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# MADRAS RECORD OFFICE

GOVERNMENT OF MADRAS

*Revenue* DEPARTMENT

G.O. No.  
B.P. No.

194

Press  
Mis.

Dated

12-2-1876 196

*Not to be folded or roughly handled*

*Proceedings of the Madras Government, Revenue Department,  
12th February 1876.*

No. 123. Read the following Proceedings of the Board of Revenue, dated 22nd December 1875, No. 3,412 :--

Read Report of Dr. Ratton on the best method of laying out and working salt-pans, dated 15th November 1875.

Dr. Ratton's Manual of Instructions for laying out and working salt-pans contains much valuable information, and is very creditable to him. It will be submitted to Government for communication to the Press, and circulated to all Collectors of Salt Districts for information and guidance.

(A true Extract.)

(Signed) C. A. GALTON,  
Acting Sub-Secretary.

No. 124. ORDER THEREON. 12th February 1876, No. 194.

Separate Revenue, No. 12.

Salt.

The Government agree with the Board that the Manual prepared by Dr. Ratton will prove a valuable work of reference.

2. It will be placed on the Editors' Table.

(True Extract.)

(Signed) D. F. CARMICHAEL,  
Secretary to Government.

To the Board of Revenue

Ed. W. J. Fischer.

No. 3,412.

PROCEEDINGS OF THE BOARD OF REVENUE, dated 22nd December 1875.

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Collectors of Salt Districts for information and guidance.

(A true Extract.)

  
Acting Sub-Secretary.

To the Secretary to Government, Revenue Department.

with copies of Dr. Ratton's Report.

To all Collectors of Salt Districts, with do.

Copy to J. J. L. Ratton, Esq., M.P., on special salt duty.

The first specimen sent had the same  
prepared by Mr. Rattan with some  
material work of reference.

It was kept on in India

and the other one

17th Feb 1876

18th Feb 1876

18th Feb 1876

1875.

18th Feb 1876

Board of Revenue,

MADRAS.

Proceedings, 23rd December 1875, No. 2412

Deputy Collector

Received

18th Feb 1876

DECEMBER

No. 2412

Madras, 23rd December 1875, to Government for  
communication to the French, and of the same to all  
Collectors of Salt Districts, D. R. Rattan, Revenue  
of Madras, for laying out and working of  
salt pans.

## REPORT

(PENDING FURTHER INQUIRY)

ON THE

## BEST METHOD OF LAYING OUT AND WORKING SALT-PANS.

From J. J. L. RATTON, Esq., M.P., Special Salt Duty, to the Sub-Secretary, Board of  
Revenue, dated Ervand, 15th November 1875, No. 76.

I HAVE the honor to inform you that, in accordance with Board's Proceedings, dated 17th October 1874, No. 3021, after selecting sites for salt manufacture in Malabar and Canara, I proceeded to Ervand to lay out model salt-pans on a small scale for the information and guidance of the West Coast Salt Deputy Collectors. To enable these officers to contrast the French and improved native systems I prepared a small modified native allum on a plot of land close to where Mr. Cammude was arranging his salt works on the French model under my instructions.

2. These two works were begun too late in the season—in April and May—to furnish satisfactory economic results, but they afforded reliable indications of a most encouraging kind and many additions to our practical knowledge of salt manufacture were made during their construction and use. The special object which the Board had in view was also attained. The Salt Deputy Collectors of the West Coast, though coming after the close of the season, saw how salt is made on a large scale in Europe and how in the native and improved native allums.

3. It is my intention to embody in this report the practical information resulting from this and previous years' work, especially with a view to assist the Deputy Collectors or others who may lay out and work the extensive and important salt-pans which are to be opened for the supply of Malabar and Canara, or which may be opened elsewhere hereafter.

4. In setting out salt-pans, having ascertained that the soil is good, that it is capable of being thoroughly drained in wet weather, and that a permanent source of brine at least 2° Beaumé in density is at hand, the first thing to do is to cut about for a brine reservoir, if one can be had. It often happens that an arm of an estuary, an inlet or a steep basin, can be banked off and isolated so as to form a reservoir of strong brine. It will make an enormous difference in the produce of the salt-pans if this can be done early in the season. This year Mr. Cammude succeeded, by enclosing a small branch of the Ervand estuary at a trifling cost, in raising his brine supply from 2° to 6° Beaumé in the course of three months. Brine at 6° Beaumé contains three times as much salt as 2° Beaumé, and three times the amount can be manufactured from it in an equal time.

