say that at some place from one to two *balties* (a *bali* = 20 acres) of lands have been left in a state quite incapable of being tilled, to the great loss of their owners.

22. The patrol officers who are deputed to distribute canal water to the cultivated lands do so sooner or later if they get or do not get any illegal gratification from the people. Thus it happens that people who are unable to satisfy these officers do not get water in time to the damage of their crop. The distributaries are so situated that it is impossible for the patrol officers to distribute water in due time to all the cultivators. Hence it happens that proper time for cultivation expires before water is received in many places and the cultivators quarrel among themselves each wishing to have his fields watered first. This brings on many criminal cases and entails much pecuniary loss to the people. Early steps should be taken for proper distribution of water.

23. If the people object to paying watercess falsely charged upon them they are not listened to by the collecting officer but are told to put in petitions mentioning their grievances. They accordingly apply to the proper authorities depositing fees for *amins* &c. The ground on which such cesses are charged on the people is that their fields were watered which in fact is not true. But as in most cases enquiry is not promptly made they fail to make good their just plea and have at last to pay the cess not to say anything of the expenses incurred while the case is under investigation. In order to be relieved of a false charge of Rs 1-8-0, twelve annas is to be paid for nothing, besides the *amin's* fee, cost of appli-



cation &c. But the cultivators do not receive any material benefit from the hands of the investigating officers, therefore they remain silent. It is desirable that speedy enquiries should be minutely made by special officers who are reputed to be honest and just.

24. The water cess officers take as annual gift from the people, paddy, tobacco-leaves, molasses, *ghce*, &c. in proportion to the lands they possess. In case of refusal for payment of the same, their cattle are maliciously sent to the pounds or they are put into some other unnecessary troubles. In this way the water cess officers compel the people to give them a share of the crops and thereby tax them too much.

25. The *amins* who were employed to make a rough survey of lands through which the canals would pass were mostly poorly-paid temporary hands and honest work could not be expected from them. Being irresponsible officers they did not hesitate, in many cases to do things in their own way solely guided by a desire to secure their own profit, no matter whether the people suffered or the interests of Government were sacrificed thereby. Water cess was imposed by them upon lands which are never watered by the canal water, upon those where no crops can grow on account of profuse supply of canal water and upon those where the usual supply of water cannot stand for the canal or the drains attached to them which take off all the water as soon as accumulated.

26. The people have been now over-burdened under this illegal taxation and it is most likely that if the evils under which they suffer be not soon remedied their condition will be indeed very deplorable. The lands may grow entirely barren by having no silts deposited upon them owing to the ways of usual water being obstructed by the canals and the distributaries and crops may not grow with success. The people have been

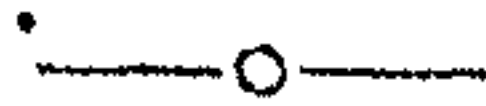
hitherto paying their land-rents and land taxes by borrowing money. They may be heavily indebted within a short time and may be never able to mend their fortune. Being placed under these painful and melancholy circumstances the people have not been able to pay their Zemindars with ease and there have been 2 or 3 years' rents in arrears and it will be most difficult for the Zemindars even to pay Government Revenue. If the Zemindars take proper action to collect their rents to satisfy the Government demand, most of the people will have take to flight leaving their lands and homesteads and no one will be forthcoming to take their lands. This state of things is already beginning to manifest itself.

Sashi Bhusan Mukerji

Delegate of the

National Society

Balasore.



## TRANSLATION OF THE PETITIONS OF THE OPPRESSED RYOTS.

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We the under-mentioned cultivators of the Mouzas Athaipali, Betra, Mulgan and Goherani in Pergunah Randiaorgora; Mouza Bara Rampur Ph Dhamnagar; Ma Bishnupur Ph Bayang; Ma Darara Ph Senaut; Ma Jalmandua Ph Jahangir situated within the jurisdiction of thana Bhudruck, Subdivision Bhudruck, District Belasore unanimously complain that we are oppressed in the following way on account of the Irrigation cess on lands lying within the vicinity of this High Level Canal. There is no tenant in these mouzas who have not given Kabuliat. The patrolling and other officers of the Irrigation Department persuaded us all to give Kabuliat for three years to irrigate our lands, assuring that there would be no inconvenience whatever. Now we have come to know that there would be no good harvest if we thus irrigate our lands. Because the outturn of our lands during the three years under irrigation was not half as much as of the years previous to it.

Here we pay for paddy fields at the rate of 1-8 per acre as irrigation cess, Rs 2 on an average as rent and Rs 1 on an average as charges for cultivation, whereas the out turn of the said acre is Rs 5 on an average. For an acre of sugarcane plantation we pay Rs 6 as irrigation cess and Rs 4 as other charges. In short, the charges on an average are Rs 10 to 15 per acre, income Rs 30 on an average. But there are very few acres of lands suited for such plantations, we think, not more than 40 acres. We cannot expect to support our families on an income of annas 8 per acre on paddy cultivations. Within the last three years we had to sell our utensils and cattle to meet the demand of the irrigation cess and the Zemindar's rent and within that time nearly 40



tenants have fled with their families and about 25 or 30 tenants have left cultivation altogether. If we are further forced to give Kabuliāt to irrigate our lands, we all are sure to leave our holdings forever. We are not willing to give Kabuliāt even if the irrigation cess be reduced to 4 or 8 annas per acre. We know we cannot expect good crops by irrigating the lands. The patrolling officers instituted many cases against us on the false plea of stealing water of the canal. A similar case of Ma. Darara is still pending and we are unable to take any measures against it. There is a Government boat to cross the canal but it is generally used by the Contractors who take it to some other places to load bricks and lime and therefore we feel much inconvenience to cross the canal, to take seeds to the fields. The moment the bullocks, going to the field, stand on the canal embankment, they are taken to the pound-house which cause us to suffer much trouble.

Out of fear of the Government officers we bear these sorts of inconveniences patiently. Since the Thesildar Achhutananda Mahapatra and a subject named Bhim Singha of Athaipali were unnecessarily harassed four years ago by a patrolling officer named Janmaioy Singh and a khalasi Madhu Guchhiat and made to pay a fine of Rs 80 by the Subdivisional officer Bhudruck on a false charge of snatching away spade & shovel during the time of cutting the embankment, we have been much terrified.

During the assessment of irrigation cess, the Amins, deputed to measure our lands, threatened to increase the area, but on taking bribe they submitted to their superiors actual measurements of lands under irrigation. During the rainy seasons the houses in the villages situated on the Western side of the canal embankment are washed away by the flood on account of the water course being obstructed by the said embankment.

Here is a rivulet called the Sankapali whose bed they keep dry by causing its water to flow to a new Nulla, consequently we suffer much from scarcity of water required for drinking, bath



ing and cultivating purposes, which difficulty would have been removed had two bridges been constructed on the sides, by cutting its *Bund*. Last year they took water through the Mouza Athaipali to irrigate the Mouzas Goherani, Mulgan and Jalmandua, and others. Before the last harvest the term of three year's Kabuliat of Athaipali expired and we did not renew Kabuliat to irrigate the said Mouza. But they let the canal water pass through the Mouza and on the plea that we have stolen water, the officers of the irrigation Department have surveyed the said Mouza by an Amin to assess irrigation cess and now and then they are demanding the said cess. We have no such means to meet the demand. We subjects of the said Mouzas numbering about 200 in your (Society's delegate) presence have said what is true and there is nothing to the contrary. We have signed this complaint of our free will. Specially we subjects of Goherani and Mulgan for want of rain required one year's lease in *Kartio* 1291 to irrigate the said Mouzas to save crops from withering away but the patrolling officers after supplying water have compelled us to sign Kabuliat for five years against our will. We do not wish to give five years' Kabuliat, as the water gives us no benefit. We have no means to pay the irrigation cess. We will not use the water of the canal even if the Government takes five years' cess forcibly from us. We will rather go to some other place leaving our homesteads.

When in *Kartio* last we signed Kabuliat we thought that we shall have to pay the cess for one year only but during the survey of our lands we came to know that the cess would be assessed for five years. During that *Kartio* we saved crops of the Mouza Bara Rampar by water taken from the ponds &c. but an Amin has measured the said Mouza and we hear that is to be assessed.

1. Arut Bulluv Mahapatra 2. Bipra Senapaty 3. Das Panigrahi 4. Lakhmi Charn Das  
5. Audi Panda 6. Bholi Panda of Bishnupur, Ph Bayang

1. Napan Panda 2. Dhani Mahapatra 3. Dattari Samol of Darai Ph. Senaut
1. Abhi Sa 2. Sandi Sa of Jalmandua, Ph. Jahangir
1. Madha Das 2. Gourl Dhal 3. Bhagbat Nayak 4. Chaitan Bohara 5. Lukhan Das
6. Harokrisno Das of Betra, Ph. Randlaorgora
1. Aparti Panda 2. Anu Patra 3. Sana Pusti 4. Bhaig Panda 5. Mana Bhora 6. Aparti
- Niak of Bar Rampur, Ph. Dhamnagar.
1. Dinabandhu Panda 2. Kosa Barik 3. Kanhai Sha 4. Abhi Baik .. 5. Kala Das 6. Bhikari
- Barik of Goherani, Ph. Randlaorgora.
1. Madhu Panda 2. Natha Sui 3. Sadai Panda 4. Gadai Panda 5. Radhu Panda of Mulgan,
- Ph. Randlaorgora
1. Bipra Charan Mahanti 2. Narahari Mahapatra 3. Markanda Panda 4. Sobhakar Misra
5. Shiba Misra 6. Dhani Sui 7. Hari Nayak 8. Aparti Jona 9. Madhu Sahu 10. Sadi Sahu
11. Gokhai Sahu 12. Bhikari Mahanti 13. Kali Sui 14. Rusi Sahu 15. Kapil Sahu 16. Hari Nayak
17. Shiba Behara 18. Madhu Nayak 19. Guni Upadhy 20. Majum Panda 21. Satari Mahal
22. Banamali Padhan 23. Atang Panda 24. Ganesha Upadhy of Athaipali, Ph. Randlaorgora.

The petition of the subjects of Mouza Dhakhindhar, ~~Ph. Sena~~  
thana Dhamnagar, Subdivision Bhadruck, Zillak-Balasore.

1. Officers of this irrigation Department supply water every year from the month of *Magh* to the Sugarcane plantations through our Mouza inundating our lands. Consequently we feel much inconvenience to cultivate our lands which remain under water from the month of *Magha* to *Aasar*. When we get any opportunity to cultivate them, the lands are again washed away by the canal water passing through our Mouzas. We have been suffering from these sorts of inconveniences to cultivate our lands for 4 or 5 years.

2. Last year in the month of *Kartik* when there was no rain, the patrolling officers intentionally causing the canal water to flow through our fields threatened us to give *Kabuliat* on the plea of our using the water. But we objected to give *Kabuliat* as we did not require water at the time. On account of their this irrigating the fields most of our *Loghu* harvest have got damaged. The Amins of the said Department have recently surveyed the the fields thus forcibly irrigated and fixed irrigation cess for the realisation of which they are oppressing us. Moreover the said Amins have forcibly caused us to sign the *Kabuliat* for five years threatening to assess at the rate of **Rs 6** per Acre. We have not consented to that.

3. Water, during the rainy season, being obstructed by the canal

embankment and getting no free passage, considerably damages our houses. Seventenants of the said Mouza have fled away with their families owing to the oppression from irrigation cess and two have left cultivating altogether. The canal officers forcibly realise irrigation cess in spite of the subjects leaving their fields uncultivated without making any proper enquiry. For which we suffer much. When the said officers fail to realise the cess thus falsely assessed, they instead of attaching our properties took steps to humiliate us and in some cases seized us by warrant in order to subject us to dishonor. Two or three respectable Zemindars, of the said Mouza, worth thousand Rupees, have been thus humiliated, for which we feel much disgraced.

4. Amins and temporary Amins taking bribe to the extent of about Rs200 from us in order to leave unirrigated lands from assessment, have assessed and realised cess. We have applied several times in several places on the subject but to no effect.

1. Chaturbhuj Sonapaty 2. Bhuban Das 3. Nalu Patia 4. Nalihar Mahapatra 5. Mondra Patia 6. Darsan Patra 7. Ganeshur Das 8. Kamal Patra 9. Gopi Patia 10. Damu Sonapaty 11. Bhag Padhan of Dakshin Ph Soso.

The petition of the subjects of the Mouzas Rahimabar, Ph Soso, thana Dhamnagar, Subdivision Bhudruk, Zilla Balasore

1. Last year in the month of *Kartik* the patrolling officers have damaged most of our harvests by irrigating our fields forcibly. Notwithstanding our objections they have surveyed the lands both irrigated and unirrigated by deputing Amins and assessed them at the rate of Rs 6 per acre. They are now oppressing us much on the plea of our stealing water. They are unnecessarily threatening us to sign 5 years' Kabuliat. But we are unwilling to give Kabuliat knowing the water to be of no good to cultivation. Moreover we have no need of water.

2. We have on several occasions ineffectually petitioned to get rid of the illegal realisation of the assessment on the false plea of using water. We are sorely oppressed for the realisation of the cess. We have no means to pay it. Two or three



villagers have fled away out of the fear of paying cess.

3. We have to suffer for supplying food to the patrol officers, Amins Chaprasees when they come to our Mouzas, otherwise we would be subjected to endless trouble and oppression.

4. The amins come to our Mouzas and frequently demand bribe on the plea of leaving unirrigated lands from assessment. But we neither have faith in them nor we have any means to pay. We are ready to prove it. Dated 16—4—84.

1. Madan Panda 2. Madhu Samal 3. Nari Pusti 4. Bhagi Sahu 5. Mohon Naik 6. Maguni Panda 7. Dason Rana 8. Chaudia Behra 9. Nabha Das

The petition of the subjects of the Mouza ~~Sorepau~~ ~~Th~~ Jajpur thana Dhamnuggur Zillah Balasore.

We do not require to irrigate our lands. We are not in want of water as our lands are very low. Last year there being scarcity of water we took water on one year's lease. But we have not been much benefitted by it. On account of our refusing to give Kabuliya the canal officers are threatening us and asking bribe to leave our lands unassessed. In this Mouza the Zemindars revenue is higher, to this if irrigation cess be added there will be no gain left to us. Subjects of other Mouzas who have given Kabuliya take water through this Mouza, we thereby suffer much and our lands are left culturable waste. 20—4—84.

1. Hari Chand 2. Dinabandhu Rout 3. Samidhi Rout 4. Gopal Rout 5. Lakhan Rout 6. Majun Sahu 7. Madhu Rout.

The petition of the subjects of the Mouza Alia, Ph Jajpur thana Dhamnuggar, zilla Balasore.

We have not taken lease to irrigate our lands, we did it before, our lands being too low to require irrigation as they are always under water. But the patrol officers have forcibly irrigated our lands in the month of *Makar* and thereby much damaged our ripe harvest by letting in water. Then the Amins surveyed these lands in *Magh*. During the survey we were not sent for to define our boundaries. Bribe was then demanded of us which being refused they have increased measurement at the rate



of one-fourth per acre and have assessed at Rs 6 per acre falsely. Further they are pressing us hard to take 5 years' lease by charging us with stealing water for which we have become helpless. 20-4-84.

1. Joyhari Dhal 2. Darsan Barik 3. Gadai Rout 4. Aiat Samal 5. Nosakar Bhunj 6. Kesur 8. Anu Samal of Alla.

The petition of the subjects of mouzas Naguan and Dhani-garia, Ph Dhamnuggar, thanah Dhamnuggar, Zillah Balasore.

In *Kartio* last the patrolling officers forcibly irrigated and surveyed the fields of ripe *Loghu* crops which were partly harvested and thus damaged the crop to the extent of four an-  
~~as.~~ Our complaints were not attended to. The patrolling officers are at present oppressing us to realize the cess at the rate of Rs 6 per acre on the plea of taking water without Kabuliat and forcing us to give Kabuliat for 5 years. We brought these oppressions to the notice of the sub-Divisional officer Bhud-druck and the Commissioner, but to no effect. We are now help less. Dated 20-4-84.

1. Bhubi Mahapatra, 2. Bhabagrahi Mahapatra, 3. Bhiknai Mahapatra, of Naguan, Ph Dhamnagar.

1. Panchananda Nayak, 2. Achhut Bohora of Dhani-garia, Ph Dhamnuggar.

The petition of the subjects of Mauza Kharsinga, Ph Jajpur, thanah Dhamnuggar, Zillah Balasore.

Last year during the time of cultivation we wanted to irrigate some high lands in the mouza and therefore we took a year's lease, but the patrolling officers forcibly irrigated even those lands where water was not required and surveyed them. They realized cess at the rate of Rs 3 per acre on those lands for which we took a year's lease and by oppression assessed the other lands which they forcibly irrigated, at the rate of Rs 6 per acre on the plea of stealing water and are forcing us to give 5 years' Kabuliat. We are therefore helpless. Dated 20-4-84.

1. Hingibla 2. Dhurub Sahu 3. Mukunda Sahu 4. Sachi Sahu 5. Apatti Mullik 6. Das Nalla of Kharsinga, Ph Dhamnuggar.

Petition of the subjects of Mouzas Lukhnisagar, Parbati, Niladry, Ph Manjuri, thana Dhamnuggar, Zilla Balasore.



'Last year we heard that some cultivators took lease to irrigate some of their fields, all of them did not give any Kabuliat. The patrolling officers in order to irrigate the lands of those who took lease, forcibly irrigated parts of the lands of those who did not, and then surveying lands both irrigated and unirrigated, assessed them. Then threatening to realize cess at the rate of Rs6 they have taken Kabuliat as well as bribe. They have become callous to our complaints. We do not want water and consequently wish not to give Kabuliat. If we are compelled to give Kabuliats for 5 years and pay cess we shall be obliged to sell our homesteads. We have no hopes to avoid giving the ~~Kabuliat~~ ~~liat~~. The outturn of the crops of the last three years has been reduced by 50 per cent. We have become totally helpless. Dated 19—4—84.

1. Prahalad Mahanty, 2. Ram Sulu of Niladiy. 1. Banamali Raut 2. Mana Raut of Kaltra.

1. Chanda Sonaputty, 2. Padan Sonaputty, 3. Bata Sonaputty, 4. Maguni Suin, 5. Dhanup Parira of Lukshigur

1. Buxi Arut mahanty, 2. Bani Khuntia, Padu Dallal of Parbati, Ph Manjuri.

The Petition of the subjects of Baligari, Ph Soso, thana Dhamnuggar, Zillah Balasore.

'In the latter part of the month of ~~Kartik~~ the irrigation officers forcibly irrigating our mouza, filled our fields with water, which made us lose half our harvest. They have also unjustly surveyed our fields whether irrigated or not and even those which were fully harvested, and assessed them. An Amin named Ram Chundra Das has beaten us, taken bribe from us and forced us to give kabuliats. We have in no way profitted by the water, still we have been obliged to pay at the rate of Rs 3 per acre. We have no intention to give kabuliat. The rent of the Zemindar is Rs 2 per acre, cost of cultivation Rs 3 per acre on an average, the value of produce is Rs 5. In addition to these the ordinary cess is Rs 3, for taking water privately Rs 6 per acre, and for the Kabuliat for 5 years, Rs 18. Dated 18. 4. 84.

The petition of the subjects of Ma Baibanapur, Ph Soso, thana Dhamnuggur, Zillah Balasore.

In last *Kartik* the patrolling officers by forcibly irrigating our fields damaged our ripe crops. Then they have forcibly surveyed all lands whether irrigated or not and assessed them. At present they are greatly oppressing us to give the five years' Kabuliat. If we give no Kabuliat they say they will realize at the rate of Rs 6 per acre. During the survey, Amin Chundra Sikhar has taken Rs 80 as bribe. We can likewise prove various other oppressions which we were ~~surveying~~.

1. Duija Jena &c. of Baibanapur

The petition of the subject Sudanandpur, Ph. Saheb-nagar, Ma Suribana, Ph Matkadabad, thana Dhamnagar, Zillah Balasore.

During the latter part of the month of *Kartik*, when there was no want of water in our mouzas, the irrigation tax collector, in order to irrigate the other mouzas filled ours with water, which cost us one-fourth of our harvest. We represented these facts to the superintendent of irrigation during his stay at Vandaripookur and prayed to take him, at our own expence, to the said Mouzas, for local investigation but to no effect, for, he instead of taking any means to compensate our loss has falsely charged Rs 6 per man, on pretence that we had stolen water and oppressed us to give Kabuliat (agreement) for five years. Now we have no means of getting our livelihood.

1. Hari Panda 2. Fakir Panda 3. Dhatri Padhan 4. Chatter Padhan 5. Madan Sahu 6. Bhogwan Raut 7. Radhu Bhui 8. Gangai Raut 9. Sarat Bisal.

The petition of the subjects of Mouzas Rata and Hajipur Ph Jajpur, thana Dhamnagar, Zillah Balasore.

We did not give any Kabuliat, but in the latter part of last *Magha* the patrol officers by force let the water pass over our lands and surveyed them as well, as those which were not irrigated at all. The surveyors, at the surveying, did not call us

to show them our respective lands, but relying on the *shonkidars* of the said Mouzas, fixed cess of one's land on another's head. They are greatly oppressing us to give Kabuliat. As the outturn of the crops of the last year was very bad, we are not in a position to pay the said cess and we hear that our household properties will be put to sale for the realisation of the cess. No one listens to our complaints and we have at last have obliged to be silent. Dated 19. 4. 84.

1. Sadasiv Das 2. Nokai Raut 3. Suraja Naik 4. Banker Naik 5. Ananta Naik 6. Donai Sankhua 7. Dusori Naik, 8. Bauri Naik 9. Apariti Naik 10. Gudai Samal 11. Mund Parha.

The petition of the subjects of Mouza Mahanandapur, Ph Shahenagar and Ma Sreepur, Ph Soso, thana ~~Dhamnagar~~, Zillah Balasore.

At the latter part of last *Kartik* the patrol officers having irrigated our lands forcibly, have thereby caused much damage to our ripe paddy crop. The Amins fixed rates upon the lands which were thus irrigated as well as those which were not and by force took our signatures on the Kabuliât form. We derive no advantage whatever from the said water ; but still we have been obliged to pay the cess and execute Kabuliat. Our several representations about these inconveniences have proved fruitless. We pay the Zemindars' of these mouzas Rs 3-8 as rent per acre, besides we have to spend Rs 3 per acre in rearing the crop. The price of the outturn is Rs 7 per acre. Over and above these if we have to pay cess for irrigation we shall be put to a great loss.

1. Bidai Behera 2. Bhujan Sahu 3. Banamali Niak 4. Bhaig Sahu.

The petition of the subjects of Mouza Baigaria, Ph Dhamnagar, thana Dhamnagar, Zillah Balasore.

On the 4th *Agrahayan* last the patrol officers destroyed half the crops of about 10 or 12 acres by forcibly letting the water pass over the lands. Rather than deriving any benefit there-from we had to suffer for it and still our lands have been surveyed and assessed at the rate of Rs 6 per acre. In order to realise this cess and to induce us to execute Kabuliat for five



years, the canal officers are now oppressing us very much. We have no need of water and are unable to execute Kabuliat. There are about 2 acres of sugar-cane plantation in this mouza, is the owners of it fall in need of water they may execute Kabuliat and we have no objection to that. We have represented the oppressions of the canal officers to the Commissioner but no order has yet been passed on our application. 18. 4. 84.

1. Bhujan Sonaputy 2. Kanhu Nlak 3. Banamali Raut 4. Kunhal Naik 5. Raja Mullio

The petition of the subjects of mouzas Karikana, Ph Jajpur and Pirpur, Ph Bayanga, thana Dhamnagar, Zillah Balasore.

In the last *Kartio* the canal officers opened the shoots and let the water pass against our will over the lands (5 or 6 *Batis*) of the two mouzas to supply water to those who have given Kabuliat, and in last *Agrahayan* bringing a charge upon us that we have taken water from the canal surveyed our lands. We did not get any benefit from it, on the other hand our ripe *Laghu* crops were all destroyed. At present the canal officers are oppressing us much for the realisation of the cess. They say that if we do not enter into Kabuliat for 5 years we will have to pay cess at the rate of Rs 6 per acre. At the time of surveying, the Amins have taken bribe from these mouzas, of about a sum of Rs 100 at the rate of annas 2 per acre. They have also assessed un-irrigated lands. As we do not want water we shall not enter into any Kabuliat. Owing to the oppression of the patrols and Amins and by the high rate of the cess we will not in any way profit by it if we give Kabuliat. The rent we pay to the Zemindars of these mouzas is Rs 2-12 per acre and the expense for cultivating per acre is Rs 2. The outturn per acre is Rs 6 on an average. If we be made to pay irrigation cess at the rate of Rs 1-8 per acre then it will leave us no balance for our labour.

1 Hari Potty 2 Lokat Nlak 3. Angi Naik 4 Rami Jona 5 Sanku Patra 5. Uddhab Sahu  
7. Ram Samal 8 Pankuj Sahu 9 Sagun Sahu 10 Kholia Sahu 11. Nabha Das 12 Bhogwan Das

The petition of the subjects of mouza Surhar, Ph Soso thana Dhamnagar, Zilla Balasore.

Owing to the oppressions of the patrols we have never executed Kabuliat. But on the latter part of last *Kartik* they out of their own will let the water go over our ripe crops that were laid to the ground by bamboos for the sake of our convenience of harvesting and thereby put us to a great loss. After that in the month *Agrahayan* the amins came and surveyed the lands in which there were crops as well as those whose crops had been harvested before this and assessed at Rs6 per acre. We have no means by which we can pay this cess. That water did us no good, still if our homesteads be brought as we hear, to auction for the realisation of the cess, we are at a loss how to live here with our families and children. From the date the canal has been excavated our fields are not inundated by the Baitarni, therefore they are gradually turning unculturable wastes. The Canal patrols and Amins are threatening us much to enter into Kabuliat for the water, but as we are not in want of the water as it brings us in no good crop and as we are unable to pay the cess and suffer the oppressions of these canal officers. If the Government kindly fix the rate of one or two annas per acre, then we have no objections. Unless the oppressions of the Canal officers be checked we can not derive any benefit. The rent, we use to pay to the Zemindar of this Mouza, is Rs1-8 per acre, the charge for cultivation is Rs 2 on an average, outturn Rs 5. We generally used to pay cess at Rs 1-8 for five years' Kabuliat, Rs 3 for a year. They generally realize at the rate of Rs 6 per acre on the false charge of stealing water; besides there is bribe.

Dated 16-4-84.

1 Ram Paria 2 Mhindar Paria 3. Paikhit Sahu 4 Agul Paria 5. Dhurub Paria

The petition of the subjects of Mouza Chandravanpore, Ph Soso, thana Dhamnagar, Zilla Balasore.

We never executed Kabuliat for water cess but on the 8th of the



*Kartio* last the sugarcane cultivators who executed Kabuliat opened shoots and let go the water through our lands thus placing our ripe paddy under water by which one-fourth of our crop was lost. Then the Amins surveyed the crop fields under the pretence of our having taken water privately by this too we have been losers. We derive no benefit from that water and we do not want it.

The canal officers are threatening us to execute Kabuliat for five years, otherwise they will realise cess at the rate of Rs 6 per acre. We cannot execute Kabuliat even if the rate be reduced to two or four anas per acre.

The productions of the lands are not half as much as before for the water of Baitarni cannot come across the canal embankment consequently the silts are not deposited on the fields.

The Zemindar's rent in this mouza is, on an average, Rs 2 per acre and the cost of cultivation is Rs 2 and the outturn Rs 6. Two ryots have fled from this Mouza. Some ten or twelve ryots have left cultivations unable to suffer these oppressions. We applied to the sub-divisional officer Bhudruck and the Collector of irrigation Cuttack, but up to date we have received no reply.

1. Bhogwan Sahu 2. Dasrathi Tilhai 3. Laki Betti 4. Kesab Bohora 5. Bhikari Panda 6. Bhujun Das.

The petition of the subjects of Mouza Sarsada, Ph Jajpore, Thana Dhamnagar, Zillah Balasore.

At the end of last *Kartio* the Canal officers forcibly irrigating our fields forced us to sign the Kabuliat. At the time of survey Amin Arut Mahanty took hundred Rupees as bribe from (our) this Mouza. Then Amin Ram Chandra Das coming to survey it again took Rs 1-4 per acre as bribe, and fixed cess at Rs 3 per acre. We have no means to pay the cess. If the cess be realised by force we will fly to the Gurjats. We can prove that the above mentioned Amins have taken bribe from us. We pay to Zemindar on an average Rs 2-8

as rent, the cost cultivation Rs 3-8 and the production Rs 5-8 per acre; if in addition the cess be levied on us there will remain nothing.

Paban Sain 2 Kamal Palia 3 Bai Nanda 4. Markanda Sain 5. Nisakar Singh 6. Madan Rout 7. Bhikari Sain 7. Dhum Singh of Sarsada.

The petition of the subjects of Mouza Palda, Ph Soso, thana Dhamnagar Zillah Balasore.

That the subjects, of the surrounding Zemindaries lying to the East and West of ours executed Kabuliats for irrigating their sugarcane plantations for the year 1290, they recieved water by digging a *nala* through our Mouza. But the current of the water being very furious, the *nala* overflowed its banks and spread its water over the villages on the East and West of the Jagunnath road and thus wasted the crops on the neighbouring fields, and made the people suffer much for communication with each other from the excess of water in their villages; the current also took away with it the fishes from the tanks and fisheries, for which they had executed Kabuliats and about 17 acres of culturable lands being left uncultivated. This has been a great loss to our people.

That some of the people on the East and West sides of our Zemindari having exeuted Kabuliats in the month of *Kartio* 1291, and some without Kabuliat wanted to irrigate their lands. On seeing that they are trying to carry water through our Zemindari, to their lands, we and our subjects went to the patrols and Amin Ram Chandra Das who were at Vandari Pokhar and informed them that we do not want to irrigate our lands. But as it accumulated in our lands, we may be put to difficulty. On this we were given to understand that no oppression should be done to us, even if the water be taken through our lands, we therefore did not file any petition on the subject; and at last the water was taken to other place through ours while we needed not any, which will be proved on enquiry.

That on account of the spreading over of water on some of the lands of our Mouza, the present Amin Nidhi Mahanty

and Ram Chandra Mahanty in conspiracy with their friend Bauribandhu Mahanty with whom we are in bad terms have measured all the low and high lands with those which are unfit for cultivation simply with the intention of leading us to trouble and the Amins turned a deaf ear to all our objections laid before them. We or our subjects would have executed Kabuliats if we had need of water or at least we would have been candidates for the same; but the case never happened. We therefore request that careful enquiries be made as to how we should be liable to pay the cess while the subjects of other Mouzas have taken water and have been benefited by it, or else it will go hard with us poor subjects.

1. Bhaghatih Sahu 2. Sudason Das 3. Bhikari Sahu 4. Kanai Basik 5. Bidu Palia 6. Andi Palia 7. Nidhi Das 8. Bhikary Satty 9. Maguni Panda 10. Gopi Sahu 11. Gobindhan Panigrahi 12. Laruni Panda 13. Parkhit Panda 14. Banamali Panda 15. Gopi Panda of Palda Ph Soso.

The petition of the subjects of Mouzas Kandita, Gobindapur, Manateri, Allando, Batimira, Haldiapara, Sampoorisahabaz Kolentira, Panapuri, Barapuri, Mahatal, Darasasan, Ph Hariharpore; Mouza Ramcoomarpur, Saungpur Archipali, Katu, Kamarpada Ph Giana Zillah Cuttack.

We from time immemorial have been tilling our fields during the rainy seasons. The outturn is sometimes full, sometimes half and sometimes one-fourth, from price of which we were paying rents. In 1284 and 85 Government gave notice to execute Kabuliats for taking water from the Canal at the fixed rate. On this we objected that the rate of rent is very high and if to it the irrigation cess be added, it will be very difficult for us to maintain ourselves. We said that, if the rates be fixed at four annas per acre we can pay, but our objections were not attended to, and our fields were forcibly irrigated and assessed at the rate of Rs 2 per acre. In this way two years were passed. During this time some of the ryots executed Kabuliat of irrigating their fields at the rate of one rupee



per acre. We all objected to the payment of one rupee eight annas irrigation cess when all the lands were assessed in 1286 for five years ending 1290 (both inclusive.) If the rate be fixed at annas six at the most we can pay without difficulty. But the officers collecting our addresses from the villages Choukidars have forced us to sign the Kabuliat. Afterwards those, who could afford, paid easily but those who could not had their houses trespassed and their cattles, utensils and doors carried away forcibly. We have therefore been much harrassed for the payment of cess, which has in some cases been doubled. Many ryots have brought these oppressions to the notice of the district officers but to no effect; for these we feel ourselves undone.

3rd. If by chance cattle happen to be found on the Canal embankment, they were impounded and a fee of annas five for each cow was realized from us. The Khalasees and the patrol officers realize money by threatening to send our cows to the pound even if they were found grazing below the embankments.

4th. Government during the settlement had measured the lands. The Canal officers, measuring the same on their own way, have taken one survey acre as one and six twenty-fifth acre and have accordingly realised the cess.

5th. Owing to our ineffectual attempt of making the sub divisional officers hear our complaints no ryot has executed Kabuliat in 1291. Therefore the officers having forcibly irrigated our lands and assessed at the rate Rs 3 and 6 we have again petitioned the District Magistrate filing the cess form. But nothing has yet been decided.

6th. If we sow two crops such as paddy and cotton or other summer crop they realise double cess. They not only realize



cess from the lands that are irrigated but even those that are not irrigated, which is unsufferable.

7th. Besides the above we are threatened to pay bribes to the Overseers, Sub-overseers, Tehsildars, Amins, Patrols, Khalasees and the Coolies. If they are not paid they make us suffer in a variety of ways. They listen to no objections for which have been suffering much. For these many of us have lost their castes and many have no utensils and doors and and some have lost their lives being unable to suffer and some have left their homesteads.

Dated 3rd May 1884.

1. Banamali Niek 2. Hari Suin 3. Fagu Suin 4. Kanahi Jona 5. Lokai Sahu 6. Narayan Das of Archipali.

1. Lokai Padhan 2. Bisai Padhan 3. Kapati Padhan 4. Rahas Rout of Kamarpada

1. Punai Suin 2. Kanika Suin 3. Gangadhar Suin 4. Hari Paira of Darasasan.

1. Jalkur Panda 2. Markanda Panda 3. Bhikari Panda of Katu.

1. Bhikari Behora 2. Kessori Misra 3. Hari Behora 4. Surja Neka of Ramcoomarpur.

1. Lokanath Maharna 2. Somnath Suin 3. Rahas Sahu 4. Raghu Sahu of Suangpur

1. Magu Suin 2. Dhanu Behora 3. Fakir Sahu 4. Ram Das of Sampoolasahabaz.

1. Kasi Rout 2. Kunahi Rout 3. Ram Baik 4. Lali Khuntia 5. Sadai Bhol of Kolentira.

1. Braja Mahanty 2. Bhugi Suin 3. Bhubni Niek 4. Sana Paira 5. Kesori Das 6. Fakir Suin of Allando

1. Chintamony Boral 2. Kmp Rout 3. Barju Panda 4. Pati Biswal 5. Ananta Behora of Hal-dipara.

1. Braja Kumar Boso 2. Anadi Mullik 3. Ponkuj Suin 4. Babun Panda of Balmira.

1. Routi Behora 2. Mon Panda 3. Babun Paul 4. Babun Panda of Panspur.

1. Dattari Thari 2. Bhujun Suin 3. Issor Padhan 4. Apari Biswal of Mahatal

1. Srikanth Jona 2. Bhubni Niek 3. Darson Misra 4. Karuni Jona of Manthil.

1. Bhubni Khunta 2. Gobinda Khunta 3. Damodar Khunta 4. Sadhu Sahu of Kundita

1. Bhagbit Suin 2. Guda Sahu 3. Apurti Mullik 4. Dasu Mullik of Gobindapur.

1. Dhanu Rout 2. Narayan Suin 3. Kessori Rout of Barapuri

Taldanda and Machhgan canal.

Petition of the subjects of Mouzas Jasole, Patuare, Jantapara, Kantuar, Arung, Sankarpur, Sibpur, Siuli, Arna and Malliunch Phs Hariharpur, Bahubisi and Paimda, Zilla Cuttack.

1. Our village is surrounded by a *nala*, if our cattle ever graze on the embankments they are instantly impounded and we are put to much loss of money to release them. We have



therefore sold all our cows and calves, keeping only one or two.

2. In some cases the level of the land is so high that no water can flow there and in others it is so low that the water always remains accumulated. This does much injury to the crops but no reduction of cess is allowed to us.

3. Owing to the embankment of the Machhgan branch canal, the mouth of the junction at Kundi having been stopped the water amasses in mouzas Arung, Sibpur, Josole and others to such an extent that crops are seriously injured yet we are not relieved from the Zemindars' rent or the irrigation cess.

4. If we grow two crops on the same land a year, we have to pay cess twice.

5. The cess is paid in one instalment; if owing to some disadvantages we delay the payment, we are put to trouble. We are treated with insult, our properties are attached and sold; men of low caste (such as *Pans*, *Kundras* and *Mehomedans*) are ordered to enter into our houses and take away our properties by which we lose our caste. By such means the cess is being realized.

6. For each acre of land we pay Rs 3-2 on an average as Zemindar's rent, annas 3 as Road and P. W. cess and 1-8 as irrigation cess and if we grow a second crop on that land we pay irrigation cess from Re 1 to Rs 6 per acre and besides according to the prevalent practice in our country, two *gaunies* (a *gauni* is equal to 11 seers) of paddy is assigned for the carpenters and four *gaunies* for washermen and barbers, and four *gaunies* for the chowkidar and khundait and three seers to the Khalasees for each acre in paddy fields and four *Biswas* (nearly 2 seers) of treacle for the patrols in sugarcane plantations.

7. At the time of survey, the Amins took from us as bribe from

Rs 10 to Rs 50 from each mouza holding out hopes of exempting high and low lands from assessment which they have not done. Besides this, on occurrence of marriage in the family of any of the canal officers, the patrols and Amins take from us coolies without hire, vegetables, ghee &c. and sometimes hard cash.

8. Last year, during cultivation, when the term of our Kabuliat had expired, we were asked with threats to renew them but we declined. The canal officers then caused canal water to pass into our field of their own accord and demanded from us either the cess or bribes instead of cess. But on our refusal they have now issued notices on us for the cess due on account of the water supplied in the above way as water stolen. We have made a representation to the Collector of Cuttack to get rid of these troubles. We had twice applied for the same without effect. Our condition is extremely miserable now, some of us have moved to other places, others have lost their furnitures, doors and utensils. Some have sold their rent-free lands to pay their cess. If we be forced to renew our Kabuliat we shall leave our abodes. In order to compel us to take canal water some fishery *bunds* have been cut through, drainages have been made and the water supplied by rain is thus made to take different course from that of our fields. We are in need of immediate redress.

1. Mahanta Hail kishna Das. 2. Hail Tlari 3. Sudorann Das 4. Hail Somonath Mlari 5. Gadadhar Das 6. Bhaghut Jona 7. Sindhu Sulu 8. Srikar Jona 9. Pankaj Jona 10. Bhilg Parira 11. Bhagbat Mahanty 12. Gundicha Nayak 13. Kusun Sulu 14. Bhagi Bastla 15. Bhagbat Nayak 16. Parikhot Nayak 17. Jogi Behora 18. Jogi Singh 19. Bissun Behora 20. Rusi Singh 21. Sib Sainal 22. Sambhu Sahu 23. Bhikari Barik 24. Avini Biawal 25. Nanda Nayak Bhabani Nayak 26. Bidyadhar Das 27. Doman Sahu 28. Chowdhry Kisorechurn Nayak 29. Chowdhry Perikhit Nayak 30. Kanahi Mahapatra 31. Bidai Sulu 32. Batatub Sulu 33. Padma Charan Nayak

The petition of the subjects of mouzas Raruasasan, Puja, Jagannathpur, Dardang, Raruamanjuri, Gambhapur, Araekana, Kaladhari, Damodarpur, Ayar, Marunia, Ambdarara Ramchandrapur, Salijung, Arundpal, Radung, Dhote, Gobindpukhri,

Kaligan, Jira, Barkarkor, Sankarkor, Basantpur, Nahanga, Mundalo, Pipula, Titinga, Balansa, Araekole, Sadaipur, Dauli, Sabung, Karkrajoinadadu, Deulisahi, Ayrmanjuri, Phs. Hariharpur and Balubisi, Zillah Cuttack.

1. On the expiry of the term of our former five years' Kabuliat we declined to renew it ( excepting a few ) but the Amins forced us to do so under the threat that our refusal would make us liable to pay double the cess. Actuated by fear, some of us complied with their requisition. But all of us have not executed Kabuliat as we have been losers thereby.

2. A great portion of the land of these mouzas is of very low level and can yield good crops by the rains. But we have been forced to execute five years' Kabuliat. The Irrigation officers having forcibly irrigated our fields have every year realised from us the cess. But this water far from benefiting, wasted our 10 annas crops. They took away furniture from our houses and sold them without listening to our complaints. Sometimes respectable subjects have been arrested by warrants for the realisation of the cess. Sometimes men of low castes such as *Pans Kundras* and *Mehomedans* have been made to enter our houses which have made many of us lose our castes. In order to make atonement for this corruption they had to incur debts of Rs 50 or Rs 60.

3. The outturn of our fields at present is not half of what they yielded before the introduction of the irrigation system. The rent we pay to the Zemindars is heavy, in addition to it if we are to pay cess at Rs 1-8 per acre and some bribes on each acre to the Irrigation officers nothing will be left to us. In this way we have been suffering for the last five years. Some of us have relinquished their lands being unable to suffer any longer. If we do not give any bribe to those men or serve them without remuneration or supply them with



vegetables or ghee they try to impound our cattle on the false charges of grazing on the embankments of the canal, but on being paid something they let them go or release them with some fines. For this we have been obliged to sell our cattle. Even after executing Kabuliat if we fail to pay something to them they will put impediments in the way of the water shoots, thus deprive us from taking water in time.

4, We can easily purchase the water tubes for shoots from potters at half anna each; but those men purchasing all, charge 2 annas per each without allowing us to try for ourselves, and sometimes break them with the intention of selling more. If we buy ourselves they fine us. Our condition is the most wretched now. If Govt does not take steps to improve our condition we shall have to starve and leave our homes. We are ready to prove these facts if necessary.

Dated 8-5-84.

1. Kapil Rout 2. Jogendra Das 3. Makund Barik 4. Nanda Barik of Arackole.
1. Rajiba Mahanti 2. Danardah Mahanti 3. Chakradhar Mahanti of Sadalpur.
1. Mathuri Mullik 2. Chakradhar Mahanti of Dauli
1. Arat Jena 2. Kanahi Suin 3. Bhaban Nanka of Baruasasan.
1. Arat Jena 2. Bhagat Patia 3. Udanath Patra 4. Jagu Patra 5. Dasrathi Patra of Puja.
1. Bhagabat Patia of Jagannathpur.
1. Basu Rout of Marunia.
1. Bhabani Neeka 2. Kurup Nlak 3. Mohani Suin of Nahanga
1. Kartick Nlak 2. Illigble 3. Bhabani Das of illigible
1. Bhikari Dholai 2. Gobinda Dohai 3. Bhagban Misar of illigible
1. Kartik Nlak 2. Fakir Suin 3. Bhagbat Suin of Arackana
1. Hursi Suspuati 2. Bidai Pusti 3. Pinal Lonka of Illigible.
1. Illigble 2. Satani Sethi 3. Pandub Batik of Damodarpur.
1. Ramsiv Suin 2. Sadhu Suin of Hatharpur
1. Kunahi Nyak 4. Bohari Nyak 5. Gopi Suin 6. Nanyan Sah 7. Jogi Suin of illigible
1. Sridhar Nyak 2. Mull Suin 3. Boni Nyak of Ayan
1. Arut Nyak 2. Kusun Samal 3. Hari Suin of Suranga.
1. Kesub Das 2. Gudadhar Bhol 3. Natin Guohint of Douli
1. Siva Bhol 2. Dhan Jena 3. Nabin Suin 4. Bhikari Suin of Ratnachandrapur
1. Hursi Das 2. Ram Das 3. Gopi Neeka of illigible
1. Dhanu Nyak 2. Lokai Suin 3. Nidhi Suin of Arunda
1. Nanda Pal 2. Urdhab Suin 3. Kurup Pal of illigible
1. Agni Suin 2. Bhabani Das 3. Kurup Bhol of Ichhapur
1. Kali Pal 2. Monti Mahanti 3. Narasing Pal of Gobindapukhi.



1. Basu Rout 2. Bidai Patra 3. Sadai Nayak of Kaligan.
1. Fakir Patra 2. Bidai Patra 3. Minai Biswal of Jira.
1. Gungal Suin 2. Sunkar Suin 3. Madan Suin of Aurundpal
1. Souai Mahanti 2. Narun Panda 3. Kurup Mahanti 4. Chaitmahanti of Barkorkora.
1. Bhagbat Senaputty 2. Fakir Senaputty 3. Arun Bastia 4. Bhagbat Khuntua of Illigble.
1. Mahadev Suin 2. Kanahi Suin 3. Munda Rout of Basantapur.
1. Raghunath Tihari 2. Rahas Barik 3. Kanhu Guchhalat of Nuagan.
1. Chilan Misra 3. Rahas Misra of Markdalo.
1. Govinda Mudli 2. Dhurba Patra of Pipula
1. Kalai Suin 2. Arut Suin of Titinga
1. Chintamani Sahu 2. Joyram Sahu 3. Bhikari Suin 4. Dhanu Mahanty of Balansa.

Petitions of the subjects of Mouzas Kitunpur, Katia, Ugalpur, Kantar, Dhote, Kalyanpur, Sidhal, Taila, Kakali-  
pur, Singipur, Gumtipur, Malpur, Kampur, Nimpur, Ubu-  
kara, Sithal, Bhogipur, Ph. Khandi and Jhunkur, Zillah  
Cuttack.

1. There being no necessity for canal water, we declined to execute Kabuliat. On this they dug a drainage to take away the water supplied by rain fall and we have been compelled to execute Kabuliat to take canal water which does not benefit our crops much, while on the other hand we have to suffer much for heavy cess and the bribe to the officers and for their oppressions.

2. On an average five-eighths part of the lands in these mouzas are low. Since the excavation of the canal its water accumulates there and injures the crop. Formerly the crops in these lands were prosperous consequently on it we depended much. The canal water cannot reach the high lands, therefore they are not well cultivated. Though we derive no benefit from canal water we are compelled to pay the irrigation cess, the Road and P. W. cess, bribes to several officers and rent to the Zamindars. The outturn of these lands have fallen short by one-fourth. Whenever we delay to pay the irrigation cess, we are arrested and our properties are sold by auction. In this way we have lost every thing during the last seven years. Many well-to-do subjects are now without doors and utensils.



Men of low origin ( *Pan* and *Kandras* ) enter into our houses and demand cess from us for which we are losing our castes.

3. Some of these mouzas are situated at a distance of a mile or thereabouts from the canal and the canal water can have no access there. Even these lands are assessed. It is therefore unnecessary for us to execute *Kabuliat* for these mouzas. If we decline to do so we are falsely accused of taking canal water secretly and charged with a cess of Rs 3 and Rs 6. Even in those mouzas for which *Kabuliat* has been executed, we do not get water in time of necessity for the patrols put something as obstacles in the shoots in the way of the water to the fields and ask for bribes to remove them; those that make any settlement of bribe with them easily get water but not the others. In this way we have lost much of our crops but we have not been exempted from the payment of the cess.

4. At the time of survey wherever the *Amins*, got nothing as bribe, determined the area of each man's holding as they liked. They thus assessed cess on some men who have no lands in their possessions and since last 5 or 6 years some have been paying cess unnecessarily. When rough survey was going on some *Amins* took bribes promising to exempt from cess all high and low lands, but this they never did. We represented these facts to the high officials in various places without effect.

5. The irrigation peons enter into our house during our absence under pretence of collecting cess and for an inconsiderable arrear of 1 pice they carry away properties worth Rs 2. From this they pay to Government the arrear and misappropriate the remainder. Once a peon named *Aziz Khan* wrested bracelets from the person of the wife of *Bacha Samal* of *Sidhal* for arrears. She has therefore been out-casted. *Gokhai Mallik* of *Sidhal* was once very severely beaten by them for arrears.

6. Since seven years we have been put to trouble, expense and insult of every descriptions; the representations we made at Cuttack on these matters produced no effect. Some men have given up cultivation altogether and others have removed to distant places where there are no canals. Those that have no lands are asked to give Ghee, treacle, eatables vegetables and if they refuse their cattle are driven to the side of the canal and impounded without any reason. For this we have sold our cattle.

7. These are some of the grievances which must need redress; if nothing be done for us it is better to kill us. We are ready to prove them.

1. Bhubani Suin 2. Saddai Suin of Kitunpur.
1. Ram Mahanti 2. Minal Mal of Katia.
1. Gopi Das 2. sai Mahanti of Ugalpur.
1. Bhagaban Hati 2. Dhuran Neeka of Kantar.
1. Naran Behera 2. Rahas Khutua 3. Bhagi Khutua of Dhote.
1. Ananda Pater 2. Kesuri Jona 3. Raghu Rout of Kalyanpur.
1. Samal Panda 2. Natha Das 3. Kojal Panda of Sidhal.
1. Arut Das 2. Gopi Biswal of Talla
1. Gurubari Khuntua 2. Madhoi Putty of Kakalipur
1. Iswar sahu 2. Haldhua Khuntua of Singipur
1. Abhan Patter 2. sai bhut of Guntipur
1. Fakir Parira 2. Sabani Das 3. Sib Sahu of Malpur
1. Bhugwan Panda 2. Sadai Mahanti 3. Nath Nenka of Kampur
1. Nidlakur Jona 2. Uchhab Sahu of Nimpur
1. Mahadev Naik 2. Sahadev Naik of Ulenkara
1. Bhagban Paikora 2. Sidh Pal of Sidhal
1. Nitai Das 2. Nidlakur Panda of Bhogpur

Petition of the subjects of mouzas Darsurdeuli, Aarain, Sampur, Ainpur, Dhuapari, Nursingpur, Patinga, Sarola, Naisingpur, Nimapara, Mukhi, Patna Banamalipur, Banamalipur Pansapara, Pitoepur, Taranga Nimpur, Kalioda, Bulbulpur, Nuapura, Tararapara, Rudrapur, Ratanpur, Sankurpatna, Bhagbanpur, Baolo, Alsuda, and Aran.

1. The term of our five years' Kabuliat expired before the last year. The Amins tried to dull us to renew them but we flatly denied. They then accused us of irrigating lands secretly



Canal water is diminishing the productive power of our lands.

Previously we used to manure our fields only once, but now-a-days after manuring them twice we do not get the same<sup>a</sup> amount of produce as before, as the silts are not deposited in them. We may have good crops with the rain water. Canal water, being forcibly let into our fields, damages our crops. From these oppressions, since last 6 or 7 years, we have been suffering beyond description. If our cattle ever stand by the side of the embankments on their way to the fields they are immediately impounded. At present it has been very difficult to get pasture for our cattle.

2. At the time of surveying and watering the fields and realizing the cess the irrigation officers such as patrols, Amins Khalasees, peons &c. perpetrate on us every sort of outrage even after receiving bribes and provisions from us. We now appeal to Government as the only authority that can relieve us from these difficulties and exclude our high and low lands from assessment, taking cess at a lower rate for the remainder. We shall have then nothing to complain of.

3 We request that enquires be instituted to ascertain how far the above descriptions are facts, for unless something be done for us we shall be obliged to fly to the *Gurjats*. We are ready to pay any reasonable amount of cess to be fixed by Government. Dated 10. 4. 84.

1. Bidyadhar Das 2. Dinobandhu Mahanty 3. Kapil Panda of Darsurdoula

1. Gangadhar Sahu 2. Muthuri Bilay Das 3. Bhubui Sahu of Aarala

1. Bhaig Muduli 2. Domai Raut 3. Bhikari Sahu of Sampur

1. Gangadhar Khuntia 2. Bachh Panda 3. Bhikari Suangi of Aimpur

1. Bachha Panda 2. Sauti Nayak of Dhuapuri

1. Bihari Charan Das 2. Hari Sahu of Narsingpur

1. Chakradhar Biswal 2. Fakir Raut of Patilga

1. Sodai Sahu 2. Fakir Parira of Sarola

1. Bhagbut Sahu 2. Agni Patil of Narsingpur

1. Babun Patil 2. Arun Patil of Nimupara

1. Din Raut 2. Debadhi Parira of Illigibla

1. Haribandhu Parira 2. Bhikari Biswal of Banamalipur

1. Illigibla 2. Kanhat Sah of Patila Banamalipur

1. Bhubni Sain 2. Jagu Settee of Pansapura
1. Raghu Sahani 2. Nabal Raut of Denga
1. Puri Mulliek 2. Bimbadihur Sahu of Pitoepur
1. Kalai Sahani 2. Karuna Sahani of Nimalpur
1. Illigible 2. Urdhub Sain of Illigible
1. Issur Sain 2. Sodai Sain of Bulbulpur
1. Illigible 2. Anadi Padhan of Nuapura
1. Rajib Das 2. Kapil Mahanty of Illigible
1. Bidyadhar Das 2. Indir Sain 3. Jiban Jena
1. Dinobandhu Sahu 2. Ohamoo Pater of Ratanpur
1. Dam Sahu 2. Bisi Sahu of Sankurpatna
1. Sibho Jena 2. Naran Mahanty of Bhagbanpur
1. Naran Mahanty 2. Markand Panda of Baola
1. Madan Mahapatra 2. Gopi Sain of Alsuda
1. Illigible 2. Karuny Khutua.

The Petition of the subjects of Mouzas Gopalpur, Saherampur, Narainpur, Nahulia Subhuin, Raghunathpur, Chandpur, Madhusudanpur, Jagannathpur, Anantapur, Arung, Radhanuggur, Dharadharpur, Arhaikul, Kandrapaty, Nedalo, Bachhuriapara, Bhasilpur, Orpara, Poorana Sarikana, Ph Balubisi and Ph Hariharpur.

1. Some lands in most of the Mouzas mentioned above, being always covered with water we cannot till them in proper time, that is, in *Baisack* and *Jaesta*. Yet the canal officers have forcibly realised cess from us.

2. Since long the canal have been excavated through some of the Mouzas, but the compensations of the lands occupied by it and situated on the verge of it, have not yet been paid to the Zemindars as well as to the Lakhirajdars. If any Zemindar or ryot happens to bring under cultivation the lands lying on both sides of the canal, rents as usual are realised from him.

3. Irrigation cess is separately realised on account of different crops such as paddy, sugarcane, cotton &c. produced from the same land in one year.

4. Waters of the canal oozing out through springs accumulating near the houses belonging to some of us injure them, but the officers of the Irrigation Department instead of



trying to make the waters flow away from the places near our houses, drain the water out from the ponds and tanks of the said Mouzas, which are filled with water in the rainy season and are most useful to crops in time of drought, by means of drains and thereby compel us to take water from the canal by executing Kabuliats.

5. According to the rule the cess is payable in one instalment, but most of us being very poor cannot pay our cess in time and the canal officers, with a view to realise the same use to take *Pans* and *Kandras* with them, enter our houses, attach our moveable properties, and put them to auction sale. Whenever they happen to find no property in our houses they arrest us by warrant and thereby insult us.

6. At the time of rough measurement the Amins and patrol officers promised us that they would exempt us from cess for low bogs, waste lands and high lands of the mouzas and some took Rs. 20 to 50 from the ryots of each mouza at the rate of annas eight or twelve per acre but they have not yet fulfilled their promise.

7. Some of us have no cultivation at all but the Amins and the patrol officers have realised cess from them by notice and attachment processes.

8. The Local patrol officers, on occasions of their marriage ceremonies &c. take brinjels, plantains and other vegetables, ghee and hard cash from the ryots and sometimes compel them to work without hire. If some one happens to refuse their requests they privately irrigate their lands and realize cess at double rates as water stolen.

9. At the time of the last harvest, the time specified in our Kabuliats expired and the patrol officers having failed to make us execute new Kabuliats threatened us that we had stolen the water which accumulated by springs out of the main canal and



wanted to take bribe from us, but on our refusal they have now served notices assessing at Rs. 6/ per acre. In order to be exempted from the assessment we have applied to the Collector of Cuttack. We are suffering much from the oppressions mentioned above. Some of us, leaving their paternal homestead lands, are beginning to live in other places, some have no doors and no utensils. Some are taking their food in holes dug in the ground. Some Lakharajdars, in order to protect their honor &c. have already sold their Lakharaj lands and paid the cess assessed on them. We shall not be able to live in these parts if not exempted from such assessments. Therefore we pray, Government may be good enough to consider the matter thoroughly and attentively, otherwise we have no other means to do any thing against the officers of the Irrigation Department. Dated 6-4-84.

1. Somenath Das 2 Sambhu Sahu 3 Illigible of Gopalpur.
1. Bighnashwar Patnaik 2 Brojokissoo Patnaik of Sahabrampur
1. Madhu Barik 2 Sudam Sahu 3 Baig Malik 4 Somenath Das of Navainpur
1. Sib Patter 2 Markand Mahanty 3 Anand Raut of Nahulia.
1. Rajib Sain 2 Madan Raut 3 Jogu Sain of Subhuin
1. Madhu Jana 2 Sadhu Bisal 3 Narayn Naik of Raghunathpur.
1. Sadai Sain 2 Gobinda Raut of Chandpur.
1. Iswar Sahu 2 Mokunda Sahu 3 Nand Sahu of Madhusudanpur.
1. Arjun Khatua 2 Bauri Sahu of Jeyannathpur.
1. Harekrishna Panda 2 Chakradhara Bhunya 3 Ananta Mullik of Anantapur.
1. Chakradhar barik 2 Balasub Rout 3 Bhagwan Das of Arung.
1. Radhu Gochhait 2 Gangal Jena 3 Ananta Sain of Radhanuggur
1. Hari Mahapatra 2. Bhuban Sain of Dharadhurpur
1. Sib Bisal 2 Naran Mullik 3 Kalai Mahanty 4 Denabundhu Bisal of Aihakul.
1. Raghu Naik 2 Gadai Naik of Kandrapaty.
1. Bhabani Sain 2. Naran Biswal of Nodalo
1. Raghu Naik 2 Fagoo Behara of Bhachhurinapara
1. Sib Panda 2 Damo Malik of Bhasilpur
1. Somenath Das 2 Bhaig Naik 3 Bhujan Singh of Orpara
1. Sambhu Naik 2 Kanni Miser 3 Arut Behara of Poorana.
1. Mandiri Barik 2 Kambhu Jena 3 Rahas Barik 4 Banamali Jena of Sarikana

The Petition of the subjects of the Mouzas Biribati, Rajhansa, Paramhansa, Taranga, Doghi, Nimaisapur, Ph. Kodinda, Zillah Cuttack.

1. The Amins measured the lands of these Mouzas in our

absence. They measured those lands as 6 acres which are in fact 4 in extent and 10 acres which are 6 in extent. On this we applied to the Collector of Cuttack and we have been exempted from these sorts of oppression but the costs incurred thereby have not yet been paid to us.

2. Whenever we refuse to give bribe to the Amins they at once order the men of low castes ( such as *Pans* and *Kandras* ) to enter our houses, attach our doors, utensils and other furniture and sell them at low rates, such as, they sell the things at 4 or 8 annas, the real worths of which are Re 1/

3. If any man whose yearly *juma* is Rs- 5/ happens to pay Rs. 3/ to the Ijaradars, at the time of collection they say that when the total amount will be paid they will grant him the receipts. If he fails to pay all the rupees due from him the Ijaradras file papers specifying the whole of his cess in arrears instead of deducting the amount he has paid. This has been very oppressive to us.

1. Chakradhar Mahanty 2 Mayadhar Mahanty 3 Sauri charn Mahanty of Biribati Ph Kodinda.

1. Bhagat Das 2 Narayan Behera 3. Benod Raut of Rajhansa Ph Do.

1. Hari Panda 2. Nand Das 3. Arjun Das 4. Nand Panda 5 Illigible of Parambansa Ph Do.

1. Jijesty Patra 2. Sapni Paty 3. Bhagbat Paty 4. Kanai Sha of Taranga Ph Do.

1. Chintamony Panda 2. Bhagbat Nial 3. Ganga Shur Panda 4. Maguni Sahn of Nimaisapur Ph Do.

1. Banuber Mahanty 2. Madan Das 3. Madhab Panda 4. Ram Rautra of Deghi Ph Do.

The Petition of the subjects of Mouzas Sankhapur, Salijang Sarosoda, Dararagram, Athanga and Sidheswarpur, Ph. Hariharpur and Kodinda, Zillah Cuttack.

1. At first we used to execute Kabuliat annually and in that way paid cess for 3 years. Then we executed a Kabuliat for 5 years and the time specified in that Kabuliat expired in 1290 B. S. We have been suffering much from the irrigation cess and especially from the oppressions of the canal officers on account of the realisation of cess for these last 8 years ; sometimes they realize the cess twice from us and if any one refuse to pay, they falsely

settle his lands in another's name and assess cess thereon.

2. Though we executed Kabuliat for irrigation we did not get water in proper time and consequently our crops withered for want of water. For this reason the cess assessed on us has not been remitted, and when we objected to have it remitted they did not remit but realized it by distraining and selling in auction our properties. Not-with-standing the payment of all the dues from us, they realized more as cost of auction under the pretension of balances thereby did us much harm. They also issued warrants on us.

3. If we occasionally delay in paying our cess they at once issue certificates, order men of low caste (such as *Pan*, and *Kandra*, Musalman &c.) to enter our houses and bring out utensils and ornaments distrain and sell them by auction to realise the cess ; by so doing they have destroyed our caste. By the process of realisation of cess in the manner mentioned above most of us have been deprived of our doors, utensils and some have died unable to tolerate such treatments.

4. If our cattle happen to graze either on the embankments or on the side of the canal the patrol officers take them to pound house and if we unfortunately break Dantoon (tooth brush) from the trees on the embankments of the canal they threaten us and take from us Rs 8 to 10 as bribe.

5. The officers drain the rain water (by which we can cultivate) away and compel us to execute Kabuliat to irrigate our fields by the canal water. Since the time the canal has been excavated, we get no good outturn of crops. Before the canal was excavated our lands were overflowed by the rivers depositing silts which added to the fertility of the soil, but by the canal that has been stopped and therefore the fertility of the soil is gradually decreasing. Last year we executed no Kabuliat therefore the patrols have issued notice of realizing double cess on the plea of our stealing water. We have applied



to the Collector of Cuttack on the subject, but nothing has yet been decided. Dated 1.5.84

1. Hail Jena 2. Madhu Jena 3. Dhabandhu Jena of Sankhapur

1. Bhikari Jena 2. Kunja Jena 3. Das Dalai of Salijang

1. Fakir Jena 2. Narsing Jena of Satosoda.

1. Huiji Maji 2. Nand Maji 3. Joy Maji of Dairagiam.

1. Arut Kar 2. Kinal Suthputy 3. Sonai Kar 4. Bhajni Misra 5. Sadai Sethi 6. Siba Mullik of Athanga.

1. Harhar Adhya 2. Hoiakrista Achaji of Sidheswaripuri

( Taldanda Canal )

The Petition of the subjects of Mouza Dharadharpur, Jaggannathpur, Ph Hariharpur, Zillah Cuttack.

1. Last year in the month of *Margasir*, the patrol officers having irrigated our lands of their own accord, in the mouzas mentioned above and under pretension of stolen water assessing at the rate of ~~Rs~~ 6/ per acre, fixed a cess of ~~Rs~~ 1749/ on Dharadharpur and Rs 402/ on Jaggannathpur. In the latter part of the month, the patrol officer Lakhan Mahanty through the assistance of two chief ryots named Sib Dhal and Bhokari Naik tried to take ~~Rs~~ 60 from us by means of subscription but finding that no good has been done to us by the water thus irrigated by the patrol officers we refused to pay. This refusal led the patrol officers to submit false reports to the effect that ~~Rs~~ 1749/ and Rs 402/ are still due from us. Accordingly to realise the amount, a notice without date has been served upon us, 2 or 3 days ago in which it is written that if we fail to pay up the amount due from us within a fortnight they will realise it by means of attachment and auction sale of our properties. In order to be exempted from the cess unjustly assessed upon us we have applied to the Collector of Cuttack. We will be put to great loss if the matter be not justly decided.

If we fail to win the favor of the patrol officers even though we execute the *Kabuliat*, we do not get water in time. But by the drains they take the rain-water, on which our crops depend, to other direction. They take properties worth one rupee for

one anna due, during the absence of the master of the house and sell them by auction. The patrols take our cows &c. to the pound house whether they go on the embankments or not. We are suffering much from such oppressions. There are many among us who have neither doors nor utensils. The *Pan* and *Kandras* enter our houses, and outrage the modesty of our women for which many of us have been obliged to lose caste. No one hears our complaints. Dated 28.4.81

1 Sahadeb Sahu 2 Barja Sahu 3 Iswar Sahu 4 Markand Sahu 5 Jagu Raut of Jagannathpur.

1. Bhikon Naik 2 Sudun Biswal 3. Padmalochan Mahapatra 4 Sibo Biswal 5 Dinobandhu 6 Ram Sum 7 Bidyadhar Misra 8 Bhagban Paul 9 Dukha Das 10 Siddhur Baik 11 Aparti Naik 12 Hari Mahapatra of Dhanadhapur.

( Machhgan and Taklanda Canals. )

The Petition of the ryots of Mouzas Tarpur, Chakinya, Gunali-pur, Taara, Patnigan, Kurutung, Charty, Kapilaswar, Gorodia, Ph. Hariharpur and Ph Balubisi, Zillah Cuttack.

1. Since 5 years, nearly 4 *Baties* of land in Tarpur are lying uncultivated owing to the water springs of the canals but we have to pay the cess, and rent of the zemindar and thereby we are suffering much.

2. In the aforesaid mouzas the high and low lands *ie* those lands that are not under cultivation either being above the water level or always being under water. During the time of rough survey the Amins promising to exempt such lands have taken bribe from us, but they have assessed those lands for which we are much oppressed.

3. The irrigation officers without proper enquiry have fixed cess for 5 acres in the place of two.

4. The rate of zemindar's rent in these mouzas is too high and over and above that we have been obliged to bribe the canal officers and pay the cess during the last seven years for which we have been totally undone; our cattle and utensils have been sold. The chaprasees of the department are men of low castes such as *Pans*, *Kandras* and Mohomedans who have forcibly enter-



ed our houses, for which many of us have lost their castes.

5. The canal embankments lie close to the aforesaid villages; if, therefore, our cattle happen to graze on them they are impounded, and the officers threaten us to impound our cattle whether they go on the embankments or not, when we refuse to pay them. For this oppression we have sold all cattle retaining only one or two of them.

6 Owing to the oppression of the Canal officers and the excessive rate of cess we have been much oppressed. If something be not done to relieve us we will fly to places where no irrigation cess is levied.

7 In the year 1290 B. S. the term of our 5 years' Kabuliat having expired, 6 of the oppressed mouzas have executed fresh Kabuliats. We executed Kabuliat for those lands only which require water, but they have assessed even those lands, where there is no need of Canal water. The Canal officers under the threat of doubling our cess, have forced us to execute Kabuliats. If the rates be not lessened we are ready to resign.

Dated 7-5-84.

1. Nanayan Das 2. Banamali Das of Tarpur.

1. Sambhu Mudly 2. Illigiblo 3. Bindhu Noka 4. Arjun Mudly of Chiknya

1. Illigiblo 2. Gurdadhur Barik 3. Subodhi Barik 4. Abin Barik of Gunalpur.

1. Fakir Barik 2. Chakur Patra 3. Ananda Rout of Tarna.

1. Suderson Sain 2. Makunda Sain of Patnigan

1. Illigiblo 2. Damathi Das 3. Bhugathi Barik of Kurutung

1. Behari Sain 2. Kali Sain 3. Moti Mallik of Illigiblo

1. Bidladhur Mullik 2 Arut barik of Kapilnagar

1. Gour Das

The Petition of the subjects of mouzas Ala, Makarpur, Nahanga, Singarpur, Bakalo, Begunia, Tiari, Barahagaria, Samang, Garual, Chhandgan, Gopal Brahmankhund, Tentol, Golasol, Torikund, Bisipotolo, Joysolo, Begunia, Harapatna, Nuagan, Ph Hariharpur.

1. Since 7 or 8 years past the irrigation cess has been introduced in the above mouzas. If we do not willingly execute

Kabuliats, the patrols, of their own accord, cause the water to flow into our low lands, and thereby greatly damage our crops, and charge us of stealing water falsely and in some cases they even imposed the irrigation cess by reporting that the canal water, oozed out of springs, greatly benefitted us. And in this way, they forcibly realized cess at the rate of 1-8 and notice and attachment fees 6 annas per acre on the lands for which no Kabuliati had been executed, both for the high lands where no water, could reach and low lands where the water swept away all the crops when passed on them; and if any objection was raised towards payment, they, without listening to our objections, ordered musalmans and other low castes such as *Pans* and *Kandras* to enter our houses by force, and carry away our utensils which we use for food and drink and realize money by selling them by auction. Thus many of us have been outcasted, and some are re-entering into their caste by borrowing money.

2. Some of the above mouzas are situated at a distance of about a mile, both from the main canal and its distributaries, where no water can reach, but we have to pay cess for all the lands in those mouzas ; and no one ever hears our objections.

3. In case where Kabuliats have been executed for 5 years', the patrols, if they don't get any bribe in time of irrigating the said Kabuliati lands, do not irrigate the fields in proper time ; and thus the crops in some of our mouzas have been totally destroyed, for want of water in time.

4. Since the introduction of the irrigation system, up to the present time we have been greatly distressed by the oppressions of the patrols, by giving them bribes.

There are boats in some places for the purpose of crossing the canal, but the Government officers take them to different places and engage them for their own purposes, so we suffer much in crossing the canal and thus two or three men have been drowned while crossing.