5. The next step is to protect the site from inundation by surrounding it with a sufficient embankment. It is impossible to state here exactly what amount of embankment will meet the various requirements of different localities. The object is to protect the works from the highest floods which may threaten them. In the south of France the works I visited were protected beyond the level of the highest flood there recorded, and I would strongly recommend the precaution of a scientific and practical people for general adoption. The earth used in the formation of the embankment is usually taken in such a way as to excavate a canal surrounding the works, and this canal, which is very generally used for storing brine, is cut within the embankment, or rather the earth for the embankment is thrown up on its outer edge. It is most important to press forward this work, having regard to the short duration of the

away, be carried out in consultation with an independent body to set the contractors to work, next study

not obtain a footing in new sites, they should be distributed in proportion to the area of the old sites, so that the number of plants per acre should be equal to one-fourth of the whole.

It will sometimes happen that the lower part of the site is the furthest from the road, and the upper part will become

whereas, it will be found cheaper and more convenient to supply the first solution

the construction of the beds and platforms, the next

2. The condenser also has a drain for returning the lubricating oil source to the first condenser. Should

and it is relatively homogeneous, a case could be made for a uniform rate of flow.

Here also the services of an Engineer are required.

to the judgment of an Engineer on the spot.

be about Rupees 100 per acre. The canal sluice-gate should be in a masonry frame.

work

also used after heavy showers to collect the surplus brine from the salt-baths.

condensates are made in a different way, and are designed to prevent leakage.

17. Completely encircling the salt works forming the outer wall of the condensers and salt-beds, a trench over a foot in width should be dug down until it reaches into the moist clay below the level of cracks in the soil. In this trench good stiff clay should be placed and puddled and moulded upwards, forming an impermeable wall surrounding the works, of the height required for the condensers. This is a practical expedient of the greatest importance in preventing leakage. In clay salt works the leakage is nearly always circumferential. Clay itself does not leak unless it is cracked. A section of yellow Ender clay, containing when air-dried 6 per cent. of moisture and air-dried 81.14 per cent. of sand, half an inch in thickness, supported one inch of brine for several days, until it slowly evaporated in my room. There was no leakage, and I found that ochraceous clay behaved in this respect quite as well as greasy-looking, black, carbonaceous clay, containing only 75 per cent. of sand.

18. The sides of the partition walls, as well as of the marginal wall, should be sloped to an angle of  $45^\circ$ . This is important, and coolies will not attend to it unless they are closely looked after. They make the beds vertical, or nearly so, and the consequence is they are gradually frayed away by the waves. The condensers should communicate one with the other at the most dependent part, and the inlet and outlet openings should be as far asunder as possible. The openings should be made in the first instance too small, and afterwards gradually enlarged to the size which will be found by experience to regulate properly the flow of brine. Vegetation should be encouraged as much as possible on the mural and condenser embankments.

19. Since rain-water is much lighter than evaporated brine, I thought that cuttings at the brine level in the salt-beds and finishing condensers would be of service in carrying it off during and after showers. Rain rests on the surface of the sea, which is comparatively of little density. From experiments made this year I find that cuttings do good where the brine to be protected is strong and deep, at least six inches in depth. Shallower strata of brine are on the contrary beaten up and carried off mechanically by the heavy rains of this country. Cuttings may be of use then on the deeper sides of finishing condensers and deeply-irrigated salt-beds. More were simply gins cut up the clay embankments.

20. When the impermeable wall, as here described, surrounding the works, the condenser floors need not be in any way protected from leakage. There will be at first great loss from leakage. Brine will sink down through cracks in the soil, through sand-drifts, &c., until it reaches the moist, impermeable clay beneath; it will then spread out until arrested by the enclosing wall, and then there will be no further loss unless caused by crabs. Crabs will have to be carefully watched for, and the wall protected against their incursions.