1. Kiritbas Sahu 2 Lakhan Sahu of Ala.
1. Sindhu Sahu 2 Arjoon Jona of Makampur.
1. Pankaj Panda 2 Dasa Sonapaty of Nuhanga.
1. Kapil Behara 2 Arit Mudli of Bakalo.
1. Madhu Sahu 2 Ananda Sahu of Begunia.
1. Lakhan Sing 2 Kali Gochhait 3 Dam Ojha of Singarpur.
1. Kapil Miser 2 Bhagyathi Acharji of Tlari.
1. Bhubani Miser 2 Jogi Jona of Barahagaria.
1. Mull Suin 2 Pankaj Jona of Samang.
1. Bhikari Jona 2 Bidai Suin of Garial.
1. Chaitan Behara 2 Madhu Behara of Chandgan.
1. Kisor Raut 2 Sam Baile 3 Bhag Nalk of Kanhatta.
1. Ananta Charan Mahanti 2 Nidhi Biswal 3 Lokenath Biswal 4 Mull Biswal 5 Gobinda Mahanti of Gopal.
1. Lokenath Biswal 2 Gobinda Mahanti 3 Muni Jona 4 Nidhi Biswal 5 Dandi Biswal of Brahmankhund.
1. Bidyadhur Biswal 2 Mull Biswal of Tentol.
1. Ananta Charan Mahanti 2 Gobinda Mahanti 3 Raghab Biswal of Golasol.
1. Guljar Khan 2 Musaud Khan 3 Yasin Khan 4 Daud Khan of Torikund.
1. Bharat Padhai 2. Dhârma Sahu of Bisipotolo.
1. Joy Biswal 2. Kapil Khuntia of Joysole.
1. Bali Sonapaty 2. Aparti Suin of Begunia.
1. Shih Sahu 2. Jhiban Sahu of Harapatua.
1. Gobinda Nalk 2. Jagu Mahapatra of Nuagan.

Petition of the subjects of Mauzas Sujang, Madhabpur, Palda, Manapur, Patasuda, Bavolpur, Markundpur, Marichapada, Ohul, Potal, Narsingpur, Dal, Deuli Ph. Hariharpur, Zillah Cuttack.

1. During the rough measurement the Amins, taking the bribe and in some places failing to take it, have assessed the fields belonging to one in the name of another and have also assessed in the name of those subjects who have no lands and thus they have raised confusion among us. We, for this reason, have suffered by paying unnecessary and extra cess for the last five years. In order to free ourselves from the payment of the cess we applied in several places and even paid the expenses of the Amins but still we could not correct and change the name of the parties; for this reason we are suffering much. We have noither doors, nor utensils, nor cows which have been sold to pay cess.

2. The patrolling officers, since our taking Kabuliya for five



years and before that oppressed us. They did not supply water in time to those Kabuliati lands for which no bribes were paid. For this reason we suffered much for want of water. Especially, the patrolling officers, for not getting bribe, took our cattle to the pound-house on the false charges of their grazing on the canal embankment.

3. The Government boats, that are kept at the Canal ferries, are used by the Canal officers and the *ijaradars* take them to other places. For this reason we feel much to take seeds and manure to our fields

4 They take away the water collected during the rains which is of great use for cultivation by drains and thus they harm much to our cultivation. Neither the Zemindar nor the subjects have yet got any compensation for the lands taken for the said drains We applied in several places to get rid of the oppressions and for a reduced rate of cess without any effect. If any step be not taken then it will be difficult to maintain ourselves.

1 Parmānanda Das 2 Gunanidhi Das 3 Biswanath Das of Sajang

1 Kasinath Das 2 Naran Nund of Madhabpur

1 Kapil Panda 2 Madhu Panda of Palda

1 and 2 Illigible 3 Das Panda of Manapuri

1 Gangadhar Nund 2 Illigible of Palasuda

1 Boli Suli 2 Ghana Padhan of Bawalpur

1 Kihul Sahu 2 Naran Nund of Markandpur

1 Bandhu Patra 2 Bhagbat Mullick of Potal

1 Selk Pancho 2 Dilli Khan of Ohul

1 Tari Sing 2 Ram Sahu of Narsingpur

1 Gadai Bol 2 Madhu Sahu

1 Saduri Behem 2 Radhu Sahu of Deuli

The Petition of the subjects of mōuzas Saidabad, Kaijahi, Chandpur, Anantabrahmapur, Nuapari, Nuatana, Ph. Hariharpur

1. The canal officers greatly oppress the ryots in our Mouzas. In every year a little quantity of paddy are allowed to them per every acre of paddy cultivation In this manner they also receive their shares from the plantation of tobacco, sugarcane, cotton.

and other cereal crops. On declining to pay their illegal demands they take our cattle to pounds if they chance to come near the canal embankment and put us to much trouble at the time of irrigating our Kabuliati lands. <sup>is</sup>, they never allow us to irrigate fields in time. We have lost a great quantity of our crops by the irregularity of irrigation. They break the shoots purchased by us. The patrols stop the water passage of the shoots lest we will take water to irrigate the fields for which we executed Kabuliats.

They even realize cess from us for the low and high lands under our possession (for which we require no water and for which no Kabuliati has been executed. In default of payment processes of distraint are issued by them. By their acts of oppression we have to undergo great loss. At the time of granting us cess receipts for the cess paid them in full they generally leave a balance of very small sums with us, if, we fail to pay them any bribe, they afterwards realize that, with cost in addition, by selling of our properties.

3. They have constructed drains through our lands, which carry away the rain water from our fields, to the great loss to our crops, and have thereby compelled us to execute Kabuliati to take water from the canals. The water of two, or three ponds in our mouzas have also been taken away by these drains, when full to the brim, thus leaving us no other expedient of saving our crops. If these drains be not stopped at once, no good harvest can ever be expected. The reason, we do not wish to execute Kabuliati for the water is the oppression of the officers and loss of caste. If the cess be levied at a moderate rate, and if the high and low lands be exempted from assessment, then we will be glad to execute Kabuliati for ever.

1 Baghat Sain 2 Ram Naik of Saldabad.

1 Madhu Jona 2 Dama Das 3 Naran Paul of Illigible



1 Das Kur 2 Bhaghiathi Kur 3 Balu Kur 4 Anadi Kur of Chandpur.

1 Dai Pani 2 Madhu Pani of Anantabrahmapur.

1 Kasinath Mahanty 2 Ohakradhar Mahanty of Naupari

1. Kinal Ojha 2 Puri Sahu of Nuatana.

Petition of the subjects of Mouzas. Mukundapur, Durgapur, Karimul, Chundra, Mataniga, Kusinga, Tararapara, Nipur, Pokapur, Joybor, Devendrapur, Narasingpur, Sipisasan, Sipigram, Kathiapara, Mukundapur, Majuri, Byjanga, Purahitpur, Kheras, Balarampur, Chatara, Mukundapur, Panisahi, Madhabpur, Ph. Hariharpur and Gandito.

1. Since last 7 years the above mentioned mouzas are paying cess. Some parts of our Mouzas were overflowed with water by the canal officers, before we executed 5 years' Kabuliat and was assessed as water stolen. They compelled us to pay cess even for the high and low lands for which no canal water is required. On our declining or making any objection to pay their demands, they levy the cess, by distraining or selling our moveables.

2. After this, these officers compelled us to execute Kabuliat for 5 years with the false temptation that there will be no inconvenience in future. Then they, exempting our homesteads only, assessed on all lands whether high or low. There are some parts in these mouzas which require no water. In some elevated parts the water cannot reach; but still we were made to pay cess for them. We have lost all that we had for payment of such illegal cess. More especially we have been oppressed to the utmost by the canal officers. If we do not pay them any bribe they use to take our cattle to pounds, on the false plea of their having grazed on the embankments. In some cases they let these cattle go, if they are paid with something. At the time of the rough measurement, the Amins, not being bribed, have assessed the land of one person in another's name and have assessed some who possess no lands at all. For such reasons many of us have been obliged pay cess unnecessarily.

3. The term of 5 years' Kabuliat in our mouzas having expired last year and no fresh Kabuliat being excuted by us they have excavated drains by which rain water have been made to pass in other direction. Consequently we have suffered the loss of  $\frac{1}{2}$  of the crops. Being oppressed in these ways we have represented our grievances by means of written petition in various places but without effect owing to our ill-luck.

1. Hari Ojha 2 Kanahi Chand of Chatara.
1. Sridhur Bant 2 Bamo Behara of Makundapur
1. Raghubanand Chowdhuri 2 Vikati Das of Kheida.
1. Adhikari Krishna Das 2 Mangobinda Das
1. Sadai Sahu 2 Sadanand Misra 3 Damo Jena of Mukundapur
1. Banamali Padhan 2 Chintamani Misra of Illigible
1. Punai Suin 2 Jagu Nalk of Karimul
1. Bidyadhar Nalk 2 Bamon misra 3 Banamali Nalk of Chundra
1. Hari narai 2 Ananto Suin of Illigible
1. Bamon misra 2 Bhagban misra of Kusinga
1. Bidyadhar das 2 Mani Devta of Tararapara
1. Loknath Das 2 Kapil Das of Nipui
1. Sadananda Sahu 2 Gungadhu Tilhari of Balarampur
1. Bidyadhar Das 2 Gudai Devta of Pokopur
1. Hadi Biswal 3 Mukunda Biswal of Paulsahi
1. Kanni Misra 2 Jagu Paulra of Joyboi
1. Bharat Majhi, Nidyakar Mahanty of Devendiapur
1. Sisiram Goehhalt 2. Ananta Suin of Patnigan
1. Agani Majhi 2 Dam Sarangi 3 Badyanath Sarangi of Sipsisan
1. Kolai Suin 2 Bidai Mahanty of Kuthiapara
1. Jai Sarangi 2 Raghu Suin of Mukundapur
1. Badai Malik 2 Hari Suin of Majuri
1. Dinobundhu Nlak 2 Aviram Biswal of Nijanga
1. Hari Panda 2 Jai Das of Parahitpur

( Kundu Patna Canal. )

The Petition of the subjects of Mouzas Sukarpara, Rani-para, Pithapara, Katarpara, Baragiri, Kanpur, Paharajpur, Haladhurpur, Tilakpur, Sunalunda, Bedogiriputna, Ayenda, Julukipara, Banamalipur, Ramchandrapur, Kuntalo, Tentolpur, Kaliabada, Pataypur, Sakhilo, Moodabad, Domkua, Jagannathpur, Loknathpur, Panchusarang, Balarampur, Garullo, Bakinraj, Kendulo, Bantola, Gopalpur, Sabalkana, Kurijunga, Jangalpur, Sabolung, Haripur, Sahaladpur, Gobindpur, Ach-

lutipur, Kanipara, Kulasukarpara, Kulakaturpara, Kulabara-giri, Kulapithapara, Katikata, Nuagan, Kadalipara, Girigola, Digidipara, Ph Asuraswar, Zillah Cuttack.

1. We did not receive water in time even after executing five years' Kubuliat. In consequence there-of all the crops of our Kabuliati lands have entirely been destroyed. But we were bound to pay the cess. Especially, at the time of rough measurement the Amins, having taken bribe from some ryot, have made a confusion in some of the villages. The land under the possession of one man has been assessed in another's name and some have been assessed who have no lands. The assessed cess have also been realized by them with force. This illegal act has oppressed us to the extreme.

2. We have to suffer the loss of half of the crops, by the drains made through our mouzas by them ; these drain away the water by rainfall. They drained away the water of some of our ponds and jhils by drains on our declining to execute new Kabuliat and for this we are suffering much for water ; great damages will be caused to our crops if these drains be not closed forever.

3. Even for Kabuliati lands, we have to pay something to patrols or else they do not allow us, to irrigate our lands. If they are not paid something they take away our cattle to the pound on the pretention of their having grazed on the embankments. By these we have been obliged to undergo much loss and put to much trouble.

4. During the last seven years ie from the time the cess has been introduced we have been obliged to sell our cattle, utensils, doors &c to meet the demand of the cess. Many ryots have lost their utensils and are taking their foods in cavities dug in the ground, some have incurred debt, some have been excommunicated from the society and some have left their houses and native villages.



- 1 Bidai Das 2 Ananda Das of Kulakaturpara
- 1 Naran Panda 2 Gadai Panda of Kulabasagiri
- 1 Sibbo Sahu 3 Samo Naik of Kalayara
- 1 Kanhai Sain 2 Jagu Sain 3 Banamali Sarangi 4 Kandru Misra of Sukurpara
- 1 Panchu Sahu 2 Basu Sahu of Ranipara
- 1 Kamblhu Pater 2 Joyram Pater 3 Raghu Pater of Pipara
- 1 Kisor Sain 2 Agani Sain 3 Bhikary Sain of Kato para
- 1 Gobinda Sain 2, Jujesty Sain of Baighi.
- 1 Ashram Naik 2 Kesori Naik of Kanhapur.
- 1 Sadhu Padhan 2 Gadai Padhan of Paharajpur
- 1 Gadai Sing 2, Nandaram Sing of Katikata
- 1 Panchu Sahu of Nuagan
- 1 Raghu Sahu 2 Kanhu Mahanta of Kadulipara
- 1 Basu Pahan 2 Banamali Pahan 3 Raghunath Baral 4 Hari Pahan of Halhampur
- 1 Sudam Pahan 2 Panu Sain of Tilakpur
- 1 Hari Mahanty 2 Hursi Padhan of Sunalunda
- 1 Gopi Sahu 2 Dinai Sahu of Bedoghilputna
- 1 Bidaiadhar Panda 2 Balkrishna Panda of Ayenda
- 1 Narahari Malik 2 Sadhu Ghara of Julakipara
- 1 Kusum Sain 2 Krushna Barik of Banamaliapur
- 1 Gopi Barik 2 Sibbo Barik of Ramohundiapur
- 1 Raghunath Singh 2 Raghu Ram of Katol
- 1 Rajani Mahanty 2 Bhagwan Mahanty of Girikona
- 1 Madhai Rout 2 Chakradhar Naik of Jugannathpur
- 1 Jogi Sahu 2 Hari Bhuyan 3 Anand Sain of Lokenathpur
- 1 Debadihi Jona 2 Sibbo Rout of Billapada
- 1 Baidi Misra 2 Markunda Raiguru of Panchasrung
- 1 Kanda Barik 2 Garai Barik of Bultanpur
- 1 Sairam Padhan 2 Raghu Padhan of Bakingraj
- 1 Arat Das 2 Dadhi Mahanty of Pabitiapur
- 1 Mani Daba 2 Kurthas Mahanty of Dakshinpara
- 1 Dinabandhu Mahanty 2 Gudai Jona of Tontolpur
- 1 Tilochan Nenki 2 Bidai Nenka of Kallabuda
- 1 Bhajan Naik 2 Hari Sain of Fatyapur
1. Kanai Naik 2 Padai Naik 3 Raghu Naik of Sakhtilo
- 1 Sudam Rout 2 Sadai Jona
1. Damo Naik 2 Hursi Sonapati of Kendulo
- 1 Lukhyai Samal 2 Balkrishna Samal of Buntola
- 1 Ballakrishna Padhan 2 Gomang Padhan of Gopalpur
- 1 Padmalaya Mahapatra 2 Joyram Mahapatra of Sabalkana
- 1 Natha Baral 2 Banamali Das of Kufjunga
- 1 Basu Padhan 2 Kanhu Padhan of Jangalpur
- 1 Madan Samal 2 Purnasotam Samal of Sabolung
- 1 Basu Padhan 2 Sibbo Das of Haripur
- 1 Raghunath Mistri 2 Bhagbut Sutar of Sahaladpur
- 1 Akuru Padhan 2 Balanub Padhan of Gobindpur

- 1 Niladri Padhan 2. Paramanan 1 Padhan of Achhutipur.  
 1. Balaram Mahapatra 2 Krupasindhu Kur of Kanipara.  
 1. Arut Sahu 2 Anand Sain of Kulusukaipara.  
 1. Arut Das 2 Dodhi Mahanti of Illigibla.  
 1 Bidai Bhuyan 2 Hari Panda of Khasrolo.

[ Kendu Patna Canal. ]

The petition of the subjects of mouzas Chundrodappur Godandi, Vigaswar, Bateswar, Rudrapur, Kalianpur, Kulia, Kasipur, Gurai-  
 pur, Sunakhandi, Barado, Bunhar, Barigol, Chamarigol, Banohara,  
 Kulusianguj, Manaharpur, Kusumbhi, Sunderpur, Mantiri,  
 Teragan, Raisingra, Dariapur, Kanhupur, Deuli, Matgan, Kur-  
 ulapara, Natokai, Nichintikoily, Buhalow, Jamora, Khandan-  
 gan, Paikarapur, Kendupatna, Natara, Risoto, Ramkrishna-  
 pur, Akarukhi, Mahajanpur, Jikiniapur, Utaka, Barakhiri, Gopuri,  
 Ranganudai, Bachakundai, Badhang, Gopinathpur Phs Suang,  
 Asuraswar, Sungrah, Saraswati, Pudmapur and Matkatnagar,  
 Zillah Cuttack.

1. The Government has oppressed us by the forcible realiza-  
 tion of cess for the lands for which no Kabuliats have been  
 executed. At the time of irrigating one field, the crops of  
 other fields are totally washed away, yet for these latter  
 fields they compel us to pay cess. We pay cess twice or  
 thrice for the same land if it produces two or three different  
 crops in a year.

2. We executed Kabuliats for the cold season-crops.  
 At the time when water was most urgently needed, the canal  
 became dry and consequently water was not available  
 for our crops. This scarcity of water made our crop suffer too  
 much; but notwithstanding we have been bound to pay the cess.  
 The canal officers do not allow us to carry water from  
 the ponds, situated on the other side of the canal by the  
 canal unless they are not paid with something.

3. The rain waters of our lands are taken away by the



drains dug through our fields. Drains have also been dug by the side of ponds and streams, to take their waters away. These drains have been dug by Government with the intention of obliging us to take water from the canals for cultivation, otherwise our crops will be lost. We have received no compensation for the lands taken for the drains. We filed objections at the time when these drains were under excavation but to no effect. The term of our five years' Kabuliats expired last year, but as no fresh Kabuliats were executed by us, they have dug the drains. If these drains be not closed at once our cultivation will fail.

\* 4. If orders for distraint and sale of moveable properties be issued against any ryot, for the realization of the cess, the canal officers generally serve them on others who have no connection whatever with them and levy from them the cost of distraint &c.

5. We have been oppressed to the utmost since the commencement of the cess by paying the same at high rates and the bribes to officers. Some ryots have left their cultivation, some have left their homesteads to escape the oppression.

\* We have several times stated our grievances to the authorities by means of written petitions but without effect. If Government be not pleased to consider our cases, we think we won't be able to live in our houses.

1. Nabin Kur 2 Binoda Sahu of Chundrodaspur. 1. Kartick Sahu 2 Madan Tihari of Godan-  
di. 1 Gobind Kur 2 Kinai Maharana of Vigaswar. 1 Bhikari Dikhit of nateswar.  
1 Gobind Kur of Rudrapur. 1 Maguni Raut 2 Jogi Raut of Kallanpur. 1 Adhikari Gopanand  
Das 2 Bhabani Khuntia of Kulla. 1 Ram kur 2 Damo kur of kasipur. 1 Fakir Sahu 2 Jagu  
Sahu of Guraipur. 1 Ram Chundra dhuyan 2 Ananda Pal of Sunakandi. 1 Panchu Raut  
2 Madhu Raut of parado. 1 Sadai Sahu 2 Panchu sahu 3 Ram biswal 4 Kambhu dhuyan of  
Bunhar. 1 Ananta Mal 2 Bhagi biswal 3 Muli dhuyan of Barigol. 1 Sham Jona 2 Dharam Das  
3 Bindaban Das of Chamarigol. 1 Kusan Das 2 Sibho Sahu of panohara. 1 Mukunda Sahu  
2 Sibho Sahu of kuhusanganj. 1 Sapani Satpatti 2 Sibho Mal of Manaharpar. 1, Sham biswal  
Nalu Mal of Kusumbhi. Bidai Sahu 2 Uchhab Sahu of Sunderpur. 1 Sudam dhuyan 2 Radhu  
Naik of Mantiri 1 Rangl dhuyan 2 Hadi dhuyan of Teragan 1 Nalu Mahanty 2 Jawar  
Padhan of Rajnigra. 1 Jawar Sahu 2 Karuna Sahu of Darlapur. 1 Fakir Sahu 2 Bhajan

1. Hrid of Goolpur 1 Sadu Sahu 2 Sibho Sahu of Kanhapur 1 Damo Sarung 2 Binode Sahu of Hrid. 1 Anand Naik 2 Sibho Sahu of Matgan. 1 Gungai Behara 2 Jagai Raut of Natokoi 1 Mukund Mahapatra 2 Bhajun suin 3 Panu Sui 1 Sadhu Raut of Nohintikolly Govinda Behara 2 Ram Naik of Jamora 1 Dantary Behara 2 Madhai Pater of Khandagan 1 Ram Samal 2 Dinobandhu Acharya of Palkapur. 1 Markunda Sahu 2 Mahant Sahu of Kendrapatna 1. Nanda Behara 2. Bhikari Das of Natara 1. Ananda Balai 2 Iswar Sui of Risoto 1. Sankar Bustia 2 Fakir Mahapatra 3 Gopi Lenka 1 Naran Naik of Ramkrishnapur 1 Ghono Panda 2 Hari Senapaty 3 Bai Das of Akankhi. 1. Madhai Raut 2. Mukunda Raut of Mahajanpur 1 Sulai Raut 2. Ram Mahanty 3. Sibho Naik of Jikinpur 1. Bhanut Panda 2 Raghu Sahu of Utaki 1. Gungai Sui 2 Gobind Sui of Buakhil 1 Bhagwan Uchhab 1 Shal Sahu of Gopuri 1. Anut Panda 2 Nanda Sui 3 Nanda Behari 4 Bhikari Das of Rungamudal. 1 Bhagbut Sui 2 Magunt Sahu of Buchakundai 1 Bisu Pater 2 Jugu Pater of Badhang 1. Raghu Panda 2. Ram Panda of Gopinathpur.

#### Kendu Patna Canal.

The Petition of the subjects of Imamnagar, Turutu, Khaira, Bhairipur, Kothbar, Satyabhanapur Gunapur, Gopinathpur, Purusotampur, Krushnapur, Trilochanpur, Mahajanpur, Gopinathpur, Madhyakach, Paschimakach, Purbokach, Champati, Khandaisahi, Bahukudh, Singipur, Lakhminarayanpur, Paga, Biswanathpur, Nuamiluck, Niamutpur, Jamalpur, Patpur, Kathara, Tantule, Bhatpara, Besorepur, Nadalo, Sambhupur, Gangapur, Baharapara, Sauri, Sarada, Puran, Mahana, Alipur, Osodha, Balisamala, Patna, Kulinda, Purusotampur, Kantikole, Naiguan Balhabpur, Sapanpur, Kuliapur, Karimabad, Rahimabad, Bija, Danapa, Sankarpur Chhanipur, Raghabapur, Sisua, Bahabulpur Balin, Barabari, Kesarapada, Ramkrushnapur, Arabari, Katharagan, Kurmuan Srutabati, Pikole Phs Pudmapur, Karimo, Saraswati, Matkutnugur, Zillah Cuttack.

1. The Canal officers by excavating drains through the said Mouzas, have let out rain water from the paddy fields, so that half of the crops was destroyed in the last year. But while these drains were under operation we complained much against the same but the officers in charge did not pay any attention to them and without paying the compensation dug the canal through our paddy fields. But as we refused to execute

Kabuliat they let out the rain water from our paddy fields, thinking that we will then be obliged to execute Kabuliat. But unless these drains be shut up our paddy fields will not produce plentiful harvest.

2. Notices, which are issued for delay in paying the cess, are not served on us in due time but remain with the officers who after a few days hang them on the walls of houses, and realize the balance cess with an addition of annas 6 (notice fee 2 annas and distraint fee 4 annas) whether the balance be a rupee or a pie. If we fail to pay bribes to the officers they make out a short balance (an anna or a pie) against us, realize it with additional cost. To realize the same they order chaprascas of low caste such as *Kandra, Pan* and Musalman to enter our houses take our utensils forcibly, for which we lose our caste. Thus we have been greatly oppressed by the officers and have suffered much from the paying of the cess, revenue and bribe. For these reasons we do not intend to execute fresh Kabuliats.

3. When the Kabuliat for 5 years was executed, we executed the same for the fields for which canal water was required. But the Government Amins at the time of the measurement taking Rs 10 to 30 as bribe have settled one's land in another's name. Those who possessed 3 acres of land and have not paid any bribe have been assessed for 6 acres, and some, who have no lands at all, have also been assessed.

4. If we do not bribe the patrols they impound our cattle on the false plea of their having grazed on the embankments and sometimes they leave them on payment of certain fees. For this purpose we have sold all our cattle keeping one or two pairs of bullocks for the purpose of cultivation only.

5. If the ~~elevated~~ lands where the canal water can not reach



and the low lands where no canal water is required be left out of assessment and the remaining lands be assessed at 12 annas per acre or all the lands at 8 annas on an average, then we can execute Kabuliats for the whole life. Now if the Government takes no steps for the prevention of the oppression of the officers we will be undone.

1. Shyam Sethi 2 Radhu Mahanti 3 Achhuti Mahanti of Raghobapur. 1 Sadi Sahu 2 Madhi behera of Sisua 1 Achhutaund Mahanti 2 Panchanund Mahanti 3 Sri Chunder Das 4 Bhatgrathi Mahanti 5 Ram Raut 6 Loka bhuyan 7 Gopal Mahlik 8 Hanif Khan of Kothbar. 1 Illigible 2 Ram Mullik of Bhairipur. 1 Dilwar Khan 2 Katlu Khan of Khaira 1 Madhi biswal of Illigible 1 Arut Behera of Imamnaggur. 1 Mathuri Samul 2 Dany Samul of Satyabhamapur. 1 Baly behera 2 Bhubni Sethi of Gunapur. 1 Jagu Mahanti 2 Dinbundhu Das of Gopinathpur. 1 Haribundhu Mahanti 2 Bhagi Suin of Purusotampur. 1 Biduri Raut 2 Achhut Raut of Bahabulpur. 1 Agni Naik 2 Sibuehh Naik of Chhanipur. 1 Panu Sethi 2 Aparti Guehbat 3 Mohamed Abdool Aziz of Sankapur. 1 Ram Maharna 2 Hari Sahu of Krushnapur. 1 Bhagi Sen 2 Gobind Suin of Tillochanpur. 1 Bhagbut Mal 2 Satali Jena of Mahajanpur. 1 Bhuban Bhuyan 2 Illigible of Gopinathpur 4 signatures all Illigible. 1 Bhagwan Panigrahi 2 Gungadhur Panda of Illigible. 1 Gopinath Kur 2 Kanhai Kur of Champati 1. Urdhub Mahanti 2 Madhub narik of Khandaisahi. 1 Arut Sahu 2 Aparti Sahu of Bahukudh 1. Sapni Nonka 2 Bauri Jena of Sigmapur. Shiv Sahu 2 Bhogu Sahu of Lakshminarayanpur. 1. Govind Santia 2 Dinkrishna Raut of Balia 1 Bhujni biswal 2 Dasuthi biswal of Barabari. 1. Anam Naik 2 Dam Naik 3 Shiv Raut of Kosrapada. 1 Bhujni Naik 2 Bhagi Padhan of Ramkrushnapur. 1 Arut Mahanti 2 Panchu Maharna of Arabari. 1 Shiv Jena 2 Bhujni Raut of Biswanathpur. 1 Nidhi behera 2 Bali behera of Nuamuck. 1 Sadi Mahanti 2 Jagu Mahanti of Jamalpur. 1 Jasim Mi 2 Miha Golam Ali beg of Niamutpur. 1 Bighaswar Das 2 Bhujni Das of Patpur. 1 Arut nai 2 Arjoon nai of Kathara. 1 Biduri Bhunj 2 Bhagwan Pajira of Tantulo. 1 Sudam Das 2 Gudai Raut of shatpara. 1 Purusotum Das 2 Bhikari Maharna of bisorepur. 1 Sheikh shikun 2 Illigible of Nadalo. 1 Mulli Sethi 2 Fakir behera 3 Sonai Sethi of Illigible. 1 Shiv Suin 2 Kusum Suin of Illigible. 1 Panu Tihari 2 Gadai Tihari of Sambhupur. 1 Kritibas Putty 2 Gopal Putty 3 Kripasindhu Putty of Gangapur. 1 Rusio Sahu (Patra) 2 Sridhar Sahu 3 Urdhub Sahu of balarapada 1 Purnanund Sutpusti 2 Mani Sutpusti of Sauri. 1 Bhajni Naik (Dogra) 2 Bauri Naik 3 Bidai Naik of Sarada. 1 Kusum behera 2 Sridhar Saingl of Puran 1 Surbaswar Putty 2 Jogi Putty of Mahana. 1 Mann Suin 3 Nikhun Khatal of Alipur. 1 Boni Jena 2 Srinibas bhuyan of Osodha. 1 Nanda Das 2 Arut Jena of Bahsamala. 1 Dwai Pujhari 2 Seik Nabab Ali of Patna. 1 Jadu Sahu (Cofectloner) 2 Monhu Sahu (Khandait) 3 Maguni Sahu 4 Bhagbut sahu of Kalluda. 1 Markund Padhan 1 Hari Padhan of Srutabati 1 Dadhibabun Naik 2 Sibachha Putnaik 3 Agni Naik of Pkalo. 1 banamall Das 2 Shiv Misar of Purusotampur. 1 Pankaj Nund 2 Dhuru Naik of Kantikole. 1. Anadi sahu 2 Kusum sahu of Nuagan. 1. Shiv Mahanti 2 Illigible of nabhappur. 1 bauri Das 2 bhobni Das of Sapanpur. 1 Madhu nurdhan 2 Netra Dutta of Kallampur. 1 Madhu bhui 2 Govinda bhui of Karimabad. 1 Fakir Panda 2 Shiv Panda of Rahimabad. 1 Madhi Das 2 Arjun Das of Bija 1 Nabin sahu 2 Raghu Pusti of Dandaya.



Kendu Patna Canal.

Petition of the subjects of Bhagbutpur, Syamsunderpur<sup>p</sup> Bishnupur, Naranpur Baghilo, Barobatia, Goverdhanpur, Nilikana, Karpura, Oldha, Fakirabad, Mantripara, Kurujanga, Mungrajpur, Nuagan, Haldia, Bākhipara, Alabank, Gohalsingi, Juidaspur, Kasoti, Baragan, Sanagan, Jantilo, Simalda, Antalo, Jamadhur, Chakoirada, Orsanka, Saharpur, Hatbanpur, Dihabanpur, Kombharjanimal, Pailo, Kambilo, Deldiha, Isandiha, Baiakan, Narasingpur, Malikapur, Lakhminarayanpur, Bholpur, Dunpur, Dakhia, Hati, Girigola, Pabitrpara, Singri, Noropa, Khundsahi, Ratodia, Burgan, Narharipur, Sorisiha, Haripur, Jhinkurdiha, Godbisi, Fagalo, Janimol, Rajang, Kesurpur, Jaimal, Dehuli, Itali, Pandari, Morarpur, Hulpur, Nankar, Mahipal Ph Asuraswar, Derabis, Nuakhund and Sricana, Zillah Cuttack.

1. As there are no canals in all the above—mentioned Mouzas the canal water cannot reach all of them and especially the high lands of the Mouzas, but still we have to pay cess for these high lands. In low lands the crops are washed away by the stress of water for which we have to suffer much. Though we have petitioned against these oppressions, nothing has yet been done to remedy the evil, but on the other hand the cess is being realized by the issue of distraint from the sale proceeds of our cattle, utensils, doors &c. Since two or three years before the 5 years' Kabuliat was executed we have been suffering much for the payment of cess and bribes to the officers. Therefore we have no wish for executing fresh Kabuliats, with the exception of a few persons who out of fear of the patrols have executed Kabuliat. During the 5 years' Kabuliat we each executed it for two or three acres as was necessary but the patrols have realized cess from all



lands in our possession. It is imposible for us to pay cess at the rate of 1-8 per acre and pay bribe &c. to the patrols after executing fresh Kabuliats. If the Government takes no steps to redress our grievances we will not be able to live here.

1 Sadhu Sahu 2 Sadai Singh of Mufadpur. 1 Srinibas Panda 2 Siddhur Panda of Lukhmi nayayanpur. 1 Nabin Panda 2 Nidhi Panda of Bholpur. 1 Dam Panda 2 Ganeswar Panda of Daupur. 1 Indianaran Das of Dakhia. 1 Fakir Naik 2 Nidhi. Piatap of Hati. 1 Aperti Sain 2 Jugai Padhan of Hulpur. 1 Bhujni Mahanti 2 Babun Das of Girigola. 1 Bandhu Das of Pabitrappa. 1 Mayadhur Panda 2 Kali Pati of Singi 1 Rasio Samul of Naropa. 1 Bhagbut Naik 2 Jogi Raut 3 Bimbal Raut of Chakolrada. 1 Sadhu Mahanti 2 Kolu Mahanti of Nankar 1 Kasinath Panda 2 Illigible of Mahipal. 1 Manu Tiari 2 Narahari Tiari of Khundsahi 1 Ramkrisna Tiari Gopi Tiari of Ratodia. 1 Gobinda Tiari 2 Satiughun Tiari of Burang. 1 Mutunjoy Tiari 2 Parsu Tiari of Narharipur. 1 Mokunda Naik 2 Madhi Naik of sorisla. 1 Arat Raut 2 Dhani Bhudor of Haripur. 1 shujoi behara 2 Fakir Behara of Jhinkurdila. 1 Panchu Mudly 3 Hari Das of Fagalo. 1 Hari Das 2 nidai sarangi of Janimol. 1 Chandrasikhar Panda 2 Markund Panda of Rajang 1 Dam Raut 2 Madhal Raut of kesurpur. 1 Madhu Miser 2 Arjoon Ruth of Jaimal. 1 Bhujun Ruth 2 Abhi Ruth of Dehuti. 1 Bhubni Mullie 2 Bali Mullie of Itali. 1 Bonomali Sahu 2 Sodai Mahanti of Pandari. 1 Kanahi sain 2 Gangadhur Naik 3 Somonath Misra of Bhagbutpur. 2 Bhagbut samul 2 Mokunda behara of Syamsundapur. 1 sribunt behara 2 Joy Behara of Bishnupur. 1 Nath Sain 2 Kalipada Sen of Narayanpur 1 Rungai Padhan Ganga Maharna of naghilo. 1 Govinda Mahanti 2 Uchhub Das of Barobatia. 1 Anterjami Mahanty 2 Lukhi Padhan of Goburdhanpur. 1 Mohoni Padhan 2 Bhikari Mahanty of Nili-kana 1 Kapili Padhan 2 Jogi Mahanty of karpura 1 Amba Sutpusti 2 Bhiku Sain of Oldha. 1 Basu Tiari 2 Guda Das of Fakirabad 1 Lukmidhur Mahanti 2 Illigible of Mantipara. 1 Bimbadhur Mahanti 2 Gokhai Sahu of kurujung 1 Bidladhur Mahanti 2 Nilai behara of Mangraipur 1 Balkrisna Padhan 2 Bhubni Das of Nuagan. 1 Sankur Josia 2 Sholk Haldia of Haldia 1 Luclahan sain 2 Nunda Das of bakhipara 1 Natan Jona 2 Nidhi sain of Alabank 1 Sankar sahu 2 Nalu Mahala of GaharSingi 1 Bhut Naik 2 Sadai Das of Jaldaspur 1 Madhu baral 2 Silva Baral of kasoti 1 Lukhi Padhan 2 Bali Mahanti of Baragan 1 Iswar Samul of Sangau 1 Bhagbut Barik 3 Boban Barik of Jantilo.

1 Nidhi Sain 2 Mayadhur Sain 1 Lakmidhur Mahanty of Simalda 1 Karnul Naik 2 Kalai Mahanti of Antalo 1 Kurum Mjan 2 Panu Mahanty of Jamdhu. 1 Dinal baral 2 Dam Parlia of Oranka 1 Hari Naik 2 Maguni Mahanty of Saharpur 1 Bali Mahanty 2 Bhujni Das of Hotbanpur 1 Agni behara 2 Sambhu behara of Dhabanpur 1 Bagl Mandol of kumbharJanimal 1 Sadai bhudhur of Palle 1 Dal sahu of Kambilo 1 Subadov ik of Doldila 1 Bighna Acharji 2 Balidhur Panda of Isandila 1 Parikhit Senda 1 Anunda of Batakana 1 Nunda Panda 2 Jogi Panda of Narsingpur 1 Bhag Panda 1 Daddi la of Mallkapur.

Petition of the subjects of Nahang, Dahapara, Urua, Fagui agannathpur, Jharpara, Dhurmaghatpur, Ramkapur, Joyrampur, Mirjapur, Govindpur, Barajpur, Umar, Asastapur, Gotoru, Uabaldhua, Apilo, Jharaswarpur, Pandia, Balipara, Chakrapur,

Dihagope, Aliara, Karole, Banpur, Narijung, Gordang, Arkana, Baramarai, Sindhupur, Badatath, Gopalpur, Baibuar, Rasalpur, Nahung, Ph Sungda, Matkatnagar, Asuraswar, Zillah Cuttack.

1. Since the excavation of the canal there has been no good outturn of the crops in our fields. Owing to the embankments, no silt is deposited in our fields, caused by the overflow of rivers, therefore the outturn has fallen off. Still we are paying the land revenue, the Road and P. W. Cess, the Zemindaree Dak cess, bribe and other cesses for which we have become too poor and involved in debt. We have sold all our utensils, furnitures, cattle &c. owing to the oppression of the Irrigation officers. For having refused to execute fresh Kabuliat, the patrols have forcibly irrigated our fields and issued notice to assess at double rate on the plea of our having stolen water. If that cess be forcibly realized we will be totally undone.

2. Even after executing Kabuliat for 5 years we could not get water in time. So every year the crops on the elevated fields were lost for want of water, and the low lands were completely washed away by the canal waters consequently we suffered much, but we have not been exempted from the payment of the cess.

3. At the time of rough measurement, the Amins, without calling us to show our lands, have settled the land belonging to one in another's name. So we have been paying unnecessary cess for five years past. We complained several times, but they, without paying any attention to our complaints, realized the cess by distraint.

4. Those lands in our mouzas which were heretofore merely waste lands have become fruitful to some extent by means of canal water, but on the other hand it proved destructive and injurious to the lands which were under cultivation for years past.

5. If Government will not take any active measures to prevent the oppression and pressure of the canal officers, it will be very difficult for us to live. If the cess be levied at the rate of annas 8 per acre, excluding the high lands i.e. lands which can not be irrigated, we will make no complaint and execute Kapuliat of our own accord for ever. The Zemindars have increased the rent on the waste lands. Those, who complained, had their lands retaken.

Madhu Jena 2 Iswar Jena 3 Ramjan Mohamed of Nahang 1 Raghunath Sing 2 Krupa Biswal 3 Ahamed Khan of Dahapara 1 Dilli Khan 2 Fakir Khan of Arua 1 Said Golamjinnap 2 Anadi Bhuyan of Fagul 1 Satru Ujha 2 Fakir Bhuyan of Jugannathpur 1 Jagannath Bhuyan 2 Kanai Das of Jharpara 1 Balli Behera 2 Godai Malik of Dhurmaghatpur 1 Balstab Das 2 Iswar Panda of Rappkapur 1 Narayan Naik 2 Jagu Behera of Joyrampur 1 Khokai Behera 2 Najari Saha of Mirjapur 1 Kanu Das 2 Dhanaswar Kanangol of Govindapur 1 Keshub Khuntia 2 Sada Das of Barajpur 1 Bhaig Panda 2 Chaitan Gochhait 3 Dam Gochhait of Umar 1 Padan Suin 2 Arjoon Mahanti 3 Padan De of Nahung 1 Sadat Sahu 2 Gadai Naik of Asatapur 1 Tuli Padhan 2 Dhani Gochhait 3 Bhicari Sarangi of Gatora 1 Kanai Padhan 2 Bharut Padhan of Uabaldhua 1 Pan Spin 2 Gandai Bahana of Apilo 1 Apiti Gochhait 2 Madhu Misra of Jharaswarpur 1 Roghu Mul 2 Bharut Naik of Pandia 1 Puri Sahu Damoder Maharna of Balipara 1 Roghu Parira 2 Jogu Mullie of Chakrapur 1 Kali Suin Gobind Suin of Dihagopa 1 Binod Mahanti 2 Kusun Padhan of Allara 1 Roghu Bhuyan 2 Dai Bhuyan of Karola 1 Sumbhu Mullie 2 Bhoban Suin of Banpur 1 Madhu Mullie 2 Kusun Padhan of Natijung 1 Roghu Padhan 2 Achintu Mahanti of Gondung 1 Hadi Bhuyan 2 Kalai Raut of Arkana 1 Acadusi Padhan 2 Kanahi Mullie of Garmarat 1 Fagu Sahu 2 Kanahi Khatua of Sindhapur 1 Sudri Behera 2 Bhicari Behera Badatath 1 Agni Samul 2 Rahat Raut of Gopalpur 1 Arjuni Ghorai 2 Apurti Biswal of Balbuan 1 Gadai Mullie 2 Dama Suin of Rasulpur

#### Putamundai Canal

The humble petition of Dasiathi Kur, Ram Kur, Bhikari Pater Shiba Das &c. of Reba Ph Pudmapur, Zillah Cuttack.

1 We cultivate lands in Mouza Reba Ph., Pudmapur and have not taken lease of canal water for 1291. B. S.

2. We have not applied to the officers in charge of the canal for supplying water to our cultivated lands.

3. Our cultivated lands, which consist of low lands generally, require little or no assistance of canal water, hence, we applied to the Collector of Cuttack to release us from the obligation of taking leases for the same, on which the said Collector assured us that in case we take no lease, we shall



have to pay no cess at all.

4. Though we used no canal water at all, yet the officers in charge of the canal have now assessed our lands at Rs 3 per acre. Our fields, being low lands, are not benefitted by canal water therefore we have executed no Kabuliats. The canal does not pass through the high lands of our mouza and we generally cultivate those fields by the assistance of rain water. We have taken no water to our fields by cutting the canal embankment. But we have been assessed at double rates. The canal lies at a distance of three miles from our lands, our crops are washed away every year by the current of the canal water let out for irrigating Kabuliati fields. Still we have been obliged by the canal officers to execute Kabuliats for five years, but being unable to pay the cess in time our ploughs, yokes, oxen, doors, seeds, utensils and every other furnitures of our houses were attached and sold by the canal officers. We could not pay the Zemindars dues therefore we have been deprived of our ~~thans~~ lands with the crops on them which has led some of us to remove their house to distant villages. We therefore humbly pray to be relieved from the double cess. This petition was written by Anadi Kur.

1 Dabfathi Kur 2 Ram Kur 3 Bhikari Pator 4 Siva Das

The humble petition of Kritibas Das, Bali Das, Kalu Das, Arat Das, Kali Maharna, Rusi Behera, &c of Elmapur Pb, Puṇampur, Zillah Cuttack.

1. We have not executed Kabuliats for irrigating our fields situated in Elmapur for the 1290 B. S.

2. We have not applied to the officers of the irrigation Department, to irrigate our fields.

3. Our lands being very low we applied to the Collector of Cuttack refusing to execute Kabuliats for irrigation.



4. At present the officers in charge of the Canal have issued notices unlawfully to realize cess at Rs 3 per acre.

5 On the receipt of the notices we appealed to Mr. Roberts, officer in charge of the canal, which he rejected .

6. Again we appealed to the Collector of Cuttack, but he upheld the orders of Mr. Roberts without hearing our grievances.

7. Having no other means of remedy we lay before you (Society's delegate) that our lands being low we will not be benefitted by the canal water, therefore we have not executed Kabuliati. There is no canal in our mouza We have taken no water by cutting canal embankments. The canal is two miles from us. Still the officers are about to realize cess at double rates. Our lands, being very low, were washed away every year by the water of the drains and the excess water of Kabuliati lands. Before this, on our refusal to execute Kabuliati the canal officers, threatening to realize cess at double rate, obliged us to execute 5 years' Kabuliati. During that time some of the ryots being unable to pay the cess in time had their cattle, utensils, seeds and furnitures of their houses attached and sold by the officers in charge of the canal department, who let men of low castes enter into our houses by which we have lost our caste. Our lands have been taken away by the Zamindars as we were unable to pay the rents due from us. Some of us have left their fatherland and removed their houses to distant places. Under the circumstances we humbly request that our cases might be taken into favorable consideration

- This petition was written by Anandi Kur of Reba Ph Pudinapur.

1 Kritibas Das 2 Boli Das 3 Kolu Das 4 Arut Das 5 Kola Mahana 6 Ruel Bohara

The humble petition of Ram Raut, Panu Naik, Govind Mis-  
er, Modun Das, Anand Barik, Panchit Das &c of Mohinapur



Ph Pudmapur, Zillah Cattaek.

1. We cultivate lands Mohinapur Ph Pudmapur, but we have neither taken lease for canal water for 1291 B. S. nor have we requested the officers in charge of the canal Dept for water
2. Our cultivated lands consist of low and *Pata* land, therefore we applied to the Collector of Cattaek to release us from obtaining lease.
3. At present the irrigation officers, having unreasonably assessed our lands at double rates that is Rs- 3 and 6 per acre, are threatening us to execute Kabuliat for Rs-8 per acre otherwise the whole of the double rates will be realized from us. We therefore humbly pray that we require no canal water as our lands are very low and susceptible of being washed away and consequently we have executed no Kabuliat. We have not taken water by cutting embankments still we have been assessed at double rates. Our crops are washed away every year owing to the rain water and the excess water of Kabuliat lands.
4. Before this we were threatened to take lease for five years, but being unable to pay the cess in time, our ploughs, yokes, oxen, utensils and the other furnitures of our houses were attached and sold by the canal officers for which we feel greatly oppressed. Under the circumstances we humbly pray that our case be taken into favourable consideration.

This petition is written by Anadi Kur.

Ananda Baik Panchu Das Ram Rout Panu Nalik Govind Mishra Modhu Das

Patamundi Kanai

Petition of the subjects of Unchdihi Ph. Sungda.

There are no irrigating canals or distributaries in our mpuza, but the officers in charge of the canal induced us to take lease for five years, holding out hopes of providing us with distributaries. Consequently we paid the cess for the

said, term and now we are not willing to take lease for another five years according to the requests of the officers of canal department, on the ground that we have paid cess for five years without receiving any benefit from the canal water. Now the officers in charge of the canal, having received false reports from the patrols and mohurirs that our fields were secretly irrigated, assessed us at double rates i.e. at Rs 6 per acre. We appealed to the Collector of Cuttack against the assessment but to no purpose, for he ordered us to pay the assessed cess. On this we stated that we have no means for paying the same, but he ordered that our houses &c. will be attached and sold unless we pay this due.

2. We will take no more lease for irrigating our fields as we can cultivate our fields with the assistance of rain water.

1 Gopal Das 2 Madhai Das 3 Cupil Das 4 Arut Das 5 Govinda Paddy of Unchadihi Ph Sungda

The Petition of the subjects of Lakhunpur Ph Sungda.

1. Previously we cultivated our fields with the assistance of the rivers Biupa and others, and now we feel much difficulty as the waters of the rivers have been shut out, since the excavation of the canal, by the embankment, thus depriving us of the advantage. We now chiefly depend on the rains.

2. We derive no benefit from the water of the Patamundai canal as most of our lands in the mouza are high-lands. The low lands are so little in quantity that we require no water for them. If any means be found to irrigate the high lands and annas 8 be fixed as cess per acre then we can take lease in future.

1 Fakir Bisui 2 Nitai Sun 3 Gopal Das 4 Dhanu Khan 5 Datta Sun 6 Apurti Sahu 7 Bodai Naik 8 Ratanaker Misra of Lakhunpur Ph Sungda

The Petition of the subjects of Haripur, Brahmankhund Durgapur, Baliapat, Jakdiha, Sadaipur, Malihata, Jagannathpur, Chapda, Ganaswanpur, Unchadihi, Lakhunpur, Narda,

Padhanpara, Bhimraipur, Makundapur, Chumpapur, Ganipur, Ichhapur, Athamania, Suakhala, Asasthapur, Padabor, Jagutapur, Anantapur, Ph. Pudmapur, Sungda, and Karola, Thana Salepur, Zillah Outtaok.

We do not require the assistance of canal water for it cannot irrigate the whole of our lands. Since 7 or 8 years we are feeling much difficulty for paying cess at Rs 1-8 per acre without receiving any benefit therefrom. If the rate be reduced and means be adopted for convenience of realisation, then we can pay cess.

1. Fagu Nalik 2 Chintamony Sain 3 Jai Ram Sain of Ganipur. 1 Sadai Panda 2 Kalu Sain Sain 3 Uchhab Sain of Ichhapur. 1 Sadai Behara 2 Madan Das of Athamania. 1 Sindhu Behara 2 Bindhu Behara of Padabor. 1 Arut Sahu 2 Khonda Khuntia of Suakhala. 1 Gangai Behara 2 Balkrista Sahu of Jagutapur. 1 Bhagbut Behara of Asasthapur. 1 Boli Raut 2 Pandub Sain of Anantapur. 1 Bhaja Mahanti 2 Bhoban Das 3 Sadhu Sathy of Brahman khunda. 1 Chandai Mahanti 2 Govinda Mullik of Durgapur. 1 Balabhadra Das 2 Madhu Misra of Ballapur. 1 Gopi Sain 2 Arut Mahanti of Jakdiha. 1 Gopal Raut 2 Dama Behara of Sadaipur. 1 Kalai Behara 2 Natha Behara of Mallkata. 1 Natha Baidai 2 Kunhai Bhai of Jagannathpur. 1 Sant Samal 2 Nand Raut of Chapda. 1 Raghu Padhan 2 Sadai Biswail of Ganaswarpur. 1 Gopal Das 2 Mudai Das of Upchadihi. 1 Nitai Sain 2 Dama Sain 3 Ananta Sain of Lakhunpur. 1 Bauri Subudhi 2 Madhai Sethi of Narda of 1 Krishna Satputy 2 Mahadeb Sain 3 Bidya dhar Sain of Padhanpur. 1 Lakhun Panda 2 Sadhu Mullik 3 Nalu Samal of Bhimraipur. 1 Anand Nanka 2 Bharat Mullik 3 Bonoda Mullik of Makundapur. 1 Gadai Panda 2 Bahari Panda of Ganaswarpur. 1 Balaram Mahanti 2 Gunganarayan Mahanti of Chumpapur.

1. Our cultivated lands are situated on the banks of the river Birupa; when the river overflowed its banks, part of the crops of the low lands were swept away by its current depositing silt on comparatively higher lands. But since the excavation of the Patamundai canal, water accumulates in such quantities in our fields that it destroys all our crops, thus depriving us of the means of paying even the land revenue. Notwithstanding this, the canal officers forcibly realized the cess from us for five years, and when we brought our grievances to the notice of the authorities no one heard our prayers.

2. The river obstructed by the canal pulls down every year our mud walls and washes away our houses, under such state



of things we have lost every thing we had, therefore we need not require such canal waters at all.

3. The fields lying to the right side of the canal were, it is true, at times swept by the river water but now those waters being obstructed by the canal the fields suffer heavy loss for want of silt.

4. The canal officers wanted to take fresh Kabuliats from us, for five years, in this year, but we being unwilling to execute fresh Kabuliats informed the authorities that we need no canal water, accordingly the shoots have been removed. But still the canal officers hesitate not a little to extort cess from us by selling our moveables. Some of the ryots being unable to suffer the exorbitant oppression of the canal officers and having been deprived of doors, utensils &c have left their houses and have gone to the villages where there is no canal.

1 Apurty 2 Fakir behara 3 Panu Satpasty 4 Honodo Nanka of Mal 1 Bholi Puty 2 Bhajni Pator of Bhainpoor. 1 Bholanath Das 2 Bat Biawal of Gargara. 1 Ananda Samal 2 Sadai Sahu 3 Gopi Raut of Bhora. 1 Arun Singh 2 Balstub Raut of Salapur. 1 Jalodhur Raut 2 Bhikai Nanka 3 Ghoni Raut of Kuarpur. 6 Mahadob Raut 2 Panchu Raut of Laptuan. 1 Monu Sarangi 2 Ram Sahu of Ramkrishnapur. 1 Bidyadhar Misar 2 Mondar Mahanty 3 Jaladhur Samal of Barahipur. 1 Bhagbut Behara 2 Sulab Sain 3 Nidhi Nalk of Mouda. 1 Saratha Behara 2 Gohind Palal of Gurda 1 Bansal Khantia 2 Fakir Punda of Tilda 1 Anadi Kur 2 Doll Kur of Reba Madhu Satpasti 2 Jatadhar Misar of Katikata 1 Sadasib Raut 2 Chatoorbhuj Das of Mahanapur 1 Domai barik of Uturol 1 Kapil Sarang 2 Dinabandhu Sarangi of Rudramapur Sadai Das of Elmapur 1 Shibo Maharana 3 Gourl Mahanti of Noapur 1 Benalk Mahanti 2 Pada Oharan Mahanti of Kakurasa 1 Chakra Mahanti 2 Dharat Padhan of Gohapur Gandadhar Dass 2 Banu satpasti 3 Arat Das.

The petition of the subjects of Patarapur, Nalipur, Charinangal, Babujung, Matkutpur, Prusotampur, Kasrapur, Palal, Nalatigiri, Akarpāra, Kalyanpur, Sahaspur, Manitiri, Sorol, Nariasahaspur, Panaspur, Bhuratpur, Parabundraswar.

1. The Mouzas in which our fields are situated are from one to three miles distant from the Patamundai Canal. The canal officers, on the understanding that the canal water from the Bali chundrapur head sluice mixing with the rain water irrigate

our fields, told us to execute Kabuliat, threatening that he who would not execute Kabuliat should be charged with stealing water and shall be liable to pay a cess of Rs6/ per acre. Therefore through fear, we executed Kabuliat for the 5 years, and appealed several times to the canal superintendents without effect.

2 Before, the river Birupa was depositing silt in our fields by its overflowings which greatly enriched the soil. But since the excavation of the Patamundai canal, the embankment of which passes along the bank of the river our fields are no more deposited with silt thus the productive powers of them have decreased to such an extent that we are unable to pay even the Zamindars' rent from their products. Under such circumstances we are unable pay cess and therefore unwilling to execute Kabuliat for the current year.

3. We took no lease till Kartio 1290 B. S. The canal officers threatened us that unless we will execute Kabuliat for the current year they themselves will cut the embankment and prosecute us of having cut the same and assess our fields at double rates. We have therefore executed Kabuliats for the current year 1291, B. S.

4. In case any ryot falls in arrears of a trifling sum he has to pay 2 annas as cost of notice 4 annas as cost of attachment and one anna as cost of drum (total 7 annas) which if he fails to pay they enter his house carry away his furniture as suit their desires and from the sale proceeds of which they realize cess with cost. If they fail to find any furniture, they issue warrants and putting us to trouble they realise the cess.

5. We therefore pray that we are ready to take lease at low rates for those lands only, which require the assistance of canal water excepting the high lands where water cannot reach and low lands which need little or no assistance of the same.



Patarapur 1 Bhikari Samal 2 Gadadhar Santra 3 Nityanand nol 4 Panchit nol of Nalipuri  
1 Sholk Enaetulla 2 Asmuttulla Khan 3 Sholk Nufu 4 Sholk Gousi of Chaitnangal 1 Sholk  
Ramjan 2 Nityanand nol 3 Danardan nol of Babujung 1 Sholk Ramjan 2 Sabadai Khan of  
Matkutpur 1 Mahant Mahanti 2 Baistab Charun Mahanti of Prusotampur 1 Dhanswar  
nol 2 Barju nol of Kasalpur 1 Duttahari Padhan 2 Mudhusudan Mahanti of Palai 1 Baburam  
Sing 3 Samsing of Nalatighi 1 Dadhi Maharna 2 Bhim behora of Akarpara 1 Ifaladhar Ma  
hanti 2 Gopal Padhan of Kalyanpur 1 Raghu Das 2 Danai Mullick of Sahaspur 1 Dass  
Samal 2 Mana Mullick of Manitil 1 Bhoi Mahanti 2 Sadai Sing of Soroi 1 Punanand  
Mahanti 2 Bhikari behora of Nailasahapur 1 Radha Charun Naik 2 Rusanand Das of  
Panaspur 1 Bidyadhar Samal of Bhumatpur and Parabundiaswai 1 Sadanand Mahapatra  
2 Jogobandhu Chowdhry 3 Kripasindhu Sahu of Baichundiapur 1 Lakhan Paria 2 Bhurut  
Paria 1 Kinai Mullick 2 Shih Sui 3 Aprati Padhan 4 Magu Panda 5 Illigible of Nanpur  
1 Ram Jena 2 Bhujun Naik 3 Fakir Naik 4 Arut Samul of Pasupur 1 Panchu Samal 2 Samal  
Senaputty 3 Durlabh Senaputty of Kallanti 1 Bhogwan Senaputty 2 Madhu Senaputty of  
Bagashurpur 1 Hari biswal 2 Madun Raut of Ohianpal 1 Chukradhar biswal 2 Gudai Samal  
of Utammodhespur 1 Panu behora 2 Mahadev behora of Mirjapatna 1 Rungi biswal 2 Hari  
Sing 3 Anam behora of Mogalpatna 1, 2, 3, 4, 5 Illigible 6 Mohendia nath Ghose for Ram  
Lokun Ghose Zemindar 7 Gour Chundia Rai of Srikrishnapur 1 Dhani Samal 2 Baistab  
Padhan 3 Ghana Pani of Jollaswarpur 1 Sadai behora 2 Ram Hari behora of Malhutta.

The petition of the subjects of Nekirai, Majhisahi, Paikirapur, Chandpur, Amritamonahi, Jogisahi, Kandrasihi, Kumbharsahi, Purbasahi, Hariharpur, Patna, Mathasahi, Hanumatpal, Indupur, Kutrang, Charpada, Balatol, Gobindapur, Sanpali, Dhumunta

1. It is a rule to issue notices on the ryots whose cess falls in arrear. The officers in charge of the canals do not cause them to be served on us regularly but keep the notices with them and on the expiration of the time stated in them come up with the attachment process and realise 2 annas as cost of notice, 4 annas as cost of attachment process and 1 anna as cost of drum amounting in all to 7 annas. Thus it will be seen that in case a ryot be in arrear of one rupee or even one pie he has to pay 7 annas as cost for the realisation of the arrear for nothing. When they find no property they, with the intention of oppressing us leave a balance of an anna or even a pie and realise the same with seven annas as cost by making the *Pan Kandrasi* and Mehomedans to enter our houses, for which we lose our caste. In this way we have been ruined Therefore

we are unwilling to execute fresh Kabuliats.

2. At the time of executing Kabuliats for five years we took lease for those lands only which required the assistance of canal water, but the Amins at time of measuring the lands asked for bribes of Rs- 10 to 30 for each acre. Of course some of the ryots were unable to satisfy them, in such cases they at the time of measurement measured<sup>n</sup> their lands as 6 acres, which are in fact 3 and 8 acres in the place of 6, and in some places assessed those who have no lands at all.

3. If we do not pay any bribe to the patrols and amins then our cattle are 'taken to the pound', on a false charge of their grazing on the canal embankments and sometimes they release them on receiving bribes. Therefore we have sold off all our cattle retaining those only which are required for cultivating our lands

4. The canal water has made our lands saline hence the productive power of these lands have been lessened. Therefore we are under difficulty to pay even the Zemindars rent. For these reasons finding no means of paying the cess we are willing to execute fresh Kabuliats for the ensuing year and have resigned our Kabuliats for 1291 B. S. before Collector of Cuttack.

5. The officers of canal have caused forged Kabuliats for 1291 B. S. to be executed on our behalf. Though we are quite ignorant of such Kabuliats, notices have been served on us. If Government officers take such steps, we are undone, for then who will listen to our greivances ?

6. Notices have been issued for the year 1291 B.S. on the strength of the forced Kabuliats. We therefore pray that the case be inquired into and we be relieved from the cess.

1 Raghu Jona 2 Iswar Jona 3 nauribundhu Jona of Nekhal 1 Madhu Jona 2 Bidu Panda of Paikirāpu 1 Karuni Sahu 2 Parli Sahu of Ohandpu 1 Bidyadhar Sahu 2 Madhai Sahu of Amritamonahi 1 Gopinath Satpasti 2 Das Satpasti of Jogisahi 1 Sholk Sadulla 2 Kandu Jona of Kumbhāsahi 1 Ban nehoia 2 Netyanand Jona of Purbasahi. 1 Raghu Sing

2 Karani Mullik of Kundrasahi 1 Naratom Thatari 2 Salabhai Sahu of Nikhailpatna  
 1 Ghana Thatari 2 Mahadev Naik of Mathasahi 1 Bhogi Khatua 3 Bori Sethi (Mishra) of Hanumatpal 1 Illigible 2 Bidai Sethi of Indupur. 1 Padalay Jena 1 Bindu Naik of Hariharpur 1 Mahadev Samal 2 Banamali Sain of Rutunpur. 1 Sriam Raut 2 Nairin Pahi of Champara 1 Gangadhar Thari 2 Gadai Thari of Balatol 1 Banamali Panda 2 Bidya dhar Panda of Govindapur 1 Kuntle Pater 2 Dahu Biswal of Sanpali 1 Bin Raut 1 Bhim Jena of Dhumanta 1 Kanhai Sain 2 Bharat Naik of Tripunariya. 1 Bhikari Pahari 2 Hari Pahi 3 Janakul Pahi of Kunderpur 1 Gopal Pathuok 2 Bhikari Tewari of Nangalpur 1 Balkuntha Jena 2 Ram Jena of Illigible 1 Dururi Jena 2 Tiga Das of Madhapur 1 Bidai Raut 2 Ram Mahanti of Netua 1 Jubani Mahanti 2 Ghana Mahanti of Illigible 1 Bida Das 2 Bhikari Thari of Nookhapatna 1 Kuber Mullik 2 Biswanath Das of Nahung 1 Mohani Sahu of Mund-sahi 1 Bauri Prusty of Dhasahi 1 Shibo Bol of Naypur 1 Achhuti Bhunj 2 Purnanand Bhunj of Dehuri 1 Nal Krishna Jena 2 Jhari Samal of Gopalpur 1 Dasa Jena 2 Bhagwan Samal of Kalasahi 1 Sapui Raut 2 Lakhmidhar Mahanti of Dighria

The petition of the subjects of mouzas Ghusibar, Kisanpur, Ersanda, Baranampur, Urimal, Jonapur, Bindapur, Amotula, Killa Chousapur, Thana Dhumasala Zilla Cuttack. Mouzas Bania, Balarampur, Janmangalpur Ph Jajpur, Sirgada, Matkalabad, Jodha, Zilla Cuttack.

No water is required for the cultivation of the fields in the first named mouzas. The officers in charge of the canal have forced us to execute Kabuliat for 5 years and realized cess from us by force. Besides they have recently forced the subjects of 3 other mouzas to execute Kabuliat.

1 Nodhi Sain 2 Dismithi Pusti of Baruan 1 Chintamani Mahapatra 2 Sindhara Panda of Ambobati 1 Rusaund Mahapatra of Baliaupur 1 Sadai Kur of Jamuna 1 Chama Sahu of Patlipur

The petition of the subjects of mouzas Khairapal, Barua, Naranpur, Rajkana, Banki, Kapapada Damaka, Nichinta, Ghusi, Unchapada, Gopisantapur, Dakalo, Jhatia, Dakadi Bainchua, Kisanpur, Jagunnathpur, Kankapada, Ph Kunohikunda and Killa Daljora, Zilla Cuttack.

Before the introduction of the 5 years Kabuliat system the inhabitants of the above Mouzas did not execute Kabuliat, but the officers in charge of the canal having let the canal water, of their own accord, irrigated some of the mouzas, and forcibly realized cess as their whims dictated without any fixed standard is from annas 8 to Rs 3 per acre.



2. The canal officers, at the time of the '5 years' Kabuliat, taking our names from the 'village chowkidars' and others forged our names on the Kabuliat and realized cess from us, for all lands excepting our homesteads.

1 Kussan ojah 2 Anant Mudali of Khatrapal 1 Madhu Mahapatra 2 Bhajan Suin of Barua 1 Kalai Pater 2 Muli Naik of Narapur 1 Gobar Samal 2 Anirudha Satpatti of Bonki 1 Bai Suin 2 Sonai behera of Rajkanna 1 Ratan Nenka 2 Sonai Suin of Damaka 1 Hari Panda 2 Gopi Raut of Nichinta 1 Jai Panda 2 Anadi Suin 3 Shyam Biswal of Ghusi 1 Kunt Naik 2 Nidhi Mahanti of Unchpada 1 Bhikari Tihari 2 Gopal Mahapatra 3 Bhajan Panda of Gopisantapur 1 Ratan Mullik 2 Bhikari Mullik of Dakalo 1 Bedai Neka 2 Naran Das of Jhatla 1 Anant Suin 2 Ram Panda 3 Sada narai of Kurai 1 Nitya Samal 2 Senai Padhan of natuchana 1 Madhu Pater 2 Gobinda Padhan of Kusanpur 1 Gadai Kur 2 Kanai Tihari of Jugannathpur 1 Sibhu Misra 2 bh hari sahu of Kankpada.

The petition of Joy Panda, Sridhur Padhan and Shyam Biswal &c. of Ghansisantapur Ph Kanchukhunda; Hari Panda and Sadhu Suin &c. of Nichinta, Bai Suin and Sonai Behera &c. of Rajkanna; Banamali Suin and Jogu Suin &c. of Dumka in Zilla Cuttack.

1. The canal officers were realizing cess forcibly at 12 annas per acre from us for 7 or 8 years ie from the beginning of the High land canal section ( I ) by letting in water into our lands without our sanction. Having no other alternative we executed 5 years' Kabuliats in 1878-79. Nearly one-eighth part of the ryots pay the cess year by year before the issue of notice. Nearly three-eighths of the ryots pay after the issue of notice and the officers realize the cess from the rest by oppressing them with warrants, consequently we are suffering too much. Formerly those lands of the above mouzas which were rented at Rs 1-9 per acre the Zemindars have now realised enhanced rent of Rs 3-2 and the lands which were rented at Rs 2-5-6 at present increased to 4-12 and those which were rented at Rs 4-12 increased to Rs 6-4. For this reason we suffered much and some of the ryots have left their houses and went to live in Jungles and as we are in most straitened



circumstances and are unable to pay cess we do not intend to execute Kabuliya. We pray that in consideration of the above facts if the cess be reduced to 8 annas per acre uniformly we will execute Kabuliya willingly. Otherwise it will be difficult for us to pay Rs. 1-8 per acre as cess and Rs 4-8 as rent to Zemindars on an average, besides the cost of cultivation. At present we get only one *varan* and 40 *gannis* (a *ganni* = 3 seers) How can we under such circumstances maintain our families. We therefore pray that our case be taken into consideration. Dated 4th *Asara* of 1291 B.S.

1 Sridhar Padhan 2 Joy Panda 3 Shyam Biswal 4 Hari Panda 5 Sadhu Suin 6 Bai Suin  
7 Sonai Behora 8 Banmall Suin 9 Joga Suin.

The Petition of the Ekadasi Samal, Das Parira &c. of Naulpur; Kandru Khan &c. of Saharabali; Rangi Jena &c. of Sarvi; Brunda Parira, Sadai Samal &c. of Sundria; Panu Mahant, Dhrub Das &c. of Sadaipur; Jagu Baral &c. of Rathia; Kanai Raut, Nidhi Raut of Fathapur; Bir Panda, Boistab Raut of Salbana; Chintamani Raut, Boli Sahu of Araipur, Api Das Nabab Alli Mia &c. of Tarapur; Kunhai Raut of Badarukhan; Panu Suin, Raghu Sahu of Sankardihi; Gopi Mahapatra and Dutta Kur &c. of Dhakinsasan; Moni Mahapatra, Madan Panigrahi &c. of Utarsasan; Bhaig Khelar, Ekadasi Palai &c. Chukmabodila; Khatra Das, Padun Das &c. of Kapilswarpur; Krupa Samal &c. of Sanmangalpur; Raghu Samunt, Chaitan Maharana &c. of Baligari; Shibo Pati, Dai Raut of Narsingpur; Golam Ali Mia of Maninathpur; Shah Bux Mia &c. of Barmangalpur; Barku Mia and Dinabapdhu Mahapatra &c. of Jalsuka; Hari Padhan, Kalai Sahu of Dubgaria; Nath Mahanti, Hrudi Das of Sabta pur; Jagu Baral, Sahadev Suin &c. of Bhaturi pari; Jagu Baral of Brahamapur of Kismut Killah Durpan, Zilla Cuttack, pray that their grounds of greivance as given below:



1. The water from the hills could not come down to our fields from the date of the excavation of the canal consequently we could not reap good harvest.

2. We can reap a good harvest if the drains be closed and the hill waters be allowed to pass over our fields.

3. The produce of our fields are at present one *varun* and 40 *gaunis* (a *gauni* = 3 Cuttack seers.) it is therefore very difficult for us to pay the land revenue, irrigation, Road and P. W. cesses with such limited profit.

4. The crops are greatly injured owing to the untimely supply of canal waters by the officers of that Department without supplying the same in times of need.

5. High cultivated lands are never watered with canal water but still the officers of the canal Department illegally realize cess for these lands notwithstanding our objection.

6. Formerly the cultivations of some of the above mouzas were carried on by the waters from springs and ponds but owing to the canal embankment, the water from those sources do not water the lands now, consequently, the crops of those lands are failing.

7. In the current year the canal officers had not supplied water in proper time but supplied it when the crops were ripe. By this though the crops were damaged yet we have not been releived from the payment of cess for such lands which were not watered at all and also those which did not produce anything.

8. Formerly it was difficult for us to maintain our family after paying the land revenue of these lands. Now a days we receive a small outturn but are obliged to pay Road, P. W. and Irrigation cesses in addition to land revenue therefore we pray that the Irrigation cess be reduced to 8 annas instead of Rs 1-8 the present rate.

1 Das Parira 2 Kundra Khan 3 Gopal Nalik 4 Bhogi Jena 5 Kritibas 6 Badu Parira 7 Sado Samal 8 Pannu Samal 9 Jagu Baral 10 Panu Sahu 11 Kanai Raut 12 Nidhi Raut 13 Nisra Behora 14 Chintamani Raut 15 Gadal Das.

The petition of Fakir Miser and Mohi Kur &c. of Sasan-prusotampur; Sadai Chowdhri and Bhajan Bol &c. of Barchana, Dhanaswar Padhan and Bhagbut Padhan &c. of Daulkur; Radhu Baral and Lakhan Baral of Khaira; Somenath Acharji and Bhikari Ota &c. of Nuasasan; Madhu Samal and Bhogi Samal &c. of Kadai; Nobin Pusti and Mohoni Pusti &c. of Dagarpura; Satri Das and Hari Mahanti &c. of Chandital; Somenath Ota and Gokhai Tehari &c. of Kanjia; Bholi Sahu &c. of Dehasahi; Joyram Das &c. of Sasanshima; Sadhu Naik Sadasib Naik, Ghana Sahu &c. of Dhanmandal; Madhu Senapati, Khetra Mahala and Anant Sahu of Sungda; Nitai Jena &c. of Khosalipur; Srinii Jena and Sadai Dhakin Rai of Nisimla; Iswar Naik &c. of Kuarpur; Lochun Sing &c. of Barchanabazzar; Banamali Das, Raghu Raut &c. of Hasana bad-chakdeulkal; Killa Darpan, Zilla Cuttack, state their greivances in the following paras.