21. Three kinds of crabs may be expected to attack the works. The first is (after Cuvier) a species of *Decapoda* or swimming crab. It makes a tunnel about two inches in diameter from the surface down to the surface. It is seldom found further than fifty yards from the shore, and will take fresh air if much interested with. The second species is the *Calappa* crab, or common calling crab. It burrows in the soil within a distance of twelve yards or so from the shore, and its burrow to the surface is about a quarter of an inch in diameter. It is easily killed and will desert the place promptly when the brine reaches a density equal to 28° Beaumé. The third and worst variety is a small *Decapoda*, having a quadrilateral dark blue or black carapace, less than an inch in length and width. This crab is very numerous everywhere in some localities. It makes the salt-beds with burrows half an inch in diameter, which it reopens as often as they are closed. No artificial condensers in which the brine is not more than 28° Beaumé in density, and is very difficult to get rid of. It may be dislodged, however, if the hole is blocked up every day for a couple of months.

22. When the condensers are finished and filled, it will be time to commence making the salt-beds. Nothing is gained by beginning them earlier, as they require to be irrigated at once as soon as they are ready for work, otherwise they crack and spoil, and until the brine has stood on the embankment for some time and evaporated to the proper density, there is none where with to irrigate them. To immerse the beds in the sea will ruin them. When brine and fresh

water filter through the prepared clay-bed floors soften and unfit them for use. This is evidenced by the softening of the beds after a heavy shower of rain has diluted the brine in them. I proved it to be the case experimentally also by filtering equal portions of fresh water, sea water, and brine at 28° Beaumé through a stratum of mixed clay and sand. Fresh water and sea water took about the same time to percolate through; if any thing, the sea water soaked through the quickest. The brine at 28° Beaumé, specific gravity 1.238, took three times as long as the others. Although 23 per cent. heavier, only one-third of it escaped in the time taken by water to pass completely through. This shows that brine loses in fluidity much more than it gains in weight. These experiments were made and remade on the same days in my own room, away from disturbing influences.

23. As the salt-beds are to occupy the lowest ground, their arrangement in rows, blocks, &c., will be controlled by the shape of that ground. A very convenient size for the beds is forty yards long by twenty yards broad. In cutting them out care should be taken that all the angles are right angles, otherwise the beds will be of unequal areas, and coolies will not attend to this. Pathways elevated six inches from the bed floors, three feet broad on top and four at the base, should surround and form, with the necessary channels, the boundary walls of the beds. Their sides will be, in this way, six inches high and sloped to an angle of  $45^\circ$ . These paths should be well and firmly made, and thickly strewn with sand. Less than an inch and a quarter of clay taken from the surface of each bed will form the paths which surround it. Where beds adjoin and the pathways are common to both, less than three-quarters of an inch from each will be required.

24. The feeding channel for the conveyance of saturated brine from the last condenser to the salt-beds must not be lost sight of when forming the latter. It will follow the slope of the ground from the highest to the lowest level. It is a common mistake to make this channel too small. It should be large enough when single to pour one inch of brine over the whole area of the salt-beds in a short space of time; but where, as will generally happen, it will be found practicable to make more than one feeding channel from the last condenser to the beds, each should be capable of irrigating the beds it is destined to supply within an hour at most.

25. The next and most important prelude to manufacture is the practical work of making the salt-beds. It may be set down as an axiom that, as salt has been hitherto scraped in this Presidency, good clean salt cannot be obtained from clay beds unless the latter are frequently repaired at a very serious loss of time, money, and even salt. It takes about eighteen days to make the beds in the first instance. After four scrapings, that is to say in about twenty days, the surface of the bed becomes a perfect slough of mud and salt crystals, and it has to be remade. This takes about a week, and so on after every third or fourth scraping the bed has to be again remade, so that about one week in every month of the salt season is lost from this cause alone. In addition the bed has to be remade after heavy rains. This is not all. The third and fourth scrapings yield dirty salt, scraped from a partially-softened bed, and a good portion of the fourth scraping, I should say from experience quite 30 per cent., sinks into the mud and is lost. Besides, extra expenditure has to be incurred for extra labor to rework the beds.