1. The outturn of our paddy crops have been considerably reduced from the date of canal system as the water from the hills do not pass over our lands.

2. The outturn of our crops will be greatly improved if the drains be filled up and the waters from the hill be let through our fields.

3. The produce of one acre of land is now at some places one *varun*, at other places one *varun* dan 40 *gaunies* (*gauni* = 3 Cuttack seers), but it has been very difficult for us to pay from that the rents to Zemindars, and the Road, P. W. and Irrigation cesses.

4. The crops are not growing well because the officers in-charge of canal do not supply canal water in due time.

5. The high lands are not irrigated by the canal water, but the officers in charge of canals realize watercess from us for those lands without hearing any objections.

6. Formerly the crops were watered from the ponds and fountains situated in the mouzas but at present the outturn of the crops of those mouzas has been reduced as the Canal embankments have stopped the course of these water.

7. These year the canal officers, without supplying with us water have assessed and realized the cess, even from those lands where the water could not reach or those in which the crops have been totally destroyed.

8. It was difficult for us to support our families after paying the land revenue to the Zemindars but at present we are paying irrigation cess, Road cess, P. W. cess in addition, while the outturn is gradually on the decrease. We therefore most humbly pray that the irrigation cess be reduced to 8 annas per acre.

Dated 5th Asar 1291 B. S

1 Mohani Pusti 2 Nitai Jona 3 Bilagi Samal 4 Iswar Nial 5 Radhu Bural 6 Bhikari Ota 7 Khatu Mahala 8 Dhanoswar Padhan 9 Sadhu Tihari 10 Mohi Kur 11 Srinai Jona 12 Sadai Behora Sadai Chowdhri of Burahana 1 Fakir Misra of Sasan-Purusastompur

The petition of the subject of mouza Chhoapatna, Nilia, Rangidaspur, Sookdebpur, Prannathpur, Sapanpur, Solara, Paikirapur, Olui, Bandalo, Akadalia, Champapur, Bidyadhurpur, Nahara, Bairi, Tapula, Satmunda, Barimul, Bontala, Kapustikiri, Hijila, Raghudasur, Padamnathpur, Gopalpur, Dulpata Kodibatia, Ranipukuri, Bapatpada, Gokulpur, Kantapukuri, Jamdhur, Sahapur, Baula, Daulutpur, Sambundalo, ~~Panes~~, Dhenkiarundha, Jagannathpur, Enaetnagur, Parisaho, Kumbhoi, Balibati, Gopur, Rampur, Killa Durpan Zillah Cutlack.

1. Formerly we obtained a good harvest with the assistance of the water from the rocks and rivers but at present owing to the obstruction of canal embankments the river water does not



pour into our fields and the lands are not silted up consequently the outturn have been considerably reduced; on the other hand the land revenue have been increased by the Zemindars and we are no gainers at present after paying Road and P.W. cesses and the irrigation cess &c. Still the lands adjacent to the hills do not require to be irrigated as they receive supply from the hills, but the officers in charge of canal are obliging us to execute Kabuliats by excavating drains which carry away such waters.

2. Owing to the enhanced rate of irrigation cess and owing to the oppression of the officers in charge of canals at the time of realising such cess and for the troubles we underwent at the time of irrigating our fields, we have been made to suffer much during the term of five years' Kabuliats. Our bullocks untensils, and other furnitures have been sold for realising the cess; for this reason some of the villagers have left their cultivations and some have left their houses for other villages.

3. We will be not able to execute fresh Kabuliats unless the rate of cess be reduced and new arrangements be not made for the realisation of the cess. When the obstruction in the way of river and hill waters will be removed we shall have no cause of complaint or grievances.

1. Panusamal 2 Mukunda Ghadai of Rampur 1 Panu Kaul 2 Sami Padhan of Gopalpur  
1 Hadibundu Nanda 2 Naram Nanda 3 Nidhi Santra 4 Fakhi Panda of Chhatia 1 Bhikari  
Padhan 2 Dai Naik of Ekadali 1 Shiba Pusti 2 Arat Naik 3 Chandri Panda 4 Samal Panda of  
Dalpat and Rampit 1 Biju behara 2 Natha behara 3 Dharti Natha of Bidyadhurpa 1 Makund  
daswal 2 Bhikari Panda 3 Mahant Sadanund Das 4 Brijan Khatua of Hinjala 1 Anant Nenka  
2 Bhikari Raut of Kaitipukhi. 1 Nidhi Santra 2 Panu Raut 2 Basu Suin of Sapampur. 1 Kasturi  
Raut 2 Ram Nenka 3 Nidhi Santra of Chamapur 1 Madhu Samal 2 Raghu Suin 3 Khali Suin  
of Nalla 1 Makund Das 2 Dam Das 3 Hasi Paikda 4 Mathuri Das of Nohara 1 Bhurat Nenka  
2 Api Tihari of Padmalabbur. 1 Narsing Padhan 2 Shyam Raut of Dihakunda 1 Bhagbut  
Sahu 2 Madhu nehara of Jamdhur 1 Ganaswai Paharaj 2 Bidyadhu Mahapatra 3 Bhagi daswal  
4 Padu Suin of Saloto. 1 Bidyadhu Mahanti 2 Radha Suin 3 Sadai Samal 4 Iswar nehara of  
Bhup 1 Sadai Samal 2 Dam Samal of Rangidapur 1 Su Sing 2 Kalai Protap of Salmanda  
1 Bhujan Padhan 2 Madhu Naik of Kandibitir 1 Apikand Mahanti 2 Dhani Raut of Shapur  
1 Hadibundu Nund 2 Arat Naik 3 Panu Sahu 4 Shiba Sahu of Patknapur 1 Ganaswai Paharaj  
2 Bhobani Nenka 3 Arat Raut 4 Satru Salut of Uballa 1 Bhikari Raut 2 Madhar Raut



3 Kusal Raut of Sukdalpur. 1 Chaudhri Sain 2 Nokai Naik of Kapasithiri 1 Hari Mahanti  
2 Naran Naik of Jagunnathpur 1 Puri Padhan 2 Dam Sahu of Ranipokpur 1 Gobind Sahu  
2 Kesab Naik 3 Modhu khatua of Baula. 1 Sonai Sond 2 Gopi Sond of Ichhanugulpata  
1 Madhu Sahu 1 Hadibundhu Nanda 3 Bidai bohara of Ramprosdpur. 1 Achhuti Sahu  
2 Bhuban Sahu of Pannathpur. 1 Apari Mahanti 2 Arjun bohara of Bantalo 1 Sibo Raut  
2 Fakir Raut of Inactnugur. 1 Bhagbut sain 2 Rajani Raut of Bapatna 1 Dharam sain 2 Rukini  
Padhan of Daulatpur 1 Rathi Sain 2 Sankar Sain 3 Arit Naik 4 Fakir Panda 5 Adhikari  
Sudam Charan Panda of Ulur 1 Gopi Sond 2 Gobind Sahu of Gopalpur. 1 Adhikari  
Das 2 Sindhu Panda of Kumbhal 1 Adikund Mahanti 2 Hari Mahanti 3 Bant Sahu  
3 Bhagut Sahu of Bandalo 1 Hari sahu of Balibati. 1 Dhanu Padhan 2 Sooboodhi Padhan of  
San-Bandalo. 1 Bhag Naik 2 Dhabadi Mukhi of Panaga 1 Hindu Mullik of Baimul Akadusi  
Raut 2 Apari Rat of Dhamasale 1 Adikund Mahanti 2 Harakriana Mahanti of Goculpur.

The petition of the subjects of Raghunathpursasan, Panuri, Bosantmaragohiri, Soonasirgohiri, Hinjumadhuban, Bhubunpur, Nijigur, Nathutha, Bhubunipur, Tapachatira, Bansanta, Srichandanpur, Khowla, Aantia, Gangutia, Nijmadhupurpat, Killa Madhupur, Thana Dharmasala, Zillah Cuttack.

1. Formerly the silt deposited in our fields by the overflowings of the rivers helped them to yield plentiful crops but since the excavation of the canals the obstruction of the embankment, has put a stop to it, consequently, the outturn has been greatly decreased. No good outturn is expected from the irrigating of the fields with canal water. Year by year the quantity of waste land is increasing. We are no gainers after paying the land revenue and the cesses.

2. We are paying the irrigation cess since last 7 or 8 years but owing to the high rates and bribes to the canal officers we have been greatly reduced in circumstance. Only two or three of the above mentioned mouzas were greatly benefited by the canal water but if the rate be reduced and if some new arrangements be made for the realisation of the cess we shall have no objections to execute Kabuliats for ever.



1 Chintamani Nanda 2 Bimbabhai Misra 3 Moniraj gu 1 of Roghunathpur 1 Sahu  
1 Dal of Ajimul 1 Mahadev Dalai 2 Chintai Dalai of Panuri 1 Bhagban Das of Jenaipur  
1 Govinda Sahu 2 Kanhai Samal of Silehundunpur. 1 Satrumaidhan 2 Bhikari Samal of Jhar  
sahida 1 Gangai Jena 2 Ram Mahapatra of Antia. 1 Sudhri Sahu of Chavanda. 1 Gadai Chow-  
dhry of Biahmampur.

The petition of the subjects of Naulpur, Saharabati,  
Soora, Soondunia, Sadaipur, Ruthia, Fathapur, Avaopur, Tara-  
pur, Talaban, Barrokha, Sankharidihi, Dharmasasan, Uttar-  
sasan, Dhokmobadila, Kapilaswarpur, Sabatipur, Monirathpur,  
Sannongulpur, Narsingpur, Baramongalpur, Bulgaria, Degam-  
berpur, Jalsooka, Dahikala, Sondapur, Bhatrapasi, Killa Durpan,  
thana Dharmasala, Zilla Cuttack.

We did not take canal water for all our cultivated lands  
either before or after the 5 years' Kabuliats. But no one hears  
our complaints to be exempted from the cess though we appli-  
ed several times. The officers in charge of canals are realising  
the cess from us in this way and for such cess our cattle  
utensils, furniture of houses and rent free lands have been  
sold. Some of us being unable to pay the cess have fled and  
we are unable to pay the Zemindars' rent for our lands.

We are now greatly reduced through paying water  
cess. We were neither willing then nor are willing at pre-  
sent to execute Kabuliats but the patrol officers by force  
obliged the subjects of some of the mouzas to execute such  
Kabuliats. Our circumstances do not allow us to execute  
Kabuliats under the existing rule. We have no need of canal  
water. But if the obstructions in the way of the ~~hill water~~,  
and water from the rivers &c be removed and the drains  
for carrying away rain water be closed, we shall have abund-  
ant harvest.

Kisori Samal 2 Das patha of Naulpur. 1 Bha Panda 2 Baistab Raut of Talaban 1 Bhagi  
Khilki 2 Ek desi Pati of Chamanbidia 1 Baku Mia of Baramongalpur, 1 Kanda Khan 2 Go

p 1 Nlak of Sahabati 1 Bolo Samal 2 Chintamani Raut of Avaepur. 1 Khetia Das Adhikari 2 Padan Das of Kapilawan. 1 Barku Mia 2 Dinabandhu Mahanty of Jaisuka, 1 Bhagi Jona 2 Kirtibas Bohera of Sarol. 1 Aphi Das 2 Nabab Ali Mia of Tarapur 1 Krupa Samal 2 Fakn Das of Sammongalpur 1 Hari Padhan 2 Kalai Samal of Dubganla 1 Brunda Pania 2 Sada Samal 3 Khatia Mahanta of Bundola. 1 Kanai Raut of Charukhi 1 Raghu Samal 2 Ratan Maharna of Daligori. 1 Natha Mahanti 2 Didu Das of Sabutipur. 1 Panu Samal 2 Mohunt Dhruva Das of Sadatpur. 1 Panu Sula 2 Raghu Sahu of Sankaidih 1 Shiba Pail 2 Dai Raut of Digamburpur. 1 Naba Bimal 2 Sadasiv Sula of Bouripasi. 1 Jagu Dalal 3 Panu Sula of Rathia. 1 Gopi Mahapatra 2 Datt Kar of Dakshinbasan. 1 Naran Maharna 2 Dai Paria of Narasingapur 1 Khanai Raut 2 Nidhi Raut 3 Nasai Bohera of Futtapuri. 1 Moni Mahapatra 2 Madan Panigrahi 3 Raghu Mahapatra of Uttarasasan. 1 Golam Ali Mia of Moninathpur

The petition of the subjects of Barchana Dhanmandua, Sasan-sima, Kantichira, Dehtasai, Naranpur, Baramania, Bidupura, Dagrappara, Kadai, Singda, Chandital, Baida, Bamigaria, Nis-mala, Kalapasi, Sasánprusotumpur, Kangia, Dabhog, Chakhar-chana, Betra, Kuarpur, Khantaposi, Chukdaulkur, Sungda, Khosalipur, Bolibur, Subhadrapur, Daulkur, Khaira, Chuk khaira, Killah Durpan, thana Dharmasala, Zillah Cuttack.

1. Before the 5 years' lease the officers in charge of canal let out the canal water to our fields out of their own accord and realised cess from us without any fixed rate. At the time of 5 years' lease they took our signatures on the Kabuliats promising that they would irrigate all our lands in time excepting the high and low lands but they supplied us with no water in time during those 5 years, on the other hand oppressed us to the extreme. They realised rents at equal rates from us for all the lands, whether they were supplied with water or not; on our objection to pay the cess they realised the same by the sale proceeds of our property. Owing to those oppressions we were in great misery. We had no intention of executing fresh Kabuliats or to take canal water to our lands, but officers of canals threatening us to realise cess at double rates forced us to execute Kabuliat.

We are not inclined to the taking of canal water and to

the executing of Kabuliats; because we pay cess but derive no profit from the cultivation. If the water from the rivers and hills be allowed to pour into our lands and the drains for carrying rain water from the fields be closed we will be able to reap a good harvest otherwise it would be difficult for us to remain in our abodes.

1 Sadai Sahu 2 Narsingh Nonka 3 Kanai Acharjee 4 Bhujai Bhol 5 Sukun Nonka of Borohani  
1 Dinal Pusti 2 Bhagi Samal 3 Chintamani Mahanty 4 Madhai samal of Kadai 1 Kanai soheri  
2 Bhagwan sahu of Debraj 1 Kohai Naik 2 Dam Mohola of Subhadiapur 1 Sadhu Naik 2 Ghana  
Sahu 3 Shiv Sahu 4 Kurupa Sahu of Dhanmadan 1 Nabini Pusti 2 Ghana Sahu 3 Manu Das  
of Uungu 1 Bhagbat Sahu 2 Jagu nai 3 Iswar Das of Chukrachana 1 Bhagbat Padhan  
2 Dhanurwar Padhan 4 Chakradhar Samal of Daulkai 1 Mohant Madhaba Nunda 2 Siddhu Das  
3 Kaku Das 4 Joyram Das of Garamma 1 Durgadhar Mahanti of Chandital 1 Gungai Paradi  
2 Data Sahu 3 Shubra Naik of Bet 1 Raghunail 2 Lakhon Bual 3 Nama Hari Mi .ee 4 Bhi-  
kui Otha 5 Lakhon Misra of Khadi 1 Mohanti Netianand Das 2 Bhajni Das 3 Soont  
Naik of Kuntach 1 Adikund Pusti 2 Sami Pusti of Baddi 1 Iswar Naik 2 Gadai Naik  
of Kuarpur 1 Gadai Sadangi 2 Madhai Samal 3 Subiswar Ocha 4 Jugisti Bual of Chuk-khadi  
1 Bhobani Sahu 2 Kurup Jona 3 Kalai Sahu Nilai Samal of Dabtasahi 1 Haddi Sethi 2 Pannu  
Mahanti of Brahmanahigait 1 Arut Naik 2 Dattai Bhol 3 Sour Sahu of Khantipasi 1 Biddi  
Acharji 2 Somnath Acharji 3 Bonomali Sadangi of Nandimara 1 Apariti Raut 2 Dandid  
Das of Naranpur 1 Sadu Dakhu 2 Saini Jona 3 Nidhi Jona of Nishnala 1 Sadai Chandi  
2 Kalai Acharji 3 Bonomali Das 4 Bholi Raut of Chukdaulku 1 Nidhi Raut 2 Bhobani  
of Boromaina 1 Khatia Mohola 2 Ananta Sahu 3 Madhu Senaputy 4 Lakhon Bhuwal of  
Sungda 1 Bhobani Raut 2 Balladhu Mahapatra of sedpu 1 Somnath Kur 2 Paki Misra  
3 Somnath Otta 4 Nalharu Misra of Sarun Pusotampur 1 Nilai Jona 2 Bhobani Jona of  
Khoshipur 1 Nabhi Pusti 2 Mohun Pusti 3 Agani Pusti of Ogarpara 1 Dattai Mahanty  
of Kungai 1 Markund Jona 2 Madhu Sahu of Ballboy 1 Madhai Jona 2 Apariti Jona 3 Arut  
Jona of Kalunpodi

The petition of the subjects of Birol, Sankastibrahmanpara, Taruan, Ghantimunda, Saranga, Naphung Korkor, Kamalpur Baraj, Narpada, Kasurpur, Hadsusua, Malpada, Baniki, Chakdwar, Tantara, Hariant, Teruan, Barjagarsahi, Saradala, Bramhunbhag, Tiranapada, Bahuda, Okarilo, ~~Khat~~, Paiguan, Tikira, Ambopari, Jaknia, Bundalo, Mongoli, Tangiramgur, Hadoo, Katanai Mothsahi, Kuarapari, Kundurkaroni, Sarata, Sulanga, Aroda, Malsosua Ph. Kukakhund, Killa Dalijoda, Kunchikhund, Zillah Cuttack.



1. The water cess is being realised from us since last 7 years. Before the 5 years' lease the officers in charge of canals realised cess from us by force from all our cultivated lands, somewhere at Rs 1-8 and somewhere at Rs 3 per acre and where they received bribes they realised at 12 annas and 10 annas per acre, although they have not irrigated all lands. If we objected to pay they realised the cess by the sale of our property and by warrants. Owing to these reasons we are in great distress.

2. The officers in charge of canal insisted us to execute 5 years Kabuliats at Rs 1-8 per acre saying that they would not demand any thing for high cultivated lands and supply us with water regularly. But we have not received canal water in due time during these five years, besides the crops of some of our low lands have been destroyed by excessive water from the canals. Still we have not been exempted from paying the cess. For these reasons we were not willing to execute any Kabuliat after the expiry of 5 years' term. On this the officers of the canal, declaring that we have taken water without lease are ready to realise cess at double rates from us. Owing to such oppressions some of the inhabitants have executed new Kabuliats, while others are unwilling to execute such Kabuliats because they think it difficult to pay cess. Some of the villagers have fled to Gurjats out of fear. Unless the cess be reduced and some arrangements be made for the realisation of the same, it will be very difficult for us to remain in peace in our abodes.

1 Anant Tihari 2 Godadhar Tihari of Bhuti 1 Bhagbut Behara 2 Hari Behara of Sasar Khasoli 1 Banudhar Sahu 2 Arut Behara of Bhamhanpara 1 Sodanund Mahanti 2 Lakhun Mahanti of Tarua 1 Ram Samal 2 Gobind Parra of Batimunda 1 Bhagabai Sing 2 Mohi Das of Naphang 1 Duttai Biswal 2 Bhikari Raut of Korkor 1 Godadhar Tihari of Kamalpur 1 Sadai Jona 2 Sital Majee of Borang 1 Iswar Lenka 3 Nairai Bhuyan of Kandrakasa 1 Panohu Khuntia 2 Arat Das of Tarot 1 Panu Sahu 2 Nari Mohamed of Tariam 1 Ram

● Chundra Raut 3 Ghana Samal 3 Hursi Samal 3 Dattari Biswal 5 Satru Mahanti of Har-  
 unta 1 Raghu Biswal 2 Kanai Raut of Tantira 1 Anandi Mongraj 2 Kamali Naik of Chou-  
 dhar 1 Achuti Sui 2 Madan Mahanti of Banika 1 Panu Mahanti 2 Hari Raut of Malpara  
 1 Bhagbat Madali 2 Banishanidhi Mudali of Matsuan 1 Bhaigi Bol 2 Sadhu Bol 3 Bhaig  
 of Kesarpur 1 Bhikari Mudali 2 Kartick Mudali 3 Mohamed Ali Khan 4 Shetu Maha-  
 nti of N. S. pur 1 Gopinath Sahu 2 Ananta chura Sahu of Alalpur 1 Ram Mahanti 2 Sam  
 Naik 3 Dinabandhu Mahanti of Sarhol 1 Ghana Padhan 2 Dadhi Mahanti 3 Bhabani Samal  
 4 Bai Sahant of Bramanbhog 1 Balstal Naik 2 Pari Naik of Tirunpada 1 Gope Jena 2 Pahl  
 Gni 3 Dam Mullok of Bakura 1 Kisur Sui 2 G. anasyam Das 3 rabballabh Das 4 Nitroni Das  
 of Chantilo 1 Bhabani Naik 2 Nalu Padhan 3 Garib Dharathi of Kani 1 Hari Kar 2 Kalu kar  
 of Paigra 1 Hari Sui 2 Achuti Pati 3 Sahadob Padhan of Tikira 1 Parami Sui of Solagan  
 1 Nalu Das 2 Ram chera of Austapari 1 Ram Chundra Sadangi 2 Ghana Sadangi of Jokona  
 1 Kandu Naik 2 Giridhari Naik of Bundalo 1 Jomani Raut 2 Bisambar Raut of Mongali  
 1 Gouri Sahu 2 Paramanund Bai of Ramgur 1 Anant Sui 2 Sooduri Sui of Hadna 1 Dai-  
 tari Sui 2 Parikhit Sui of Matsuan 1 Arat Mullok 2 Bhikari Sui of Matsahi 1 Qadai  
 Sui 2 Goni Samarana of Kuarpur 1 Sadanund Tihari 2 Qadadhar Tihari of Avara.





# HYDRAULIC WORK

IN

## THE IRAWADI DELTA

BY  
ROBERT GORDON, M. INST. C.E.

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# THE INSTITUTION OF CIVIL ENGINEERS.

## SECT. II.—OTHER SELECTED PAPERS.

(Paper No. 2678.)

### “Hydraulic Work in the Irawadi Delta.”

By ROBERT GORDON, M. Inst. C.E.

THE construction of embankments in the delta of the Irawadi was accompanied by great natural changes in the *régime* of the river in the immediate neighbourhood of the works, the design of which had to be modified from the first plans. The Government of India required that surveys and studies should be made of the river and its floods, and of the localities affected by the embankments, and permitted only a slow and tentative progress in the extension of the latter; which was for the most part carried out during the years 1863 to 1883. The principal works are situated on the western side of the main channel of the river. The names of these and the cost of their construction and repair to the 31st of March, 1892, are:—

(1) *The Kyangheen Embankment*.—About 9 miles long. Protects the town of Kyangheen and about 4 square miles of rice land.

|                                   | Rupces.        |
|-----------------------------------|----------------|
| Capital cost . . . . .            | 1,22,294       |
| Repairs and maintenance . . . . . | 41,512         |
|                                   | <hr/> 1,63,806 |

(2) *The Myanouny Embankment*.—About 41½ miles long. Protects the towns of Myanouny and Kyangheen by separate marginal embankments, and about 150 square miles of country.

|                                   |                 |
|-----------------------------------|-----------------|
| Capital cost . . . . .            | 9,67,507        |
| Repairs and maintenance . . . . . | 2,41,082        |
|                                   | <hr/> 12,08,589 |

(3) *The Henzada Embankment*.—The Irawadi branch, 78 miles long, and Nawoon branch, 79 miles long; with marginal embankment protecting the town of Henzada; protects the north and east and north-west sides of a triangular area of over 1,600 square miles.

|                                   |                 |
|-----------------------------------|-----------------|
| Capital cost . . . . .            | 23,09,897       |
| Repairs and maintenance . . . . . | 6,00,745        |
|                                   | <hr/> 29,10,642 |



(4) *The Mawobin Embankment*.—74 miles long; protects 250 square miles.

|                                  |                  |
|----------------------------------|------------------|
| Capital cost. . . . .            | 1,77,205         |
| Repairs and maintenance. . . . . | 87,850           |
|                                  | <hr/> 2,65,055   |
| Total . . . . .                  | Ruppes 45,48,032 |
|                                  | <hr/>            |

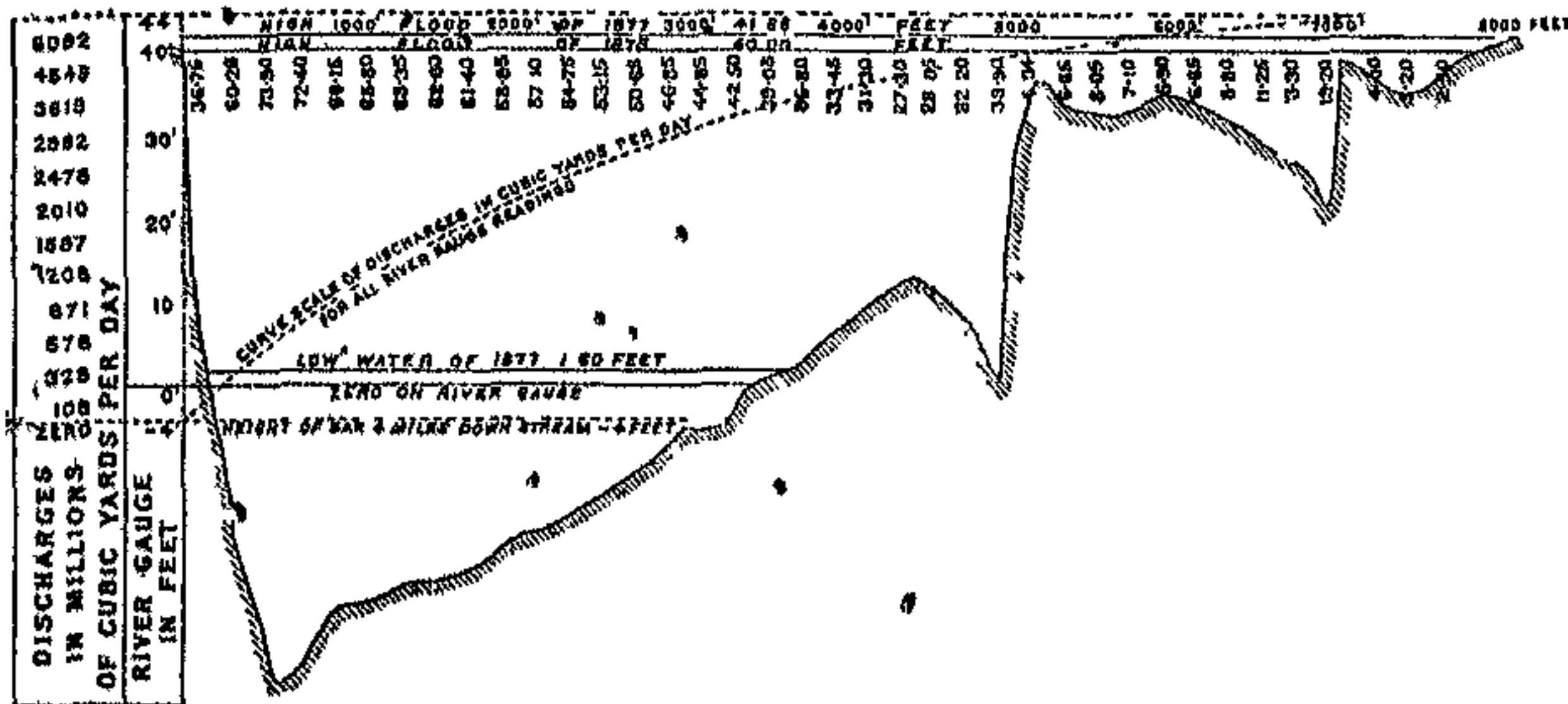
All except the first of these works are still incomplete, their lower ends being open and turned by floods; but they form the first stage of a partially projected system, which may be gradually extended over the remaining 12,000 square miles of the delta plains as the requirements of the population increase.

The plain lands of the delta (Fig. 1, Plate 7) spread over a triangular-shaped area, the apex of which is near Prome in lat.  $28^{\circ} 15' N.$ , about 200 miles from the sea; fronting which, the curved base extends over 150 miles between the Rangoon and the Bassein rivers, both of which receive branches from the Irawadi. Spurs from the Aracan Yoma Mountains, which rise from sea-level at Cape Negrais to over 3,000 feet opposite Prome, bound these plains to the westward; while on the east they are limited by other plains of sedimentary deposit borne down by the mountain torrents of the Pegu Yomas, the lower altitudes of which terminate in undulating ground near Rangoon. The Iline river, rising near Prome, follows the base of these plains, running parallel with the Irawadi for over 150 miles, and receiving the flood spill-water from the left bank of this river, which it conveys by a separate course past Rangoon to the sea. The valley on both sides of the Iline is low and in high flood years it is inundated to depths of 10 and 12 feet and upwards for a length of over 110 miles and an average width of 10 miles. Colonel Alexander Fraser proposed in 1867 to reclaim this tract of land by a continuous embankment and minor works from Talokmoh to Yandoon, along the left bank of the Irawadi. But as embankments were then in progress on the right bank in the same locality, the Government refused to allow this until the effect of these works should become apparent and the results of double embankments could be in some measure estimated.

A measuring-station was established in 1872-73 at Saiktha, opposite Talokmoh, the highest point where the river channel loses water during floods, and a cross-section was marked out on the only suitable position for measuring the discharge of the river (Fig. 2, p. 5, and Figs. 3 and 4, Plate 8). The methods generally adopted were those used by Generals Humphreys and Abbot on the

Mississippi. Double floats, consisting of wooden cylinders connected together by fine fishing-lines, were used; the lower one being of teak, 1 foot long by 6 inches in diameter, hollow underneath and loaded with clay to sink to any required depth; the upper float was of light wood 1 inch thick, to swim on the surface, and carried a small flag. The surface-velocities were measured by floats, of which the lower was kept 1 metre below the surface, and 30 to 60 of these were distributed across the river on each occasion. Sub-surface velocities were measured by series of floats started from an anchored boat, increasing by depths of 1 metre till the bottom was reached. A large number of surface-floats were dropped in from boats moving across the river considerably above the site of the intended section, and their paths were fixed by

Fig. 2.



MEASURING-SECTION AT SAIKTHA, 1872-73.

observers with theodolites at the ends of a base line 1,000 feet long. The paths were plotted, and a line normal to the majority of these was chosen as the measuring-section, *Fig. 2*. Posts were fixed on both banks to fix this section, and masonry pillars were built for bench-marks. A second line, 200 feet higher up the river, was also laid out parallel to this section, and a new base-line at right-angles to these was carefully marked. Observers with theodolites and watches recorded the times and the positions of the floats as they passed both section lines. Cross-sections of the river were taken from time to time on the lower line. Observations were made continuously, excepting Sundays, from the 1st of August, 1872, to the 30th of August, 1873. A river-gauge to show



the highest point said by the residents to be reached by the 1871 flood, was fixed, and recorded daily. The water-level of the river varied from 0.75 foot to 36.00 feet on this gauge while the measurements were taken. The cross-section was regular in form and nearly 1 mile long. Beyond the left bank, the low ground, between 5,000 and 8,000 feet on the section, would be covered by water at extremely high floods, as in 1875 and 1877, but this did not occur in 1872-73. The calculations of discharge involved dividing the cross-section into 10 sub-areas at points 220, 500, 1,400, 2,400, 3,000, 3,700, 4,200, 4,600, 4,900, and 4,980 feet from the right bank, as it was found that the surface-velocities were somewhat similar within those areas; and each of the areas was multiplied by the mean of its surface-velocities as a first approximation. The vertical curves of sub-surface velocities were also grouped together for the same areas and the average velocity was taken for each vertical. The ratio of this average to its corresponding surface-velocity was found for each vertical curve; and the ratios of all the vertical curves for the days during which the river remained at about the same level were grouped together and the mean ratio was taken for the whole in each sub-area. This formed a multiplier to correct the quantity of discharge found by the first approximation for each sub-area for each separate day. The sums of these quantities gave the daily discharge. The discharges thus obtained were plotted on a large scale with the gauge-readings as co-ordinates; when it was found that a scale of discharges could be constructed of three in-osculating curves—the centre one representing the discharges from 6 feet to 27 feet on the gauge, being a very flat parabola of the 2nd degree; while the discharges below these figures and above them on the gauge were given by parabolic curves of the 4th power. The maximum deviation was under 13.2 per cent., the average being 2.4 per cent. The curves were approximately represented by the following equations, where  $y$  = discharge in cubic feet per second,  $w' = 2 \times$  gauge-reading + 8, for the lower curve,  $w'' = 2 \times$  gauge-reading - 11 for the middle curve, and  $w''' = 2 \times$  gauge-reading - 55 for the higher curve.

1st Curve,

$$y_1 = 8450 w' + 1.69 \frac{(w' - 1) \times w' \times (w' + 1) \times (w' + 2)}{24}$$

2nd Curve,

$$y'' = 170666 + 10376.6 w'' + 300.3 \frac{w''^4 + 1}{2} \quad d/ \times d/$$

3rd Curve,

$$y''' = 924533 + 23589.8 w''' + 300.3 \frac{w''' + (w''' + 1)}{2} \\ + 9.99 \frac{w''' (w''' + 1) (w''' + 2) (w''' + 3)}{24}.$$

The most remarkable feature about the curve of discharges is that, when continued below the zero of the river-gauge which was assumed as the lowest point to which the river surface falls, it was found that the discharge vanished at 4 feet below the zero, although the cross-section at the site shows a depth of 34 feet and an area of over 46,000 square feet below the same point. On taking soundings along the *thalweg* of the river channel it was found that, about 4 miles below the site, there existed an extensive bar, the top of which lay at almost the level at which the discharge at Saiktha ceases, a result which might have been anticipated. This "dead" area of cross-section, lying below the level of the bar regulating the discharge, exists on almost all rivers in places where they are suitable for discharge-measurements; and some method must be found for deducting it from the areas used in hydraulic formulas for discharges of rivers.

Measurements for discharge were made on the main channel from August to October, 1872, and from June to August, 1873, for, in all, 119 days, at Zaloon, 100 miles south of Saiktha, and, about the same periods, for 134 days at Thapangyo on the Nawoon River; in order to compare the total volumes of water in the river at those places and at Saiktha. During the high flood of 1875 further measurements were made at Saiktha for 63 days, when the river varied from 21 to 40 feet in the gauge; while regular observations were made on the Nawoon river at Thapangyo and other points in 1875 and 1878.

From time to time endeavours were made to check the system of measurement by double-floats, by comparing them with revolving meters. Ships' logs, kept at fixed depths for short times, were tried; but, as the river at high floods carries immense quantities of silt and vegetable matter which accumulate round the logs, the results were not satisfactory at such times, although they agreed with the floats for low velocities in clear water. In 1882 further tests were made with three Deacon electrical recording-motors.<sup>1</sup> Extreme care was used, and it was found that, while for the smaller depths and low velocities double-floats give

<sup>1</sup> Minutes of Proceedings Inst. C.E., vol. lxix. p. 398.

fairly accurate results, at high velocities and great depths the velocities shown by these floats were too high. In the case of the Irawadi, it was found desirable to correct the calculations for discharge by reducing the results for 27 feet on the gauge and upwards by 10 per cent., gradually diminishing the correction to nothing at 4 feet on the gauge. It was found convenient to do this by altering the formulas given above, thus—

$$\begin{aligned} \text{1st Curve, } & -4 \text{ to } +4 \text{ feet,} \\ & w' = 2 \times \text{gauge-reading} + 8. \\ \text{2nd Curve, } & 4 \text{ to } 27 \text{ feet,} \\ & w'' = 2 \times \text{gauge-reading} - 8. \\ \text{3rd Curve, } & 27 \text{ to } 44 \text{ feet,} \\ & w''' = 2 \times \text{gauge-reading} - 54. \end{aligned}$$

and

$$\begin{aligned} \text{1st Curve,} \\ y' &= 8450 w' + 1.69 \frac{(w' - 1) w' (w' + 1) (w' + 2)}{24} \\ \text{2nd Curve,} \\ y'' &= 140372 + 9609 w'' + 213.2 \frac{w'' (w'' + 1)}{2} \\ \text{3rd Curve,} \\ y''' &= 812855 + 19416 w''' + 213.2 \frac{w''' (w''' + 1)}{2} \\ &\quad + 10 \frac{w''' (w''' + 1) (w''' + 2) (w''' + 3)}{24} \end{aligned}$$

These equations can be simplified for purposes of computation. From them corrected scales of discharges, given in Appendix I, were compiled. A Table of the total discharges of the Irawadi for the period 1869–1879 has been computed. This has been corrected by reducing the totals for the flood seasons by 10 per cent. The result is given in Appendix II. The quantity of silt carried by the water was determined from samples taken daily between March, 1877, and March, 1878, from different parts of the stream. The mean annual discharge of water from the Irawadi for the years 1869–79 was about 521,000,000 cubic yards, of which 80 per cent. passed down during the five months June to October; July and September averaged each over 18 per cent. and August nearly 22 per cent. The greatest daily discharge known is that of the 19th of August, 1877, at Saiktha, when the flood rose to 41.88 feet on the gauge, and the corrected discharge gives



about 1,900,000 cubic feet per second. The amount of silt carried down yearly in mechanical mixture with the water is about 261,000,000 tons; but it is believed that as much more is rolled along the bottom, as the lower layers of water appeared heavily charged with mud.

A careful survey was made in 1876-77 of the main channel of the river for over 160 miles from Saiktha southwards, and also down the channel of the Nawoon to Bassein. Accurate levellings had from time to time been made along the lines of the intended works, and masonry bench-marks had been fixed every 3 or 4 miles to show the heights of the floods. Inspection-bungalows had been built at 10 to 12-mile intervals, where river-gauges were fixed and recorded every morning, the readings being sent to headquarters and recorded very frequently. Soundings were taken at low-water along the *thalwegs* of both rivers in 1877. The plan of the Irawadi channel is given in Fig. 4, Plate 8. Twenty-seven cross-sections between the permanent banks, or extreme limits of the bed of the river, were also taken—of which 16 are reproduced in the Plate. The areas of these sections for the main channel and the minor channels—or areas within which the flood-discharge spreads—are given in Appendix III. The elevations of the floods and low-water of the rivers above mean sea-level at the different stations, with the ranges from low- to high-water of 1877 and the flood surface-slopes per mile, are given in Appendix IV.

On examining the plan of the Irawadi channel and comparing it with the cross-sections and their areas, Appendix III, it will be observed that while the channel is firmly held in position by the rocky banks near Saiktha, it has wandered widely from side to side throughout the next 120 miles of its course—in some places  $5\frac{1}{2}$  miles, and in one part, at Thambyadeing, over 10 miles. The average lateral variation is nearly 4 miles, within which limits the river follows a sinuous course that is continually changing. The lower 80 miles of the river show comparatively slight variations within recent periods, and the channel becomes narrower and deeper as it feels the influence of the sea and the tides; but here, also, it begins to break into branches which spread over the lower delta. In the upper channel, a large bend near Kyangheen causes a continuous variation of the river's course. In 1856 the channel was near the western bank at Kyangheen, but since that time an S-shaped curve has formed, the extremities of which from north to south approach, while it widens laterally. In the centre of the S is the bar, regulating the discharge at Saiktha. It has caused



serious obstruction to navigation for many years, at every dry season having sometimes little more than 3 feet of water upon it. The whole curve travels down the river. It will probably disappear owing to the formation of cut-offs. To the south of this, the channel follows a tolerably straight course for 24 miles, closely hugging the west or right bank. Then a series of curves begins which culminates in the great Thambyadoing bend and continues to the south of Zaloon. Throughout the whole of this portion of the river the channel shows a strong tendency to keep to the western side of the bed. The movement was continuous for many years and towns on the east bank, like Seingong, Yaygeon, Mengyee, Monyo, Teindau, which at the time of British occupation in 1852 were flourishing places on the navigable channel, have been left far inland.

In 1868 the Author called attention to Professor Baer's<sup>1</sup> law, which ascribes the tendency of rivers running north and south in the northern hemisphere to erode their right banks to the rotation of the earth, which compels particles of water approaching the equator to describe continually increasing parallels of latitude. In the case now considered, the figures are:—

| Latitude. | Daily Velocity of Earth's Surface. | Increased Distances Traversed. |
|-----------|------------------------------------|--------------------------------|
| ° ' 18 30 | Miles. 23,613                      | Miles. 2                       |
| 18 15     | 23,617                             | 31                             |
| 18 0      | 23,681                             | 68                             |
| 17 45     | 23,715                             | 102                            |
| 17 30     | 23,748                             | 135                            |

The Volga and many other rivers in Russia and elsewhere may be instanced as examples of this law, the water generally hugging the right bank with the navigable channel, so that almost all the important towns and villages are found on that side. In 1871, when the Author was in charge of the works which this westing tendency threatened, he caused off-sets to be measured at every quarter-mile of the Myanoung ombankment to the edge of the channel. Even when the curves of the river turned eastward the tendency was apparent; and navigable channels were formed across the western sides of their necks, which kept opening out

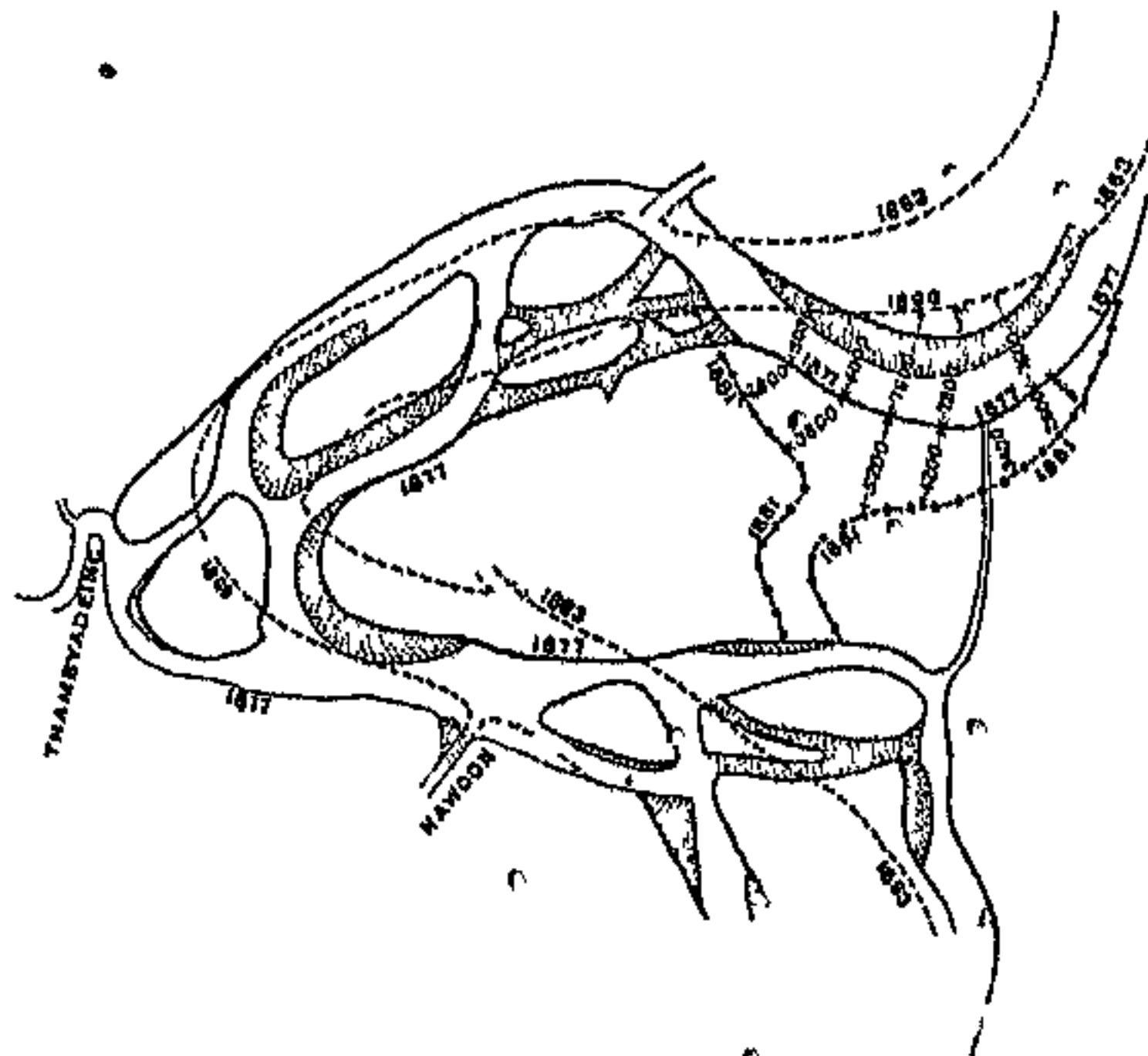
<sup>1</sup> Elisée Reclus' "La Terre et les Hommes" Paris, 1870-84.



and deepening yearly. The off-sets sometimes end on these. The jungle was cut every second year and the lines were re-measured. It was found that along the whole length of channel from Kyangheen to Thambyadeing, the progress westward was steady and continuous. To the north of Myanoung an average width of over 200 feet was lost by 1879; and, at that place itself, from 40 to 100 feet. Further south, the loss of bank increased to 300 feet at the sixteenth mile; while near the Thambyadeing bend more than 2,000 feet had been removed. Similar losses occurred near Hienzada and Zaloon, though no record of them was kept. At Zaloon the embankment had to be moved.

It seems impossible, however, to admit the persistent action of such a general cause during long geological periods, without finding all such rivers flowing hard by the rocky western confines of their course. It is more probable that the general cause has a temporary effect when any great disturbance of the regime of the river occurs, such as was caused by the Thambyadeing bend for many years. Old residents at Thambyadeing told the writer in 1869 that the bend assumed a distinct shape about the period of the first British occupation in 1824. The point of it worked slowly westward at first; but when it was surveyed shortly after the annexation in 1854, it had acquired the shape of a horseshoe, 8 miles long from east to west by 4 miles broad. The entrance from the Irawadi to its Nawoon branch was almost closed by sandbanks and islands and had ceased to be navigable during the dry season in 1829. Mr. Login examined it about 1854, to see if it could be re-opened; but reported unfavourably upon it. At that time a creek at Thambyadeing discharged drainage from the country into the Irawadi, a few miles above the Nawoon entrance. In 1865 Mr. Founnessy found the direction of the creek reversed, and it then carried water from the Irawadi to the Nawoon. Its width was at that time 170 feet, its depth  $42\frac{1}{2}$  feet, and its area was 3,600 square feet on the line of survey for the projected embankment, which was to cross it after it had been crossed by a dam. In 1869 the Author measured it at the same place. Its width had increased to 276 feet and its depth to  $54\frac{1}{2}$  feet. The point of the bend was rapidly encroaching on the bank at this spot, having advanced from 4,800 feet to 1,603 feet distance from the survey line. In 1871, 1874 and 1875 the same cross-section of the creek was measured and found to be 10,700, 16,710, and 42,240 square feet in area, respectively; the point of the bend having in 1875 almost reached the site of the survey-line, when this westward travel ceased. A short distance down-

stream another section gave an area of 18,770 square feet, showing the enlargement of the Thambyadeing river at this time. The eroding action from the point of the bend was transferred to other points north and south of it. But rapid erosion was continuous at the neck or root of the bend, especially on the upper side, where, between 1868 and 1877, nearly 8,000 feet in width had been eroded. From 1877 to 1881 about 5000 feet in width were removed from the northern side, until the distances across the neck measured only 8,400 feet; when, in July 1881, the Author observed the river to be breaking its way across the upper side of the neck, *Fig. 5*. On inquiry it appeared that the ground on

*Fig. 5*

Scale, 4 miles to an inch.

CHANGES FROM 1868 TO 1881 AT THAMBYADEING BEND AND CUT-OFF.

the southern side was swept away first, carrying with it a fishing hamlet and monasteries, and forming a new channel, as shown in *Fig. 5*. This channel continued to enlarge, with some changes of direction, until 1883, when the Author's opportunities for observation ceased. The most remarkable feature in the history of this bend is the persistence of the river channel at the eastern limit of the root of the bend, both on the north and on the south side; although for many miles above and below this part it moved continuously westward.

From the occupation of the country in 1854 until 1862, when

Colonel Short was deputed to report upon and devise a scheme for the systematic embankment of the river, no observations of value had been recorded of the changes of its channel, or of its floods. Some light embankments constructed by the natives and by civil officers had been destroyed, with serious injury to agriculture. The inexplicable movement of the channel away from the towns on the eastern bank, with the building up of enormous islands and sand-banks in front, could not fail to be noticed; as was also the destruction of a great part of the town of Henzada, and other places on the right bank, previous to 1862; but nothing seems to have been known of the general westing of the channel, nor of the rapid rate of change in the Thambyadeing bend. Had the information now possessed been available, it is probable that Colonel Short would have begun by embanking the left bank instead of the right one, from Talokmoh to Yandoon, and thence along the Panlang creek for many more miles towards Rangoon. No difficulties of any kind would have been raised by this work, which would have protected the Iline Valley. Most of the cultivation, however, with the larger towns and villages, lay upon the right bank, as well as the small embankments the failure of which caused Colonel Short's visit; and he gave this side his exclusive attention.

A small embankment, 9 miles long, to the north of the Patashin creek, was designed to protect the town of Kyangheen, and about 4 square miles of cultivation. It was constructed between 1863 and 1865, and has since been raised and strengthened at a total capital cost of about Rs.1,22,294 to the year 1891-92. The repairs up to the same year cost Rs.41,512. It entirely excludes the river floods, but rainfall gathers within it at high-water, and is drained off when the river falls by automatic sluice-gates formed of narrow parallel iron-plates hinged together and hung with a slight batter against wooden framing on the outer ends of masonry sluices 5 feet by 2½ feet in area. Three of these are found sufficient to keep the ground free for cultivation.

To the south of Kyangheen, the Patashin creek, draining about 400 square miles of hill country, enters the river. Colonel Short proposed to make an embankment from the high ground on its right flank for 4 miles to the Irawadi, and then to carry it for 180 miles to Pantanau, closing both the Nawoon and the Thambyadeing river-entrances. The first portion of this work, 7 miles long, was constructed in 1864, and continued for 8 miles over elevated rocky ground to the south of Myanung. A further extension of 56 miles was projected by Mr. Fennessey to Henzada, with the inten-



tion of closing the river-entrances named; and, although this part of the work was deferred, the embankment was partially constructed in 1867-68. The Myanoung embankment was made continuous for  $44\frac{1}{2}$  miles. A length of 10 miles was raised, from the Nawoon River to the town of Hienzada, and intermediate portions were thrown up. It was found, however, that the Thambyadeing opening was enlarging so greatly, and the Irawadi was approaching the site so rapidly, that a change in the design became expedient.

Colonel Short had observed the set of the current locally against the river bank. He laid down as a cardinal principle of his alignment, that it should be so far removed from the river bank as to obviate all danger from erosion. He fixed a minimum distance of 500 feet from the edge of the bank near Myanoung, where the ground is hard, and increased the distances up to 3,000 feet and even to 4,800 feet near the great bend (since actually cut away, with the embankment upon it). His prudence and foresight in thus retiring the line were justified. But as, since the writer took charge of the works at the end of 1868, a change has been made in the principle, and the alignment of the embankments has been taken much closer to the river's edge, the merits of the two systems may be here considered. In common with all silt-carrying rivers, the ground near the channel stands at a higher level than the country inland. Near the Myanoung embankment it slopes away from the edge with a fall of 8 to 10 feet within a few hundred yards. An embankment retired 500 feet and over from the river-bank must thus stand higher above the ground, be more costly to construct, and at the same time be less able to resist floods than one situated nearer the edge; and the land between it and the river is liable to be submerged by flood-water. This happened with the towns of Myanoung, Kanoung, and Hienzada in 1868, when a high flood rose and inundated those places, all of which lay between the embankment and the river. Marginal embankments were constructed in front of them in 1869, actually on the river's edge. One of these, at Myanoung, 2 miles long, cost Rs.4,250 per mile; one  $6\frac{1}{2}$  miles in length, at Kanoung, Rs.2,130; and one 6 miles long, at Hienzada, Rs.6,300. Now the 44 miles of Myanoung Embankment cost about Rs.17,000 per mile; and the 10 miles of Hienzada embankment, made in 1868, cost Rs.22,400 per mile. At the latter place the retirement was excessive, and parts of the town were liable to be flooded to depths of 10 and 12 feet.

It became obvious that if the embankment works were to be



extended, the alignment must be brought generally nearer to the river bank, in order to take advantage of the higher ground and to reduce the cost. At the same time, it was decided to postpone indefinitely the closing of the two entrances to the Nawoon river; and, instead of constructing a continuous embankment along the Irawadi, to protect the Henzada plain by two branches of an embankment starting from the south side of the Nawoon entrance and running along the right bank of the Irawadi to Baudee, opposite Pantanau, on the one side; and along the left bank of the Nawoon as far as the mouths of the Taboo or Daga on the other (Fig. 6, Plate 7). Proposals had been made by different authorities to divert and control the erosive action of the river, both at the Thambyadeing bend and elsewhere, by spurs, mat protection, cuttings of canals and other works; but the Author opposed any general work of such a character on the Irawadi, on the score of expense and unsuitability to the existing conditions. He has since examined the great works on the Mississippi near St. Louis, where, for many miles, protection has been successfully accomplished; and is confirmed in his view that in the undeveloped state of the country it was unadvisable to undertake the control of the Irawadi channel. When it acted upon the bank, the deepest part of the current, sometimes exceeding 80 feet in depth, moved close in to the bank, attacking it over a length of some miles, often with a velocity of 5 to 7 miles per hour. The Author has seen cracks appearing in the soft ground over 100 feet inland from the edge, the intervening mass slowly settling into the river. At the time of its greatest erosive activity the river must have excavated and transferred yearly 2 square miles of solid ground 80 feet thick within the region of the Thambyadeing bend. Any diversion of the point of attack, if this had been possible, would have only changed the locality of the erosion without apparent advantage. Where large towns were threatened, local protection was necessary; but during the period referred to this was hardly required. During high floods, when the water topped the bank where it was being eroded, it carried with it immense masses of earth and silt to spread over the ground, thus raising a new permanent bank for itself. In one place, near Thambyadeing, a lake 20 feet deep was cut into and filled with deposit almost to flood-level. It was thought best to let this recuperative action have free play, as the areas of waste land in the delta available for reclamation at small cost were very extensive compared with the wants of the scanty population.

These views prevailed. The alignment of the works since



1868 has been fixed at a minimum distance of 200 feet from the permanent bank, except when this was protected by new land, when it was taken close to the edge. The old embankments had been designed with a top-breadth of 5 feet, at a height of 5 feet above flood-level, and slopes of  $2\frac{1}{2}$  to 1 on the river side and 2 to 1 on the land side. The new embankments were constructed with top-breadths of 14 feet, at 8 feet above the levels of the highest floods, and the same slopes as before; the older embankments being altered to these dimensions. Where bad earth was met with, or in very low ground, as at the neck of a bend north of Ngathaingyoung, which is about 20 feet below flood-level, these dimensions were increased—slopes of 3 to 1 and 4 to 1 being given, with a higher elevation above floods. In constructing new works, the ground was cleared of all grass and tree jungle; sand was removed from the site and weak places were strengthened. The base area was marked out and lock-spitted, and skeleton cross-sections of bamboos were put up at frequent intervals, with an allowance for settlement of one-fourth to one-sixth the height. The earth in the later works was taken from the river-side from rectangular pits not deeper than 4 feet; and was laid evenly in thin layers. As a rule, the earth took two to three flood seasons to consolidate. For the first year, Rs.300 per mile was allowed for labour in maintenance and watching during floods; but this was reduced to Rs.100–150 after two or three years. An Act was passed, empowering the embankment officer to proclaim portions of the embankments in danger during high floods, when the neighbouring residents could be called out to assist in protecting the works and were entitled to receive pay 10 per cent. above local rates. Substantial bungalows for inspection purposes were built at 10- to 12-mile intervals along the works. As will presently be shown in detail, the successive floods of 1868, 1871, 1875 and 1877, rose to continually increasing heights on the Irawadi, independently of the influence of the embankments; and in 1878 and 1879 local floods rose in the Nawoon, owing to the extension of the works there, necessitating the raising and strengthening of the entire embankments affected, the normal dimensions given being adhered to. Breaches occurred from time to time locally, without any serious or general disasters; and weak places became apparent during floods, both in the embankments and in the ground on which they stood. When the water flowed through cracks, or through tunnels made by white ants or vormin, it was found sufficient to build up an open well with earth around the outflow, permitting this to run at a safe velocity—an expedient

which has long been used in Holland and elsewhere. About the 5th and 6th miles of the Nawoon branch of embankment, it was found that a sandy layer existed a few feet below the surface, which permitted a free passage to the water. A trench 2 to 3 feet wide was dug through this along the outer toe of the work, and a puddle wall was carried above ground and covered with a thick facing of earth. This proved effectual in stopping the seepage.

The two branches of the Henzada embankment were extended very slowly, as follows:—

| Irawadi Branch.         | Nawoon Branch.         |
|-------------------------|------------------------|
| 1868, to the 10th mile. | 1869, to the 4th mile. |
| 1872, „ 25th „          | 1872, „ 25½th „        |
| 1878, „ 40th „          | 1878, „ 40th „         |
| 1875, „ 53rd „          | 1874, „ 54th „         |
| 1883, „ 78th „          | 1876, „ 70th „         |
|                         | 1884 (?) „ 79th „      |

The first of these terminated on the Baudee river, which drains the eastern side of the plain from near Henzada; the second stopped at the Taboo river, which rises near Ngathaingyoung, and empties into the Nawoon at the 79th mile of the embankment. In both cases, the embankment may be carried further by stopping and diverting these rivers by means of canals to points lower down, and continuing the embankments—on the Nawoon side to the Daga river, on the Irawadi side to near Shwoyloung—but the works required will be heavy and costly. In the meantime, as large areas of valuable land can be reclaimed at a much smaller cost, there is no probability of this being done at present. The water flows up these rivers during floods, turning the embankments and inundating the lowest-lying lands.

The construction of the first 10 miles of the Irawadi branch cost Rs.22,400, and of the remaining 68 miles, Rs.5,300 per mile. The first 69½ miles of the Nawoon branch cost originally Rs.5,37,354, making, with the subsequent extension of the Nawoon branch to the 79th mile, a total cost, roughly, of Rs.12,00,000. This original cost has been increased to Rs.29,09,837 by retirements near Zaleon on the Irawadi side, and by successive raisings and strengthenings on the Nawoon side to provide against the increased height of the floods and for special repairs to breaches. The area of land included between the embankments and the

margin of the inundations is 1,600 to 1,700 square miles. How much of this is valuable agricultural land is not accurately known. The latest revenue returns show that in the Henzada district 192,091 acres are protected, of which 100,481 acres now pay Rs.3,12,268 yearly. In the Thongwa district 29,470 acres, paying Rs.58,898, are given; but no returns are available for the Bassein district, in which the largest area is protected, so that a complete account cannot be given. In 1888-9, however, the total revenue for the lands protected in the three districts by the Henzada embankment is given as Rs.6,10,789.

The Myanong embankment could not be completed while the river channel changed position so rapidly near it; and it was stopped abruptly at the 44½th mile. It protects probably 150 square miles of land and is credited by the Revenue Officer with the protection of 61,435 acres—of which 38,508 acres pay Rs.73,881 as revenue; but the revenue accounts for 1888-89 show it to yield Rs.1,46,888; its total cost for construction and repairs to 1891-92 amounted to Rs.12,08,589. When the cessation of the river-action near it permits its continuation down to and along the Thambyadeing river, or its junction with the Henzada embankment as designed by Colonel Short, an additional area of 300 square miles may be reclaimed by it; but costly drainage works will also be required to carry away rapidly the water discharged by hill-streams.

When the eastern embankment is constructed from Talokmoh to Yandoon, and continued along the Panlang river towards Rangoon, 1,100 to 1,500 square miles of excellent land, most favourably situated with respect to markets and the carriage of produce by rail and water, will be reclaimed from a waste condition at a cost of Rs.1,000 per square mile. The dangers from enclosing a river entirely by double embankments have been much exaggerated; and little rise of surface need be apprehended in a river flowing, like the Irawadi, in a bed of its own deposits, so long as no great increase occurs suddenly in the amount of water delivered into its channel. The difficulties met and overcome on the Nawoon river, where for several years the discharge was greatly increased, will shortly be stated; and these afford encouragement to undertake the eastern Irawadi embankment at an early date. Should this be carried out, the true delta of the Irawadi would then be transferred entirely to the region south of Yandoon, known as the Lower Delta.

In the Lower Delta, the Irawadi begins to throw off arms at Yandoon and at Pantanan, and to continually bifurcate into new channels, which join the enormous estuaries called the "mouths"



between the Bassein and the Rangoon rivers. The greater part of the Irawadi discharge passes down the China-Buckeer river, though a considerable quantity flows by the Dala and Irawadi arms, the western branches receiving very little. The south-western part of the Delta is known locally as the "Region of Ten Thousand Creeks." All the mouths, except those of the Bassein and Rangoon, are obstructed by shallow bars of sand and shingle; but the sea-water sweeps in and through the broad estuaries and innumerable lagoons and creeks, the muddy banks of which are sheltered by the foliage of lofty trees and lined by mangroves and swamp palms. Cyclones and destructive storm-waves are almost unknown here. Cultivation has spread slowly among the scanty inhabitants of the islands into which the western delta is split up. Towards the east and north, however, the islands are larger and the population is more dense. The 260,000,000 tons of silt and the important mass of heavier material annually brought down by the Irawadi have long been employed in filling up the smaller creeks, and consolidating the eastern half of the Lower Delta into extensive areas, the margins of which are occupied by agriculturists. These areas are invariably saucer-shaped, the interior lowlands being covered with 6 to 10 feet of water in times of flood.

The Macobin Island is typical of the whole of these. In 1875 the eastern half of the delta was made into a new civil district called Thongwa, the headquarters being fixed at Macobin, on the China-Buckeer. In 1879 the commissioner reported that "the whole island is nothing but a swamp, producing nothing but myriads of mosquitoes and a few fish, with a narrow fringe of garden along the river bank." The Author had long urged the construction of an embankment along the upper sides of the island; and in 1883 this was done. Two branches of a light embankment, in all 74 miles long, were made for about Rs.180,000. Only at the north side of the island was there danger from erosion, where the alignment was retired and the work heavy. The southern side of the island was left open to the floods which turn the embankment ends, and inundate the lower lands. Irrespective of this, about 250 square miles of excellent land were reclaimed. A special officer was deputed to report on the results. His report, which was issued in 1892, says that between 1881 and 1891 the population had increased by 105 per cent.; 100,000 acres of cultivation were yielding a revenue of 70 per cent. on the outlay, whilst other 42,000 acres were reclaimed, but not yet yielding revenue. The work is of an extremely simple character and presents no features of engineering interest. It would not pay now to finish off the



lower end of the work and exclude the floods, draining the water from the interior by pumps, as the maintenance of such work would be costly; and there are other islands near which can be dealt with in a similar manner. At some future time, however, when land is scarcer, these areas may be completely enclosed.

Having now enumerated the principal features of the river and of the embankment works, a brief notice will be given of their effects on the principal floods of the period under consideration. Appendix 4 groups together the chief data of these between the years 1868 and 1879 for the river stations along the embankment works of the upper delta. The Maoobin embankment had no perceptible effect on the *régime* of the river. Fig. 7, Plate 8, and Fig. 8, Plate 7, give the profiles of the Thalwegs of the Irawadi and the Nawoon, with the flood heights for the same stations; and the latter Plate cross-sections of the Nawoon near those stations. Fig. 9, p. 22, gives the hydrograph or daily gauge-reading for the year at Myanong, of the great flood years 1875 and 1877, the latter being the highest known on the Irawadi. Fig. 10, p. 23, shows the modifying influence of the river-channels on the principal flood-wave of August 1877, as it passed the several stations on the Irawadi and on the Nawoon.

When Colonel Short designed the first embankments in 1862, the high-flood marks were uncertain and imperfect; and the flood of 1868 attained a general elevation above the highest floods previously recorded. It was accurately marked from Myanong to Henzada, at the former place rising 75.28 feet, and at the latter 48.00 feet above mean sea-level. The works then consisted of about 60 miles of main embankment on the right bank of the Irawadi. They could have had but little influence on the height of the flood, which spread freely over the left bank and down the Hline. In 1871 the high flood rose 1.68 foot higher at Myanong, 1.60 foot at Nyoungyo, and 1.29 foot at Henzada. The embankments remained in about the same condition, as only 4 miles had been added on the Nawoon. But this flood was considered abnormally high; and as, at this time, the Thambyadoing entrance had become enlarged from 3,800 feet to 10,700 square feet in area since 1865, a much larger quantity of water was supplied to the Nawoon than it could carry. The Author and Mr. Richard found the water passing over both banks of the Nawoon and destroying the cultivation, which was mostly situated on isolated higher ground, the low ground being annually inundated. It is important to note this, as the embankments afterwards constructed were accused of causing the injury to the cultivation. In 1871 it was

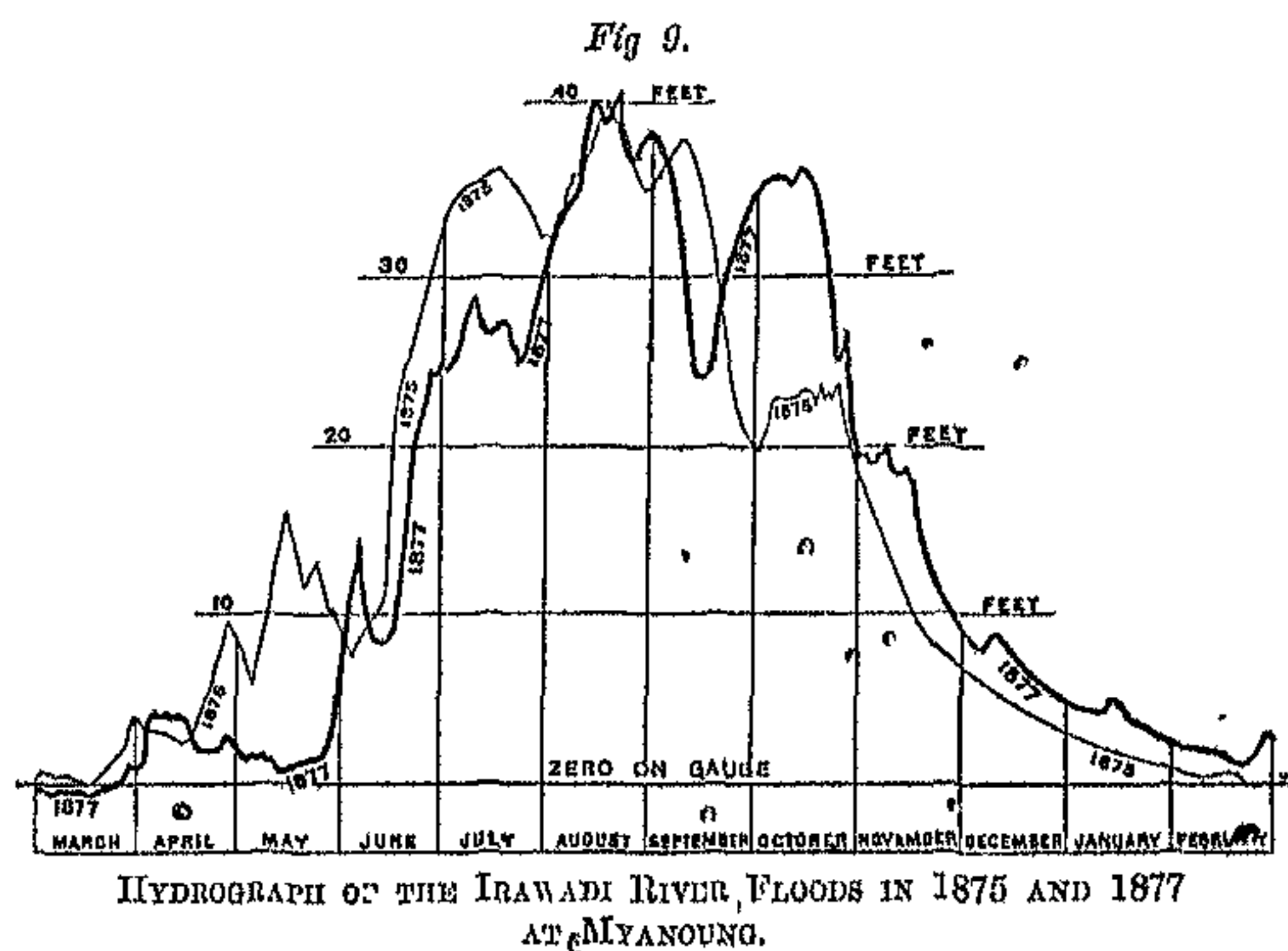


apparent that embanking was absolutely necessary to preserve the existing cultivation on the left bank, and to reclaim the waste bottom lands. On the right bank cultivation only existed on a narrow margin near the river's edge, and this was destroyed in 1871. Bench-marks of the flood-levels were fixed at certain stations.

The high flood of 1875 is marked at Saiktha at the same height as that of 1871 (81.67 feet + M. S. L.), probably due to an error in the latter, which was only determined from native marks when the station was established there in 1872. At Myanoung it was 0.76 foot higher, at Kanoung 0.83, at Shwaygyeen 0.86, and at Henzada 1.00 foot higher. The gauge at Nyoungyo gave the same height, the river current being diverted. The discharge was measured at Saiktha during the highest flood, and gave about 5,216 million cubic yards per day. On comparing the hydrograph for that year with those of the years 1869-1879, it was found that an exceptionally large discharge in July preceded the flood-wave of August; the gauge standing above 35 feet for some weeks and reaching to 36 feet on the 16th July. At 36 feet on the gauge it is assumed to be high flood, as the water, besides filling all the channels of the river, passes over and through the left bank in low places, and the inundation lies deep on all the bottom lands, diminishing their reservoir-capacity for relieving subsequent higher flood waves. This was so in 1875. All the Irawadi river gauges were marked to indicate 40.00 feet at high flood of 1875, and 38.00 feet is taken to imply danger to the works with a rising flood. In 1875 the surface rose above 38 feet for only 9 days, during which time 45,500 million cubic yards passed Saiktha. It stood above 37 feet for only 11 days, when 54,600 million cubic yards passed the same place. The Irawadi channel between Saiktha and Zaloon occupies nearly 305 square miles. The islands and banks of alluvium rarely rise higher than the flood-surface, corresponding to 37 feet on the gauges. Beyond the rainfall on these 305 square miles, and on the 400 of the Patashin creek, no water enters the Irawadi channel south of Saiktha; and these quantities, although considerable during heavy, prolonged falls of rain, are negligible compared with the volumes discharged daily in high floods. The filling of the channel from 37 to 40 feet on the gauges between Saiktha and Zaloon takes nearly 945 million cubic yards, exercising an appreciable effect in lessening the sharp crest of a very high flood-wave when it passes for only a few days, especially when it finds an empty channel. The 1875 flood-wave, however, found the channel already filled, and its crest

assumed a slightly higher elevation at the lower stations on the Irawadi for the same gauge readings at Saiktha than the floods of 1871 or 1877. The embankment was completed in 1875 to the 53rd mile, below Donabyo.