26. Considering that artificially-made beds of permanent materials, notwithstanding their initial expense, would be cheaper in the long run than clay beds, I made some small experiments with such materials as I could collect at Ender at a late period of the past season. The desideratum is a bed that will stand the wear and tear of being walked upon, scraped and flooded with fresh water and strong brine for a few years. Such a bed will always yield clean salt. It will yield all the salt in the brine with which it is irrigated. It will, weather permitting, always be at work, and it will cost nothing to remake or repair. How far my experiments may have advanced the solution of this problem may be judged from a consideration of my notes regarding them to be furnished further on in this report. To avoid encumbering the portion of my subject I will merely say that I am not yet in a position to recommend the adoption on a large scale of any artificial material for salt-beds.

27. The process of making clay salt-beds is as follows:—1st, remove all vegetation and

level the ground; 2d, if the soil is very hard, dry and fissured, dig up about a foot in depth all over it and break up the clods; 3d, let it be with brine as will reduce the floor of the bed to a depth of six inches, to the consistency of soft mud; 4th, tread and puddle it under foot until it is so dry that the foot ceases to make an impression on it; 5th, let it set and harden until it shows signs of cracking; 6th, irrigate it with sufficient brine to test the levels accurately and shovel it; 7th, puddle it under foot until it is again dry and firm; 8th, sand it with fine sand and dunmice or roll it well; 9th, let it rest and harden in the sun, watering the surface from time to time to prevent cracks until cracking can no longer be avoided. The bed is then ready, and should be irrigated at once before cracks actually develop.

28. The foregoing process takes eighteen days more or less according to the weather. The natives of this coast make it a point invariably to dig up the surface of salt beds which are being laid out for the first time, irrespective of the condition of the soil. This is not necessary where the soil is well soil and free from cracks as I have satisfactorily established by experiments both on a large scale and in the laboratory, and as the practice is one involving considerable expense, it is well to know when to avoid it. A watering pot with a fine rose will be found very useful for watering the bed and preventing surface cracks in the last or hardening stage. Rolling the beds as a substitute for dunmicing was tried during the past season at Mr. Cammudo's works and found to fail. A very heavy roller was, however, used, about three times as heavy as that in use in the south of France. I believe myself, from what I saw of this experiment, that a broad, light garden roller might be substituted for the dunmice in the eighth stage of bed making with the greatest advantage. The beds during the eighth stage should be sanded with fine sand, just sufficiently to prevent the laborer's feet and the dunmice or the roller from sticking to the earth. From experiments made this year with sand both large grained and small, it was found that the more sand was worked into the surface of the bed and the finer it was in grain, the greater the bed disintegrated.

29. Having thus made the bed, it must be divided by small clay partitions, one down the center and two across into six equal and continuous compartments. The object of this is simply to break wind waves on the surface of the brine to obtain as much rest as possible for the process of crystal formation. It has been found practically impossible to protect the beds from wind. Mud walls and palm-leaf fences, barriers were tried both by Mr. Cammudo and myself, and found to do more harm than good. By using these clay breakwaters and very shallow partitions of concentrated brine, I have, however, succeeded in obtaining even on the windward side a sufficiently tranquil surface for the formation of good salt crystals. It is well, where the clay bed is directly irrigated, to peg down about a square yard of planking in front of the irrigation opening to prevent the bed from being cut up by the influx of brine.

30. I will suppose that the beds are finished, and that the brine in the last condenser reaches its saturation. The question, what system of manufacture to adopt? now presses for decision. The native system, which consists in scraping up small quantities of salt at frequent intervals, is wholly unsuited in my opinion to dry works. It results in the manufacture of dirt salt, and even at that, there is, as I have shown, great loss of time, money, and salt. The French system, which is the reverse of the native and is the opposite pole of manufacturing systems, is easily adaptable. It consists in leaving the salt to crystallize from a considerable depth of saturated brine continuously for a period of three months, when it is removed at one harvesting in blocks. Our climate, it is needless to say, does not lend itself to this system. Few people in this country would risk all or anything on the chance of even one month without a tropical shower. At any rate, the hazard attending it puts it out of consideration.