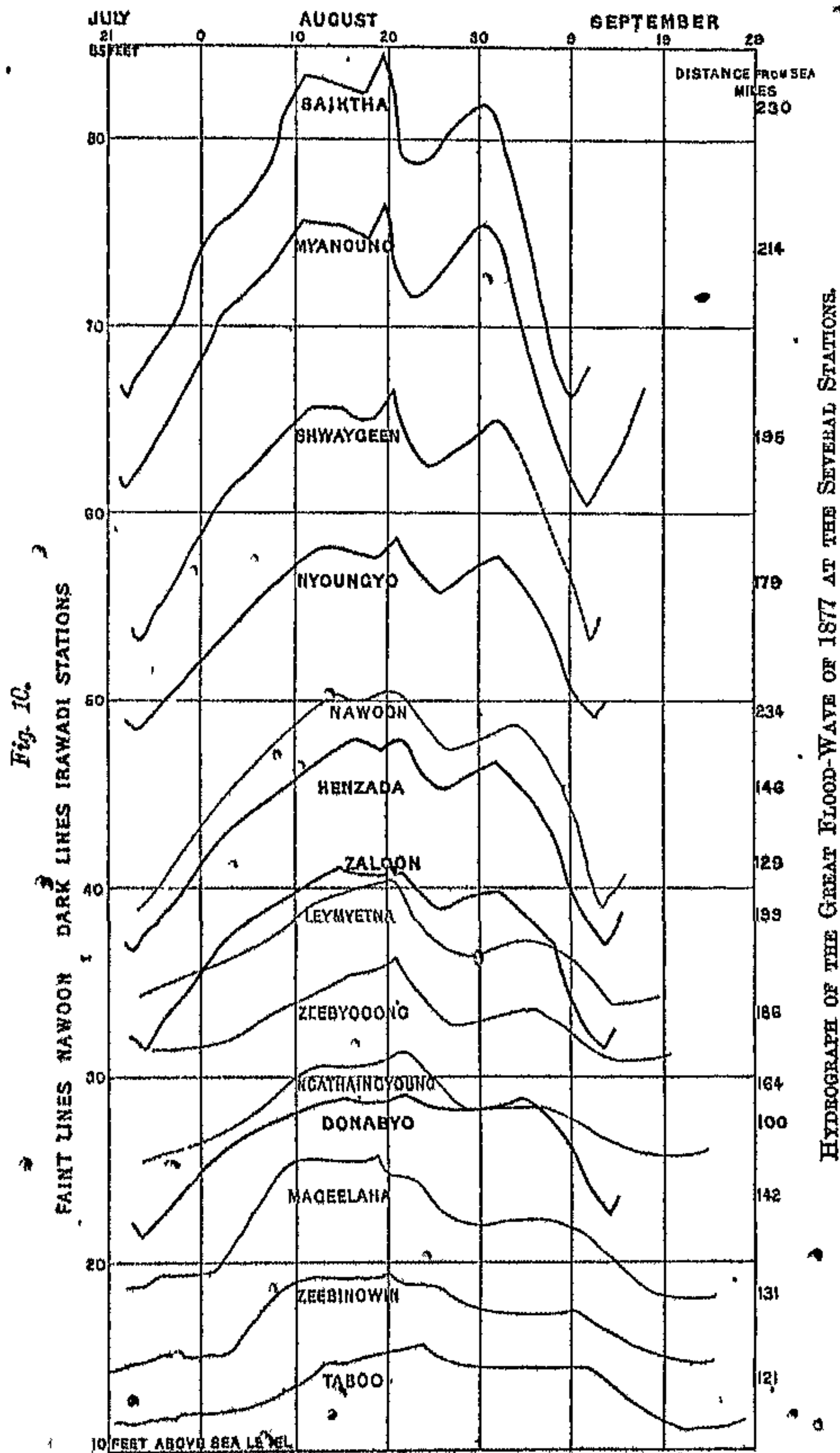
It was not extended further in 1877, when the next great flood occurred; but the Irawadi works had been raised and strengthened to the normal section with the top 3 feet above the flood-level of 1875. The hydrographs, *Figs. 9 and 10*, show that two wave-crests passed Saiktha and Myanounng, the first on 11th August and the



second on 10th August, 1877. They stood at the different stations above the 1875 flood as follows:—

| Miles below Saiktha | 0    | 15½  | 22   | 35   | 51   | 72   | 84   | 101  | 180   |
|---------------------|------|------|------|------|------|------|------|------|-------|
| 1st Wave . (feet)   | 1.08 | 0.35 | 0.41 | 0.41 | 0.08 | ..   | 0.15 | 0.42 | -0.17 |
| 2nd „ . „           | 1.88 | 0.96 | 0.80 | 0.73 | 0.33 | 0.40 | 0.30 | 0.43 | -0.04 |

The figures show a diminution in the height of both crests over that of 1875 as they passed down the river; and at Donabyo, the 180th mile from Saiktha, they were actually lower. The first crest reached Donabyo in four days, and the second in two days after passing Saiktha. The principal cause of the diminished





height is due to the fact that the 1875 flood-wave found the channel already filled, while that of 1877 found it comparatively empty. Thus in July, 1875, over 110,600 million cubic yards passed Saiktha, the gauge marking over 36 feet; while in July, 1877, only 78,700 million cubic feet passed, the highest gauge-reading being 29 feet; the flood rise of 1875 started from a gauge-reading of  $32\frac{1}{2}$  feet, while that of 1877 was only 25 feet. The moderating effect of the 305 square miles of channel area is seen. Possibly also the entrances to the Nawoon, by drawing off more water, afforded some relief. That they possessed an increased capacity in 1877 over that of 1875 was shown by actual measurement in 1878, although this would account for only a small portion of the effect. The reservoir-action of the channel is shown by the hydrograph of the 1877 flood-wave at Donabyo, between which place and Saiktha there is a storage-capacity in the channel for 3,000 million cubic yards, as the river-surface only varied 1 foot in the twenty-six days from the 11 August to the 6 September, while at Saiktha it varied 6 feet.

Telegrams from up-river stations permitted the formation and approach of these flood-waves to be known beforehand. Both in 1875 and 1877 the greater quantity of the water came from the north beyond Mandalay; but it appeared as though the rain-clouds supplying it were travelling southwards simultaneously and filling the smaller tributaries of the Irawadi as the flood-waves passed down; and in both 1875 and 1877 a heavy rainfall occurred in Lower Burma just as the crests of the waves reached the embankments. Without this, the moderating action of the channel above and below Saiktha would have further reduced the height of the crests. It is important to note that in 1875 the discharge was actually being measured during the whole flood period, as it proved that the flood-rise was due to an increased volume of water discharged at the time and not to the backing action of the embankments. It seems trivial to mention this; but the civil officers, writing officially at Thyetmyo, 100 miles above Saiktha, and at Bassein, and most of the inhabitants on the eastern side of the river who suffered from these floods, ascribed them to the action of the embankments; and petitions were sent to the Governor-General of India for their abolition, with compensation for injury. So far as could be ascertained, the embankments on the Irawadi channel had no appreciable effect on the flood-heights.

With the Nawoon river and its embankments the case was different. The steady westward progress of the point of the Thambyadeing bend, with the continuous increase in size of the

entrance to the Nawoon, between 1865 and 1875, when it ceased, had been under the Author's observation; and he could testify that the high flood of 1871, with the excessive influx to the Nawoon from the Irawadi, devastated the country on both banks of the former river to a point far south of Ngathaingyoung. The only way to preserve any portion of the previous cultivation and to reclaim the inundated low lands was by embanking the left bank of the Nawoon. This embankment was extended very slowly—to 4 miles in 1869; 25½ miles in 1872; 40 miles in 1873; 47½ miles in 1874; and to 53 miles in 1875. The Nawoon river has its own watersheds, which add to its volume as well as the supply from the Irawadi. About 800 square miles of plain and hill country to the west and south of Myanoung drain into it above the measuring-station of Thapangyo, which was established in 1872, just below where the Nawoon receives the Thambyadeing. To the south of this some 680 square miles of torrent-basins and 220 square miles of plain-land to the west of the river, discharge directly into it. Measurements were made of the discharge of the Nawoon at the station of Thapangyo in the years 1872, 1875, and 1878, on the same section line. The area of the cross-section (Plate 7, Section 2), increased from 20,810 square feet in 1872 to 24,120 in 1875, and to 29,700 square feet in 1878. The measurements were made continuously, except Sundays, for a considerable period on each occasion, from low water to high flood. The discharges were calculated as for the Irawadi; but as the depths were not so great (40 feet maximum as compared with 80 feet maximum), nor the velocities so high on the Nawoon as at Saiktha, the original results<sup>1</sup> are retained, but the cubic metres of the Author's Report<sup>1</sup> have been converted into cubic yards.

## DISCHARGE OF THE NAWOON—1872, 1875 AND 1878.

| Gauge Reading. | 1872.                | 1875.                | 1878.                |
|----------------|----------------------|----------------------|----------------------|
| Feet.          | Cubic Yards per Day. | Cubic Yards per Day. | Cubic Yards per Day. |
| 36             | 216,512,000          | 253,883,000          | 297,439,000          |
| 37             | 249,100,000          | 291,159,000          | 338,772,000          |
| 38             | 291,470,000          | 330,161,000          | 390,700,000          |
| 39             | 316,102,000          | 400,379,000          | 455,176,000          |
| 40             | 416,810,000          | 477,682,000          | 536,149,000          |

<sup>1</sup> Report on the Irawadi river, Rangoon.



## DIFFERENCES OF DISCHARGE FOR THE YEARS 1872, 1875 AND 1878.

| Gauge Reading. | 1872 and 1875.       | 1875 and 1878.       | 1872 and 1878.       |
|----------------|----------------------|----------------------|----------------------|
| Feet.          | Cubic Yards per Day. | Cubic Yards per Day. | Cubic Yards per Day. |
| 86             | 87,841,000           | 43,556,000           | 80,897,000           |
| 87             | 42,059,000           | 47,618,000           | 80,672,000           |
| 88             | 47,694,000           | 51,536,000           | 99,280,000           |
| 89             | 54,277,000           | 54,797,000           | 109,074,000          |
| 40             | 60,872,000           | 58,467,000           | 119,389,000          |

The enlargement of the Thambyadeing entrance is thus proved to have brought with it an enlargement of the trunk and the carrying capacity of the Nawoon lower down; as indeed is shown by all the cross-sections of the river measured at different dates up to 1879, as far as Ngathaingyoung, 64 miles south of Thambyadeing. At Laymyetna, the 30th mile by river, the flood cross-section increased from 23,770 to 25,460 square feet between 1875 and 1878. The increase at Zimbyogong, the 42nd mile, was from 15,770 to 20,110 square feet between 1875 and 1879. All flood-sections are referred to the 1877 flood. At Ngathaingyoung, the increase to 1879 was slight. Near this place the river changes in character. Sixteen cross-sections taken between Thambyadoing and the 70th mile, give an average low-water area of only 7,200 square feet, with average widths of channel under 600 feet; while twenty sections between the 78rd and 127th miles show an average low-water area of nearly 22,500 square foot, with 1,200 feet width. The flood cross-sectional areas correspond in size with those at low-water. The difference is due to the scouring action of the tidal waters south of Ngathaingyoung, where the river assumes the character of an estuary. Another feature of great importance is that the river here meets on its right bank high rocky outspurs from the Aracan Hills. From Mageelaha, near the 68rd mile of embankment, southwards, the flood-waters are entirely confined to the river channel; whereas, to the north of this rocky elevated ground, they have full play on the right bank over the low-lying land between the river and the hills, averaging 30 miles long by 4 miles broad. This exerted a marked effect in moderating the high floods.

In 1873 and 1874 the floods were low. In 1875 the flood-height on the Irawadi was unprecedented; and as, owing to the enlargement of the Thambyadeing entrance, the water thrown

into the Nawoon had increased at the measuring-station on the 12th mile by one-sixth between 1872 and 1875, while the relative increase in size of the channel was less than this—progressively diminishing to nothing at Ngathaingyoung—a large part of this water rose above the banks and flooded the country. The embankments had been completed for 53 miles with the normal section to a height of 3 feet above the 1871 flood-level; but, between the lower end and the cliffs lower down the river on the right bank, a gap was left free for about 7 miles as an outlet for the flood-water. The 1875 flood rose above the 1871 flood in the Nawoon as follows:

| From the Thambyadoing Entrance . . . . . | Mile.<br>0    | Miles.<br>8   | Miles.<br>30  | Miles.<br>42  | Miles.<br>64  | Miles.<br>87  | Miles.<br>98  |
|------------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| .. .. .                                  | Foot.<br>1.00 | Foot.<br>1.76 | Foot.<br>1.75 | Foot.<br>2.25 | Foot.<br>2.00 | Foot.<br>1.03 | Foot.<br>0.40 |

The water rose in places to between 9 inches and 15 inches from the top of the embankment for a length of 40 miles, but the works held good.

In the dry season, of 1875-76, it was proposed to extend the embankment 26 miles further to the Taboo river, and to raise the entire works with the normal section to a height of 3 feet above the 1875 flood. The estimated cost of this was Rs.2,52,615; but only one-half this sum was available and only 19 miles of extension were carried out. This closed the gap between the embankment end and the cliffs, leaving only the width of the channel as an outlet for the floods, where before they had free exit over the left bank. So far as the money allowed, the old works were raised and strengthened. The flood of 1876 was lower by 1.18 foot than in 1871 on the Irawadi at the Thambyadoing entrance; but along the Nawoon, the differences were:

| From the Thambyadoing Entrance . . . . . | Mile.<br>0     | Miles.<br>8    | Miles.<br>30   | Miles.<br>42  | Miles.<br>64  | Miles.<br>87  | Miles.<br>98  |
|------------------------------------------|----------------|----------------|----------------|---------------|---------------|---------------|---------------|
| .. .. .                                  | Foot.<br>-1.18 | Foot.<br>-0.10 | Foot.<br>-0.10 | Foot.<br>1.41 | Foot.<br>2.50 | Foot.<br>3.58 | Foot.<br>1.44 |

The effect of restricting the outlet at the lower end is at once apparent, as the surface of the river was raised from the 64th mile southwards above the flood-heights of 1875—at the 87th mile by

no less than 2.55 feet, although at the Thambyadeing entrance it was lower by 2.18 feet. This entrance continued to enlarge, and the volume of water drawn from the Irawadi increased so much that the floods spilled over the right bank from the 10th mile southwards; and local rainfalls of 4.80 inches on the 1st of July and 4.95 inches on the 15th augmented the flood, which rose to its highest on the latter date. Some slight damage was done to the works, which, however, held generally good.

Financial reasons again prevented the embankments from being raised and strengthened to the normal section above the 1876 flood; and, beyond repairs and improvements to the weaker parts, they were in much the same condition when the 1877 floods came down the Irawadi. The hydrographs of the Nawoon stations, *Fig. 9*, show that, on this river, the two wave-crests are merged into one; and this stood above the 1871 and 1875 flood-heights as follows:

| From the Thambyadeing Entrance . } | Mile.<br>0    | Miles.<br>8   | Miles.<br>30  | Miles.<br>42  | Miles.<br>64  | Miles.<br>87  | Miles.<br>98  | Miles.<br>108 |
|------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Above 1871 flood .                 | Feet.<br>1.86 | Feet.<br>2.82 | Feet.<br>3.25 | Feet.<br>4.00 | Feet.<br>4.83 | Feet.<br>5.12 | Feet.<br>2.02 | Feet.<br>1.00 |
| „ 1875 „ .                         | 0.86          | 1.06          | 1.50          | 1.75          | 2.39          | 4.09          | 1.62          | „             |

The crest of the wave passed the upper stations as far as the 64th mile on the 21st of August, but appears at the 87th and 98th miles on the 19th and 20th of August, reappearing on the 22nd at the 108th mile. Four separate causes concurred to produce these phenomena, the first being the greater height of the Irawadi at the Thambyadeing entrance; the second, the continual increase in capacity of this entrance, as subsequently shown by measurements at Thapangyo in 1878; the third, local effects of the heavy rainfall on the 19th of August; and fourth, the failure of the Nawoon embankment in its unfinished state. The several effects will be better understood after an account of the discharge measurements made in 1878 on the Nawoon river.

Measurements of the discharge were made for some months in 1878 at Thapangyo, at the 10th mile, where the whole of the water received by the river from the north is carried by the channel; and at the 98th mile, where all the water spilled over the banks has been restored to its channel, with the addition of the rainfall on the 900 square miles of watershed to the west, which interposes. During September a similar measure-



ment was made at the 90th mile, where also the river contained the whole discharge; and at the 80th mile, where much of the spill-water had passed to the low ground on the right bank. The discharges for high floods at Thapangyo for the years 1872, 1875, and 1878 have already been given, showing the large increase of one-sixth its volume in the first three years, and from 1872 to 1878 of one-third its volume; the excess in the latter interval rising from 81 million cubic yards at 36 feet on the gauge to 119 million cubic yards at 40 feet on the gauge. Almost the whole of this increase must have been thrown over the right bank of the river between the 10th and 64th mile, passing slowly down the flooded lowlands in a separate stream nearly 4 miles broad, and re-entering the river over the right bank above the 87th mile, where the embankment closes in towards the hills on the west. Comparative measurements on the upper trunk at different dates previous to 1879 prove that this was slowly enlarging throughout its length above Ngathaingyoung; and doubtless this action has been continued and extended since. But in 1877 and in 1879, when the embankment remained intact, there was a marked contrast between the protected lands behind the works on the left side and the submerged country on the right, with the water up to the roofs of the houses in the lower villages.

The results of the measurements during August 1878, made simultaneously at the 10th and 98th mile, showed that with the water-level varying from 35.73 feet to 37.87 feet on the gauge at the former place, the total discharge during the thirty-one days was 11,020 million cubic yards. At the 98th mile, at 37.08 feet to 39.92 feet on the gauge, the total volume of water passing was 11,816 million cubic yards—a difference of 796 million cubic yards.

During September, 1878, the water-levels at Thapangyo varied from 35.31 feet to 37.31 feet on the gauge; and the quantity of water passing there daily was calculated from the previous measurements and found to be 9,726 million cubic yards for the month. The staff of observers was transferred to Laymyetna, the 80th mile, where the gauge recorded 37.33 feet to 38.25 feet; and the actual volume passing down the channel at that place was found to be only 7,908 million cubic yards during the same period; no less than 1,818 million cubic yards having in the interval of 20 miles passed over the right bank to the low land between the river and the hills. During the same time the other measuring party observed the discharge at Payagyee, the 90th mile, where all the spill-water is returned from the low land to the river. The gauge-readings here varied from 36.17 feet to 38.67 feet,



and the volume passed in the 31 days was 11,054 million cubic yards, or 1,828 million cubic yards in excess of the quantity in the channel at Thapangyo, and 8,146 million cubic yards in excess of that at Leymyetna.

The rainfall records of Henzada to the east, and of Bassein to the south of the watershed of 900 square miles, the drainage of which enters the river between the measuring stations, gave the following figures:—

| 1878                                 | July. | August. | September. |
|--------------------------------------|-------|---------|------------|
| Bassein . . . . . inches             | 11·27 | 20·81   | 12·71      |
| Henzada . . . . . „                  | 15·22 | 12·43   | 7·52       |
| Mean rainfall . . . . . „            | 13·40 | 16·63   | 10·12      |
| Ditto . . . . million of cubic yards | 10/27 | 12/87   | 8/22       |

Some portions of this rainfall would be evaporated and some absorbed in the ground; and of the remainder probably one-half of each month's fall would reach the river in the following month and furnish the excess volumes found at the lower stations. The figures given explain to a certain extent the curious hydrograph of the great flood-wave of 1877 on the Nawoon. The two wave-crests so marked in the wave on the Irawadi are preserved at the uppermost station of the Nawoon, but disappear at the 30th mile, where only one very high crest is seen on the 21st, and a little later at the 42nd and the 64th mile. At Mageelaha, the 87th mile, the wave-form presents a singular contrast with those of the upper stations. The rise of the river at these places is gradual for over 20 days, the free spill over the right bank relieving the channel near them. Evidently the inundation passed down this basin as in a separate channel and did not reach Mageelaha for eight days after it entered the Nawoon and passed the 30th mile; when it suddenly raised the river 5 feet above the high-flood level of 1871 in five days, and remained at this height for ten days longer, until the 19th August. On that date, a rainfall of over 4 inches occurred over the entire delta region, and the river-surface responded to this at Mageelaha with a sharp rise, after which there was a sudden fall of over 18 inches in the gauge-readings. The explanation of this is that the embankments from the 25th mile southwards were heavily breached in twenty places, mostly on the 19th. The total width of the breaches extended over 6,000 feet, the ground



being deeply scoured out in some instances. The damage done was slight, most of the water escaping by the Taboo creek, the hydrograph of which, at its exit, shows a flood-wave similar in its features to those of the upper stations, but of lower height.

The works were restored and strengthened, although funds were not available in 1878 and 1879 to give the embankment the normal section throughout; but, by means of the Embankment Act, securing the help of villagers near the more dangerous parts, and the devotion of the staff, the whole of the Nawoon embankment was maintained intact, although the highest flood of 1879 rose 1.17 foot higher at Mageelaba than that of 1877. Since that date all the embankments have been raised and strengthened to at least the normal dimensions of 14 feet top width, 3 feet above highest known flood-level, with slopes of  $2\frac{1}{2}$  to 1 and 2 to 1; and the work has been continued to Taboo on the one side and to Baudae on the other; at which places the highest known flood elevations are 17.00 feet and 18.00 feet above mean sea-level respectively—the greater part of the Henzada plain lying above those levels. A few breaches have taken place, for the most part owing to weakness in the ground; and at one or two places on the Irawadi a short portion of the line has had to be retied on account of the erosion wrought by the river. But the purpose for which they were built has been attained; and an immense extent of country, some 2,000 square miles in extent, has been reclaimed and protected at a moderate cost.

The Paper is illustrated by 2 maps and 5 sheets of drawings, from which Plates 7 and 8, and the *Figs.* in the text have been prepared.

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#### SUPPLEMENTARY NOTE PERIOD 1883-1893.

The Author was connected with the works described between December, 1868, and July, 1883, and his opportunities for personal observation ceased at the latter date. At his request, Mr. H. J. Richard, M. Inst. C.E., Chief Engineer of the Public Works Department in Burma, has supplied some information regarding the river and the works to March, 1893. From this the following supplementary note has been compiled.

The Assistant Surveyor-General of India furnishes the following data regarding mean sea-level:—Simultaneous observations on the sea-coast at Elephant Point, and on the river at Rangoon, establish the mean river-level at Rangoon at 2.145 feet above the mean sea-level (M.S.L.). The series of embankment-levels given in the Author's report on the Irawadi river had been connected before December, 1868, with mean river-level at Rangoon—assumed as mean sea-level, by levels through Prome and Myanong, over 200 miles. When

Continued to tide-level at Tandoon and Bassein, these showed a discrepancy of more than 4 feet below the mean river-levels at those places. The new lines of levels carried through Burma by the Trigonometrical Survey Department have since been connected with the embankment-levels, and show that the 1875 flood bench-mark at Henzada is 50.29 feet above M.S.L.; whereas it was formerly taken to be 48.48 feet + M.S.L. The principal flood-levels have accordingly been corrected by adding 6.81 feet, and the results are given in Appendix IV.

With regard to the lateral variation of the main channels of the Irawadi, within the embanked region and the entrances to the Nawoon River, Mr. A. de Crettes, Executive Engineer of the Irawadi portion of the embankment-works, writes: "Whilst the river maintained its course fairly, between its true and permanent banks, carved out of the old alluvium of the valley, its deep channel ranges amongst banks and islands of its own deposits, so that these channels vary from time to time." No mention is made of the development of the Kyangheen curve. "In the dry season of 1889 the navigable channel was some miles to the east of Myanong, where it had not been for twenty years, so that steamers were obliged to unload cargo for that town some 5 miles south of it. The Irawadi Flotilla Company stopped this eastern channel by means of a dam, and next year the river resumed its old course past Myanong. The erosion of the right bank of the river which caused such serious trouble to the Myanong embankment from the 35th mile southwards, from 1881 to 1885, has nearly ceased, and it will soon be practicable to complete the Myanong embankment." As regards the Thambyadeing entrance to the Nawoon river, he says (on 8 September, 1891): "In 1883 the Thambyadeing branch of the Bassein river was open for steamers plying between Bassein and Henzada all the year round." (It had then to be kept open by a steam-dredger removing a bar of river deposit in the dry season.) "In 1889, and since, steamers from Bassein were only able to ascend as far as Ngathaingyoung, owing to the diminished flow of the Thambyadeing due to the cut-off in 1881." On the 27th April, 1892, he says: "The cut-off has resulted in a silting up of the old river-channel to such an extent that last year (1891) steamers and launches were only able to use the channel for three months, from June to September; so that, instead of an efficient waterway open at all seasons, there is now a deteriorated channel open to small boats for three-fourths of the year and to large ones for one-fourth of the year." In 1881-85-86 large sandbanks and an island in front of Henzada were washed away, and the existence of the town was threatened in 1887 and 1888; fortunately, the erosion seems to have ceased. Since 1880, the Pantanau branch of the Irawadi has deteriorated. The Panlang creek has become shallower at its head, where it leaves the Irawadi, carrying off less water than it is said to have done formerly; thus contributing to the increased flood in the lower channel." The Thambyadeing cut-off shortened the main channel by 14 or 15 miles, bringing the floods down more rapidly.

In consequence of these and other changes in the upper delta channel of the river, the channels to the west of Macobin Island receive a greater volume of water than formerly; the flood-levels to the south of the Thambyadeing cut-off have been raised, while those to the north of it have been lowered. Mr. de Crettes gives two Tables (Appendix V) showing these results for the periods 1868-1881 and 1882-1891. "During the early years of embankment-construction in Burma there was an augmentation in the heights of successive floods over those of previous years, and this successive increase was synchronous with the extension of the embankments. This gave colour to, and seemed to

confirm the opinions of, those who maintained that the embankments were the sole cause of the increased high floods, while it obscured the true origin of the phenomena. Civil officers were at this time unceasing in their condemnation of embankments, and they were extended only after much opposition."

Table I shows the progressive increase in the general height of the floods from 1868 to 1880—Myanounng at the upper end of the embankments, and Donabyo near the lower end, showing the highest records then known in the latter year. A reference to Table II will further show that since 1881 the high floods have been again lowered in the upper part of the embankment-area at Myanounng and in the lower part at Maoobin; that they are not higher at Henzada, but that at Donabyo, Setkaw, Pantanan, the north and west of Maoobin island and at Shweyloung they have increased in height. During the period the two high floods of 1875 and 1877 affected the entire river from Bhamo to the sea, and during the latter the high floods of 1886 and 1890 were equally extensive and influenced its whole course. Comparing the two periods, it is found that at Myanounng, during the first period the highest flood rose to 41.33 feet, and during the second to 39.50 feet. The average of high floods of the first period was 38.68, and that of the second 37.11 feet. At Henzada, during the first period the highest flood was 40.30 feet, and during the second 40.25 feet; and the average of the high floods was during the first period 38.58 feet, and during the second 38.66 feet. At Donabyo, the highest flood of the first period was 40.25 feet, and of the second 41.42 feet, whilst the average of the high floods stood 5 inches higher in the second period than it did in the first. In explanation of these figures, it must be again mentioned that all the river-gauges on the Irawadi side were fixed to read 40 feet at the height of the 1875 flood, for convenience of comparison. Mr. de Crettes concludes "that embankments have not been the cause of successive additions to the heights of floods," so far as the Irawadi river is concerned; but that "it is to alterations in the river-channels and its branches that variations in the flood-levels may more reasonably be ascribed."

No new embankment-works of importance have been carried out or are in progress at present. Village roads on the left bank, from opposite Donabyo northwards, have been consolidated for a length of 14 miles; and an embanked road has been constructed at Shweyloung, some miles to the south of the Henzada embankment, with a length of  $12\frac{1}{2}$  miles. Both works are unsupported at both ends, and can have no influence on the floods in the river. Mr. de Crettes says (9 January, 1893): "No large or destructive breaches have occurred in the Henzada division for years. In 1886 a small breach occurred in the 6th mile of the Nawoon embankment. It was closed, and no damage to crops resulted." "In 1890, the Maoobin embankment was topped for many miles, but . . . no breach occurred." A breach 280 feet long took place at the lower end of the Henzada embankment in the same year; but the Bawdee river drained off the water admitted, and "there was no damage to crops."

On the Nawoon side, no definite information is given as to the heights of recent floods, except that Mr. de Crettes says that the gauge at Myogwin, about 5 miles below the Thambyadoing entrance, averages in the last ten years 1 foot lower than formerly for high floods. "The extreme high flood during the first period reached 41.06 feet, and during the second 39.89 feet." These figures indicate that the gradual silting up of the entrances from the Irawadi to the Nawoon are considerably diminishing the supply from this source to the latter river. Notwithstanding this, the Executive Engineer of the Nawoon embankment reports (10 December, 1892) that "the embankment from the 19 $\frac{1}{2}$  mile southwards was in great danger during the rains of 1890, when the flood rose



to the crest in places. A serious breach took place—1,000 feet of the embankment was carried away—on the 15th mile, when a retirement was made 2,225 feet in length. It was decided that the embankment should be raised to a height of 3 feet above that flood, and estimates were submitted for the work, aggregating Rs 307722. The work has been in hand since February, 1891, and is now about four-fifths complete."

While the financial results of the embankments as a whole are satisfactory, the Chief Commissioner of Burma, in his resolution on the settlement operations for the years 1890-91, pronounces the Macobin embankment to be a "phenomenal success."



## APPENDICES.

## APPENDIX I.—DISCHARGE-SCALE FOR SAIKTHA RIVER-GAUGE, 1872-1873.

| Formulas for Discharges for Gauge-readings                                                                                         | $x$                                        | Gauge-reading. | Discharges.                     |                                     |
|------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|----------------|---------------------------------|-------------------------------------|
|                                                                                                                                    |                                            |                | $y_1$ in Cubic Feet per Second. | 3,200 $y_1$ in Cubic Yards per Day. |
| $y = 8,450 x + 1.69 \frac{(x-1) \times x \times (x+1) \times (x+2)}{24}$                                                           | $x = \text{gauge-reading} \times 2 + 8$    | 0              | 0                               | 0                                   |
|                                                                                                                                    |                                            | 2              | 16,902                          | 54,086,000                          |
|                                                                                                                                    |                                            | 4              | 33,826                          | 108,243,000                         |
|                                                                                                                                    |                                            | 6              | 50,819                          | 162,624,000                         |
|                                                                                                                                    |                                            | 8              | 67,956                          | 217,472,000                         |
|                                                                                                                                    |                                            | 10             | 85,338                          | 273,088,000                         |
|                                                                                                                                    |                                            | 12             | 103,093                         | 329,898,000                         |
|                                                                                                                                    |                                            | 14             | 121,877                         | 388,416,000                         |
|                                                                                                                                    |                                            | 16             | 140,872                         | 449,184,000                         |
|                                                                                                                                    |                                            | Feet.          |                                 |                                     |
| $y' = 140,872 + 9,609 x' + 213.2 \frac{x' \times (x'+1)}{2}$                                                                       | $x' = \text{gauge-reading} \times 2 - 8$   | 5              | 160,280                         | 512,736,000                         |
|                                                                                                                                    |                                            | 6              | 180,540                         | 577,726,000                         |
|                                                                                                                                    |                                            | 7              | 202,503                         | 648,000,000                         |
|                                                                                                                                    |                                            | 8              | 224,919                         | 719,744,000                         |
|                                                                                                                                    |                                            | 9              | 248,188                         | 794,208,000                         |
|                                                                                                                                    |                                            | 10             | 272,310                         | 871,392,000                         |
|                                                                                                                                    |                                            | 11             | 297,485                         | 951,936,000                         |
|                                                                                                                                    |                                            | 12             | 323,141                         | 1,034,048,000                       |
|                                                                                                                                    |                                            | 13             | 350,031                         | 1,120,096,000                       |
|                                                                                                                                    |                                            | 14             | 377,521                         | 1,208,064,000                       |
|                                                                                                                                    |                                            | 15             | 405,710                         | 1,298,272,000                       |
|                                                                                                                                    |                                            | 16             | 434,948                         | 1,391,840,000                       |
|                                                                                                                                    |                                            | 17             | 465,039                         | 1,488,128,000                       |
|                                                                                                                                    |                                            | 18             | 495,983                         | 1,587,136,000                       |
|                                                                                                                                    |                                            | 19             | 527,780                         | 1,688,896,000                       |
|                                                                                                                                    |                                            | 20             | 560,430                         | 1,793,376,000                       |
|                                                                                                                                    |                                            | 21             | 593,932                         | 1,900,576,000                       |
|                                                                                                                                    |                                            | 22             | 628,287                         | 2,010,528,000                       |
|                                                                                                                                    |                                            | 23             | 663,495                         | 2,123,168,000                       |
|                                                                                                                                    |                                            | 24             | 699,556                         | 2,238,592,000                       |
| $y'' = 812,855 + 19,416 x'' + 213.2 \frac{x'' \times (x''+1)}{2} + 10 \frac{x'' \times (x''+1) \times (x''+2) \times (x''+3)}{24}$ | $x'' = \text{gauge-reading} \times 2 - 54$ | 25             | 736,470                         | 2,356,704,000                       |
|                                                                                                                                    |                                            | 26             | 774,236                         | 2,477,568,000                       |
|                                                                                                                                    |                                            | 27             | 812,855                         | 2,601,220,000                       |
|                                                                                                                                    |                                            | 28             | 852,377                         | 2,728,616,000                       |
|                                                                                                                                    |                                            | 29             | 893,001                         | 2,857,600,000                       |
|                                                                                                                                    |                                            | 30             | 935,088                         | 2,992,278,000                       |
|                                                                                                                                    |                                            | 31             | 979,188                         | 3,133,408,000                       |
|                                                                                                                                    |                                            | 32             | 1,025,891                       | 3,282,840,000                       |
|                                                                                                                                    |                                            | 33             | 1,076,127                       | 3,441,636,000                       |
|                                                                                                                                    |                                            | 34             | 1,130,863                       | 3,618,752,000                       |
|                                                                                                                                    |                                            | 35             | 1,191,266                       | 3,812,064,000                       |
|                                                                                                                                    |                                            | 36             | 1,258,650                       | 4,027,680,000                       |
|                                                                                                                                    |                                            | 37             | 1,334,497                       | 4,270,400,000                       |
|                                                                                                                                    |                                            | 38             | 1,420,447                       | 4,545,440,000                       |
|                                                                                                                                    |                                            | 39             | 1,518,299                       | 4,858,560,000                       |
|                                                                                                                                    |                                            | 40             | 1,630,014                       | 5,216,032,000                       |
|                                                                                                                                    |                                            | 41             | 1,757,703                       | 5,624,640,000                       |
|                                                                                                                                    |                                            | 42             | 1,903,673                       | 6,091,751,000                       |
|                                                                                                                                    |                                            | 43             | 2,040,837                       | 6,529,078,000                       |
|                                                                                                                                    |                                            | 44             | 2,260,303                       | 7,132,969,000                       |





APPENDIX III—DIMENSIONS OF CROSS-SECTIONS OF THE IRAWADI AND NAWOON  
RIVERS, ALONG EMBANKMENTS.

*Irawadi.*

| Number<br>of<br>Section. | Miles<br>from<br>Sancha. | Widths of       |                   |                         | Areas of Channels |             |              |
|--------------------------|--------------------------|-----------------|-------------------|-------------------------|-------------------|-------------|--------------|
|                          |                          | Main<br>Channel | Minor<br>Channels | Total Flood<br>Channel. | Main.             | Minor.      | Both.        |
|                          |                          | Feet            | Feet.             | Feet                    | Square feet       | Square feet | Square feet. |
| 1                        | 1                        | 5,000           | 3,000             | 8,000                   | 255,000           | 17,000      | 272,000      |
| 2                        | 13                       | 3,000           | 13,800            | 16,800                  | 148,000           | 236,000     | 384,000      |
| 3                        | 16                       | 4,100           | 12,500            | 16,500                  | 203,000           | 128,000     | 231,000      |
| 4                        | 20                       | 5,000           | 14,000            | 19,000                  | 188,000           | 145,000     | 332,000      |
| 5                        | 24                       | 6,200           | 6,800             | 13,000                  | 221,000           | 106,000     | 327,000      |
| 6                        | 28                       | 5,600           | 9,900             | 15,500                  | 219,000           | 114,000     | 333,000      |
| 7                        | 33                       | 4,000           | 9,000             | 13,000                  | 171,000           | 131,000     | 302,000      |
| 8                        | 37                       | 6,000           | 23,000            | 29,000                  | 229,000           | 207,000     | 436,000      |
| 9                        | 43                       | 6,300           | 22,700            | 29,000                  | 213,000           | 285,000     | 497,000      |
| 10                       | 55                       | 7,000           | 22,000            | 29,000                  | 237,000           | 230,000     | 527,000      |
| 11                       | 78                       | 4,600           | 18,400            | 23,000                  | 214,000           | 149,000     | 363,000      |
| 12                       | 83                       | 7,200           | 6,800             | 14,000                  | 230,000           | 40,000      | 270,000      |
| 13                       | 87                       | 6,700           | 2,300             | 9,000                   | 170,000           | 52,000      | 222,000      |
| 14                       | 93                       | 6,000           | 11,000            | 17,000                  | 267,000           | 122,000     | 389,000      |
| 15                       | 97                       | 3,000           | 19,000            | 22,000                  | 174,000           | 145,000     | 319,000      |
| 16                       | 101                      | 5,000           | 17,000            | 22,000                  | 186,000           | 98,000      | 279,000      |
| 17                       | 107                      | 5,000           | 7,000             | 12,000                  | 187,000           | 160,000     | 247,000      |
| 18                       | 114                      | 4,300           | 14,700            | 19,000                  | 156,000           | 112,000     | 268,000      |
| 19                       | 117                      | 8,000           | 6,000             | 14,000                  | 121,000           | 106,000     | 287,000      |
| 20                       | 122                      | 5,700           | 2,300             | 8,000                   | 149,000           | 68,000      | 217,000      |
| 21                       | 128                      | 6,000           | 1,300             | 7,300                   | 163,000           | 48,000      | 211,000      |
| 22                       | 135                      | 3,000           | 2,400             | 5,400                   | 150,000           | 5,000       | 155,000      |
| 23                       | 137                      | 4,000           | 2,600             | 6,600                   | 146,000           | 28,000      | 174,000      |
| 24                       | 141                      | 2,900           | 10,100            | 13,000                  | 147,000           | 68,000      | 215,000      |
| 25                       | 143                      | 3,600           | 3,400             | 7,000                   | 165,000           | 16,000      | 181,000      |
| 26                       | 148                      | 3,000           | 12,000            | 15,000                  | 145,000           | 72,000      | 217,000      |
| 27                       | 152                      | 3,600           | 15,400            | 19,000                  | 144,000           | 61,000      | 205,000      |

## APPENDIX III—continued

## Nawoon

| Number.             | Miles from Irawadi | Width between Banks | Areas in 1877 |                     |
|---------------------|--------------------|---------------------|---------------|---------------------|
|                     |                    |                     | High Flood    | Low Water           |
|                     |                    | Feet                | Square feet   | Square feet.        |
| 1                   | 0                  | 700                 | 42,200        | 17,600              |
| 2                   | 1                  | 458                 | 18,900        | 4,500               |
| 3                   | 3                  | 420                 | 19,700        | 5,600               |
| 4                   | 8                  | 600                 | 37,200        | 17,900 <sup>1</sup> |
| Thapangyo station } | 10                 | 830                 | 31,400        | 5,700               |
| 4a                  | 16½                | 723                 | 17,200        | 1,600               |
| 4b                  | 24                 | 419                 | 15,500        | 2,600               |
| 5                   | 31                 | 830                 | 25,400        | 2,500               |
| 6                   | 34                 | 594                 | 23,500        | 6,600               |
| 7                   | 36                 | 407                 | 15,600        | 4,800               |
| 8                   | 39                 | 484                 | 15,000        | 1,500               |
| 9                   | 43                 | 488                 | 15,800        | 2,200               |
| 10                  | 46                 | 506                 | 22,200        | 9,100               |
| 11                  | 50                 | 523                 | 20,200        | 5,700               |
| 12                  | 63                 | 1,270               | 51,300        | 17,100              |
| 13                  | 65                 | 614                 | 23,300        | 7,200               |
| 14                  | 70                 | 442                 | 22,500        | 9,900               |
| 15                  | 73                 | 460                 | 25,600        | 14,000              |
| 16                  | 78                 | 452                 | 16,800        | 15,800              |
| 17                  | 87                 | 1,227               | 40,300        | 12,600              |
| 18                  | 92                 | 1,020               | 33,700        | 14,300              |
| 19                  | 95                 | 897                 | 37,900        | 21,700              |
| Measuring-station } | 98                 | 1,100               | 40,400        | 22,600              |
| 20                  | 102                | 1,128               | 36,000        | 18,000              |
| 21                  | 108                | 1,508               | 37,400        | 21,500              |
| 22                  | 116                | 974                 | 48,600        | 35,700              |
| 23                  | 118                | 773                 | 21,400        | 11,300              |
| 24                  | 118                | 1,080               | 37,500        | 22,800              |
| 25                  | 119                | 1,322               | 36,900        | 19,600              |
| 26                  | 120                | 1,800               | 13,800        | 25,300              |
| 27                  | 121                | 1,800               | 52,200        | 44,900              |
| 28                  | 122                | 720                 | 34,400        | 25,200              |
| 29                  | 123                | 1,240               | 43,800        | 28,500              |
| 30                  | 125                | 1,220               | 32,100        | 16,800              |
| 31                  | 126                | 730                 | 30,600        | 21,600              |
| 32                  | 127                | 1,050               | 33,900        | 21,000              |
| 33                  | 127                | 2,676               | 62,500        | 32,900              |

<sup>1</sup> Section across both Thambyadeing and Nawoon Rivers above junction.



# THE IRAW

PLATE 7

Fig. 6.

PLAN OF NAWOON RIVER AND EMBANKMENT.

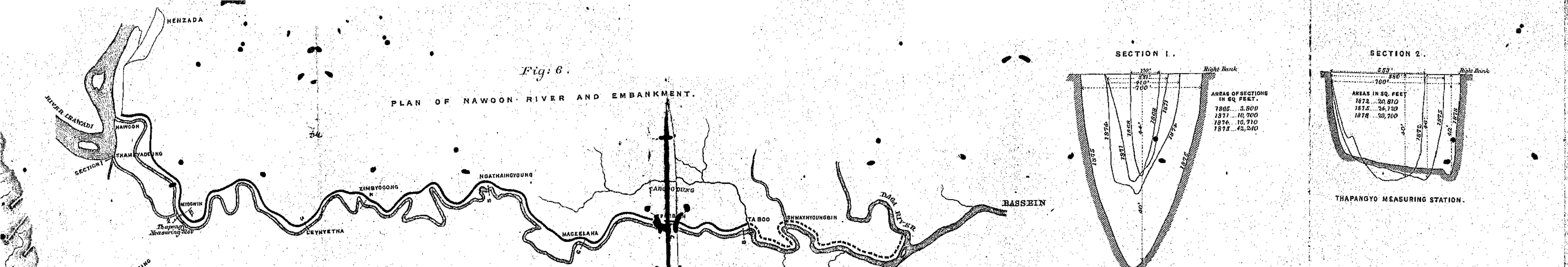
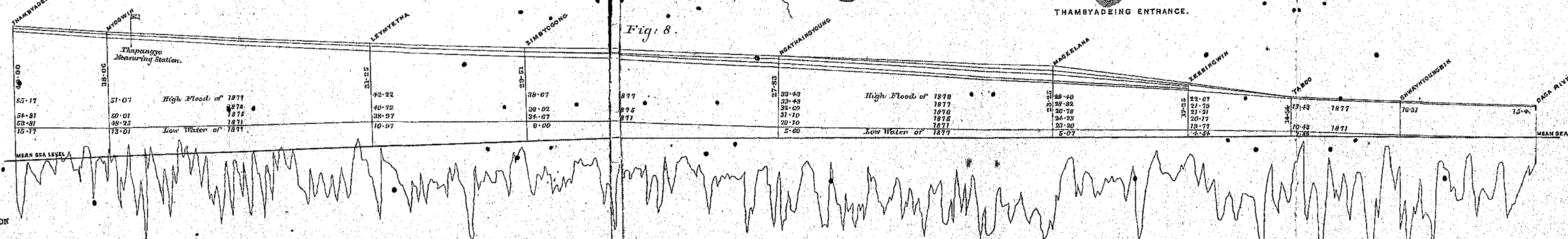
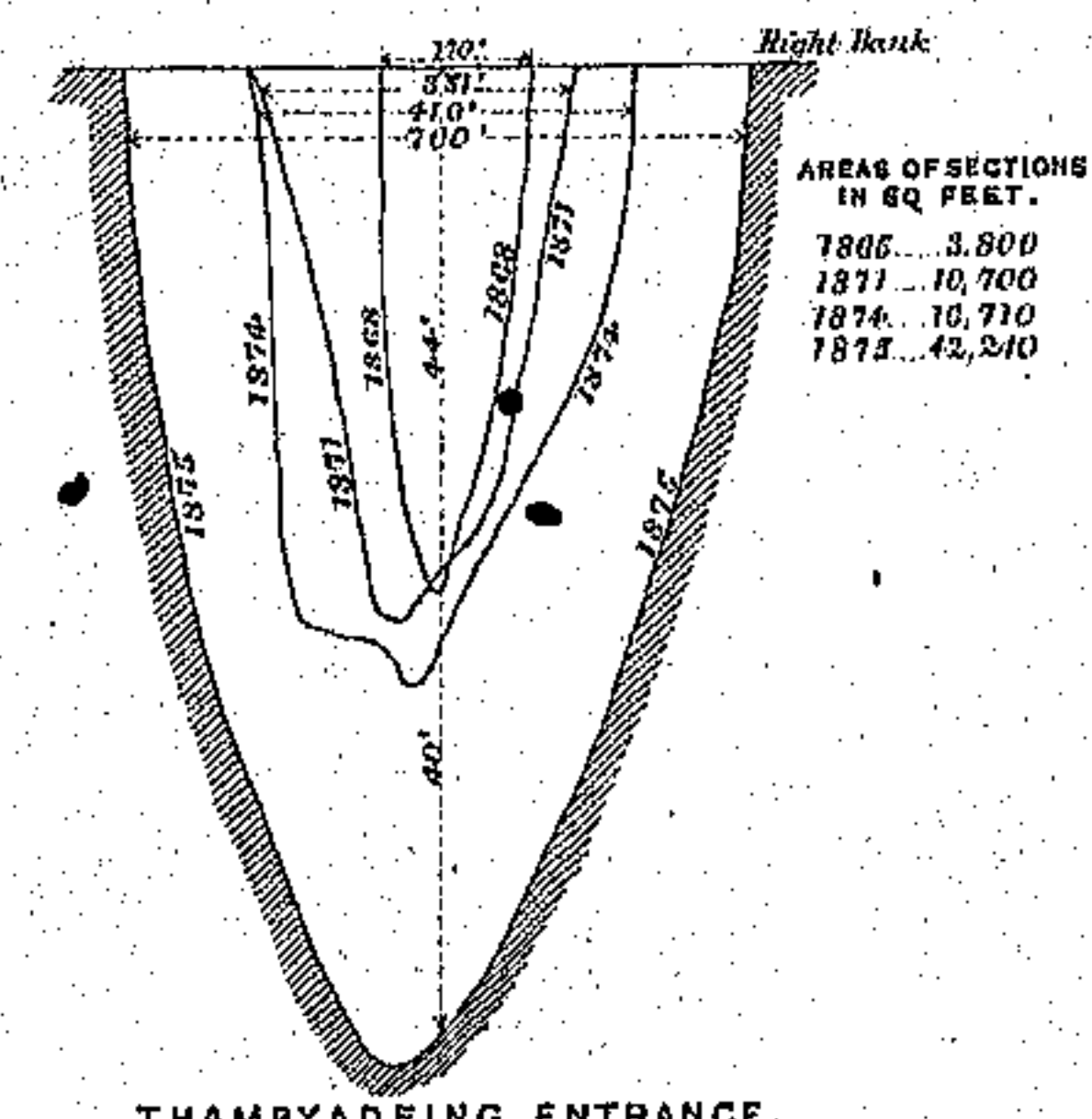


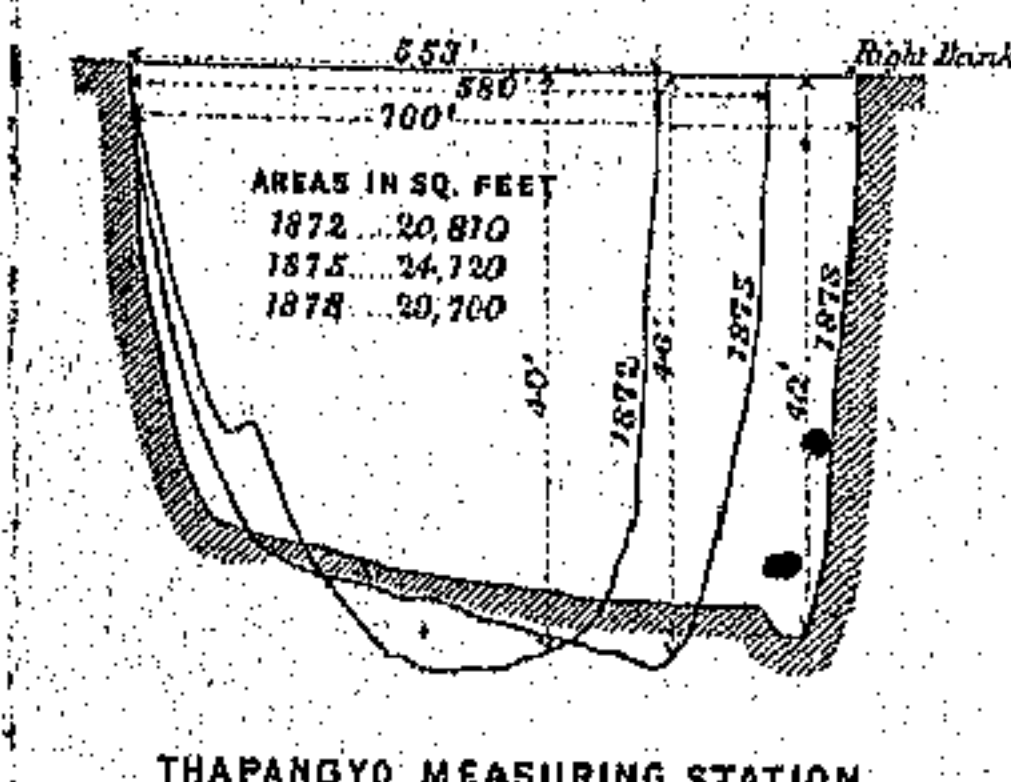
Fig. 8.



SECTION 1.

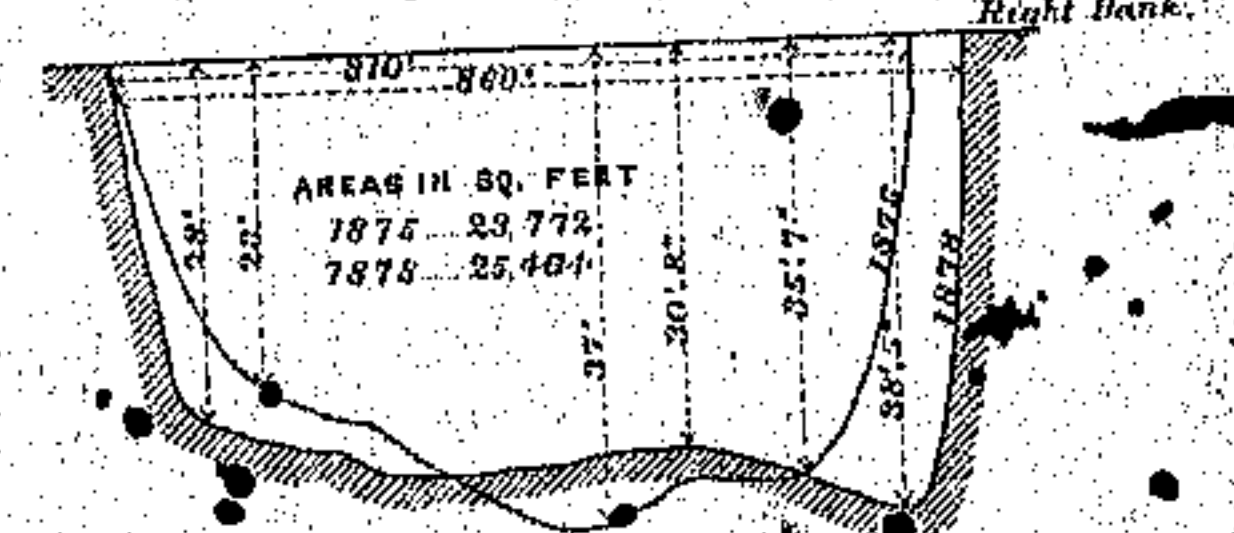


SECTION 2.



THAPUNGU MEASURING STATION.

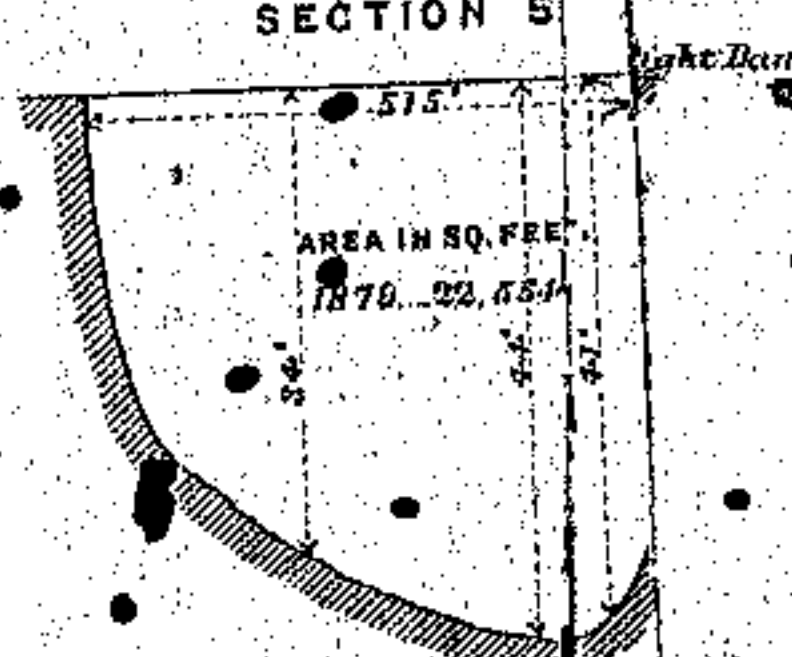
SECTION 3.



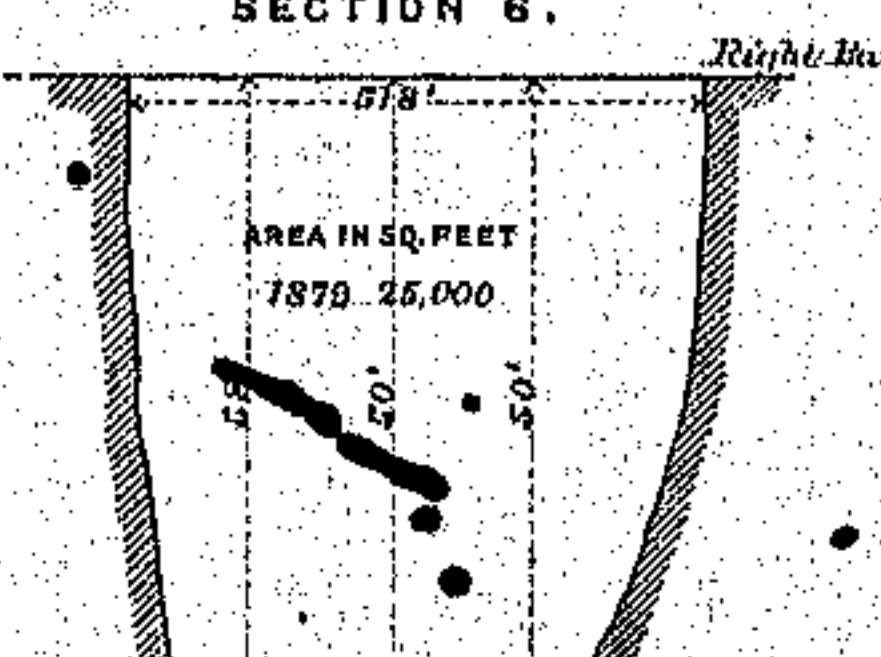
SECTION 4.



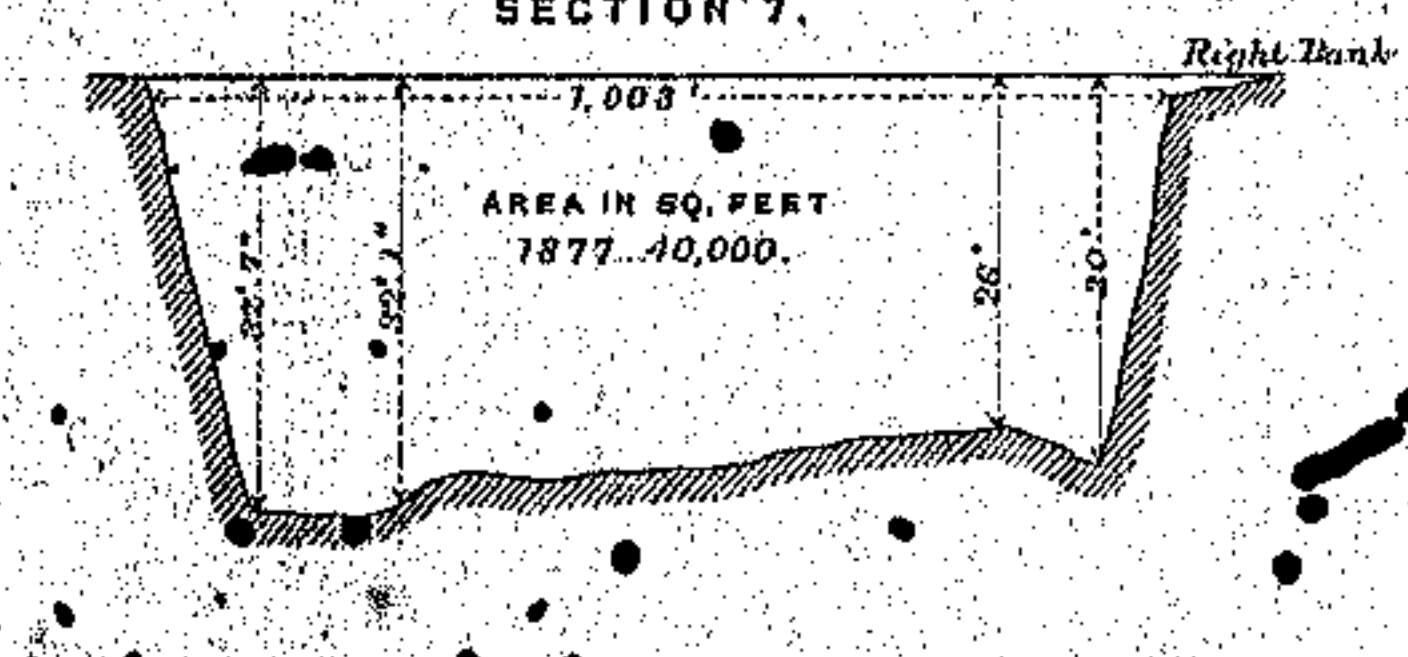
SECTION 5.



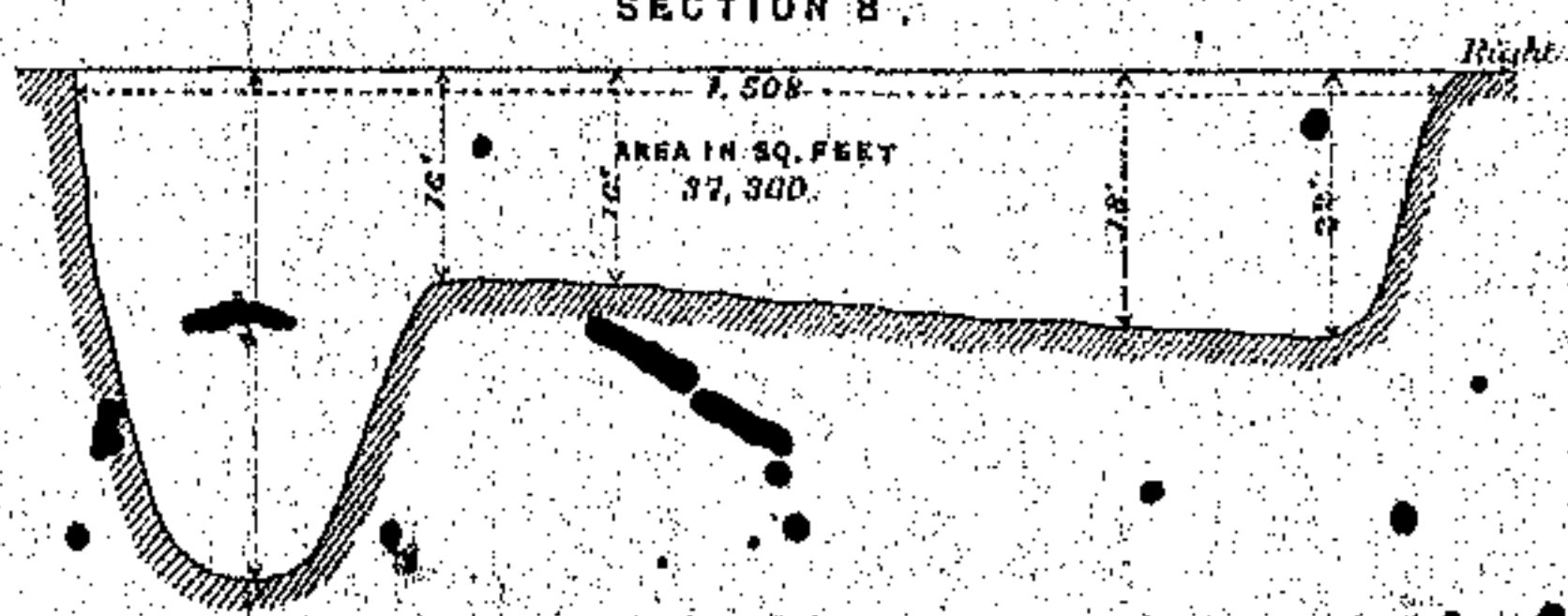
SECTION 6.



SECTION 7.



SECTION 8.



LEMYETNA.

ZIMBYOGONG.

NGATHAINYONG.

MAGEDELAHA.

ZEEBINGWIN.

TABOO.

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NOTE  
The determination of the  
altitudes that are  
added to all figures  
in this map, e.g.  
12.5, read 12.5.



| Distance from            | Heights above Mean Sea-level. |      |        |       |       |       |              |       |       |       | Tidal Range of River in 1877. | Increase in Height of Floods. |       |       |       | Rise above 1871. | Surface Slope in 1875 |       |       |        |
|--------------------------|-------------------------------|------|--------|-------|-------|-------|--------------|-------|-------|-------|-------------------------------|-------------------------------|-------|-------|-------|------------------|-----------------------|-------|-------|--------|
|                          | Floods of                     |      |        |       |       |       | Low-water of |       |       |       |                               |                               |       |       |       |                  |                       |       |       |        |
|                          | Salktha.                      | Sea. | Miles. | 1868  | 1871  | 1875  | 1876         | 1877  | 1879  | 1877  |                               | Feet.                         | Feet. | Feet. | Feet. |                  | Feet.                 | Feet. | Feet. | Miles. |
| <b>Irawadi Stations.</b> |                               |      |        |       |       |       |              |       |       |       |                               |                               |       |       |       |                  |                       |       |       |        |
|                          |                               |      | 0      | 230   | 214½  | 208   | 195          | 179   | 168   | 146   | 129                           | 100                           | 86    |       |       |                  |                       |       |       |        |
| aiktha . . .             |                               |      | 15½    | 75.28 | 84.67 | 76.96 | 77.72        | 78.68 | 77.97 | 78.68 | 77.97                         | 78.68                         | 77.97 | 78.68 | 77.97 | 78.68            | 77.97                 | 78.68 | 77.97 | 78.68  |
| Iyanoung . . .           |                               |      | 22     | 73.00 | 74.04 | 74.88 | 75.68        | 74.91 | 75.68 | 74.91 | 75.68                         | 74.91                         | 75.68 | 74.91 | 75.68 | 74.91            | 75.68                 | 74.91 | 75.68 | 74.91  |
| anoung . . .             |                               |      | 35     | 66.36 | 67.31 | 68.17 | 68.90        | 67.98 | 68.90 | 67.98 | 68.90                         | 67.98                         | 68.90 | 67.98 | 68.90 | 67.98            | 68.90                 | 67.98 | 68.90 | 67.98  |
| hwaygyeen . . .          |                               |      | 51     | 58.98 | 60.58 | 60.58 | 60.91        | 60.25 | 60.91 | 60.25 | 60.91                         | 60.25                         | 60.91 | 60.25 | 60.91 | 60.25            | 60.91                 | 60.25 | 60.91 | 60.25  |
| youngyo . . .            |                               |      | 72     | 48.00 | 49.29 | 50.29 | 52.91        | 52.01 | 52.91 | 52.01 | 52.91                         | 52.01                         | 52.91 | 52.01 | 52.91 | 52.01            | 52.91                 | 52.01 | 52.91 | 52.01  |
| Nawoon . . .             |                               |      | 84     | 48.00 | 49.29 | 50.29 | 50.59        | 49.94 | 50.59 | 49.94 | 50.59                         | 49.94                         | 50.59 | 49.94 | 50.59 | 49.94            | 50.59                 | 49.94 | 50.59 | 49.94  |
| Henzada . . .            |                               |      | 101    | 42.28 | 42.80 | 42.80 | 43.23        | 41.97 | 43.23 | 41.97 | 43.23                         | 41.97                         | 43.23 | 41.97 | 43.23 | 41.97            | 43.23                 | 41.97 | 43.23 | 41.97  |
| Zaloon . . .             |                               |      | 130    | 31.28 | 31.28 | 31.28 | 31.24        | 30.98 | 31.24 | 30.98 | 31.24                         | 30.98                         | 31.24 | 30.98 | 31.24 | 30.98            | 31.24                 | 30.98 | 31.24 | 30.98  |
| Donabyo . . .            |                               |      | 144    | 25.31 | 25.31 | 25.31 | 25.31        | 25.31 | 25.31 | 25.31 | 25.31                         | 25.31                         | 25.31 | 25.31 | 25.31 | 25.31            | 25.31                 | 25.31 | 25.31 | 25.31  |
| Sethaw . . .             |                               |      | 165    | 18.31 | 18.31 | 18.31 | 18.31        | 18.31 | 18.31 | 18.31 | 18.31                         | 18.31                         | 18.31 | 18.31 | 18.31 | 18.31            | 18.31                 | 18.31 | 18.31 | 18.31  |
| Baudee . . .             |                               |      |        |       |       |       |              |       |       |       |                               |                               |       |       |       |                  |                       |       |       |        |
| <b>Nawoon Stations.</b>  |                               |      |        |       |       |       |              |       |       |       |                               |                               |       |       |       |                  |                       |       |       |        |
|                          |                               |      | 0      | 229   | 221   | 199   | 187          | 165   | 142   | 131   | 121                           |                               |       |       |       |                  |                       |       |       |        |
| Thambyadeing . . .       |                               |      | 8      | 53.81 | 54.81 | 54.81 | 55.17        | 54.81 | 55.17 | 54.81 | 55.17                         | 54.81                         | 55.17 | 54.81 | 55.17 | 54.81            | 55.17                 | 54.81 | 55.17 | 54.81  |
| Myogwin . . .            |                               |      | 30     | 48.25 | 50.01 | 48.06 | 51.07        | 49.71 | 51.07 | 49.71 | 51.07                         | 49.71                         | 51.07 | 49.71 | 51.07 | 49.71            | 51.07                 | 49.71 | 51.07 | 49.71  |
| Laymyetna . . .          |                               |      | 42     | 38.97 | 40.72 | 39.07 | 42.22        | 41.05 | 42.22 | 41.05 | 42.22                         | 41.05                         | 42.22 | 41.05 | 42.22 | 41.05            | 42.22                 | 41.05 | 42.22 | 41.05  |
| Zimbyogong . . .         |                               |      | 64     | 34.67 | 36.92 | 36.10 | 38.67        | 37.62 | 38.67 | 37.62 | 38.67                         | 37.62                         | 38.67 | 37.62 | 38.67 | 37.62            | 38.67                 | 37.62 | 38.67 | 37.62  |
| Ngathalangyoung . . .    |                               |      | 87     | 29.10 | 31.10 | 32.60 | 33.43        | 33.43 | 33.43 | 33.43 | 33.43                         | 33.43                         | 33.43 | 33.43 | 33.43 | 33.43            | 33.43                 | 33.43 | 33.43 | 33.43  |
| Magelaha . . .           |                               |      | 98     | 23.20 | 24.23 | 26.78 | 28.28        | 28.49 | 28.28 | 28.49 | 28.28                         | 28.49                         | 28.28 | 28.49 | 28.28 | 28.49            | 28.28                 | 28.49 | 28.28 | 28.49  |
| Zeeingwin . . .          |                               |      | 108    | 19.77 | 20.17 | 21.21 | 21.21        | 21.21 | 21.21 | 21.21 | 21.21                         | 21.21                         | 21.21 | 21.21 | 21.21 | 21.21            | 21.21                 | 21.21 | 21.21 | 21.21  |
| Naboo . . .              |                               |      |        | 16.43 | 16.43 | 16.43 | 17.43        | 17.43 | 17.43 | 17.43 | 17.43                         | 17.43                         | 17.43 | 17.43 | 17.43 | 17.43            | 17.43                 | 17.43 | 17.43 | 17.43  |