31. I believe that somewhere between these two systems that which is best adapted to the climate and soil of this Presidency will be found. A most important indication is to obtain the salt with as little disturbance of its crystal as possible. Keeping this in view, it must not be exposed to a storm on the windward side, nor must it be left too long, lest rain destroy it. My

experience suggests, all things considered, a fortnight as the most suitable interval for salt scraping, but of course a great deal would depend upon the weather. Adopting then an increased interval from the French, in all things else we must follow the native track. Deep irrigations are not suited to our coasts. The violent and regular trade winds, and land and sea breezes, which blow throughout the salt season, shunt up such irrigation in a way to frustrate proper crystallization. Shallow irrigations, not deeper than one inch, on the other hand, preserve a tranquil surface in ordinary winds, partly because the fluidity of saturated brine is considerably diminished, and partly because the wind cannot get a grip on shallow strata of heavy brine, and excellent crystals are the result. These suggestions point to a modified accretion system, abbreviated from that of Merkanum, as being the best adapted to our circumstances.

32. Whether to lift the salt off its clay bed with trowels, to scrape it off with boards, or to provide a bed of sand on top of the clay for its special support and to prevent disturbance of the clay? is a further question which results from the adoption of the system of manufacture sketched above. Ordinarily speaking, at the end of every fortnight there will be a salt cake about three-quarters of an inch in thickness to remove. Whether it is scraped up or lifted off it will cling to the clay, and both the surface of the bed and the purity of the salt will be impaired. An experiment that I made with sand during the past season was brought to a premature end by the rains, but I saw enough to gather hope from it and to recommend it for further trial. I made a salt bed in the way described at paragraph 27 and let it harden. I then covered it with two inches of sand, and irrigated it until the sand was covered with half an inch of saturated brine. Excellent salt crystals were deposited from the brine on the surface of the sand, but before the bed could be irrigated a second time rain swamped it. I anticipate that salt cakes could be lifted off the sand without in the least disturbing the clay bed, and also that by gathering them in the wet, as is the present custom, the sand would wash off. In the adoption of these two expedients, harvesting seldom and lifting the salt carefully from an intermediate sand bed, I think we have the best available solution of the problem how to get clean salt uninterruptedly from earthworks.

33. A not unimportant advantage attending the use of sand as described is that the planking usually pinned down in front of the irrigation opening to prevent the prepared clay from being scooped into ruts by the rush of brine may be altogether dispensed with, as the sand takes the force of the waters and is driven into grooves, which can be smoothed down as soon as the brine settles.

34. Now as to the proper conduct of manufacture, I believe myself that the best salt is formed in this country from thin sheets of brine never allowed to exceed half an inch in thickness and 27° Beaume in density, renewed from time to time as may be required, according to the weather. Of course I mean half an inch reckoning from the surface of the sand, or of the salt cake when it forms. These very thin sheets of brine are scarcely at all affected by the wind, and by keeping their density low, crystallization is not hurried. To maintain this arrangement the density of the fresh irrigation will very soon have to be reduced below 25° Beaume, or else 25° + 25° for example will give at once 20°, causing salt to fall too rapidly, and 27° will be reached again too soon, necessitating frequent renewals of brine.

35. As the season advances the residual salts contained in the mother liquor will begin to exercise a potent influence in expediting the separation of sodium chloride from the brine, and this action will be easily recognizable by the altered condition of crystallization. Directly, therefore, the salt crystals begin to lose in regularity of size and shape, before small, hollow, and thick forms actually appear, the fresh irrigations must be still further reduced in density, and the prepared brine maintained uniformly at 20° Beaume and afterwards even at 20° Beaume if necessary. If this be attended to with care, I do not think it will be necessary to remove the brine at all during the ordinary four months crystallizing season. It would be a great saving of power, of time, and of expense if they could be retained. In the south of France, using irrigations about a foot deep, never allowed to be 20° Beaume, the mother liquors are retained

during the whole process, that is for about three months, until the salt cakes are ready to gather, when they are drained off. But if in the system sketched, notwithstanding the precautions taken, crystallization begins to deteriorate manifestly, a sign which precedes actual magnesian adulteration, the beds must be filled to overflowing with the weakest brine procurable, which should be agitated for an hour or so, and then drained off as completely as possible. That this operation, if it be needed, will injuriously affect the beds, is almost certain.

35. Manufacturing in this way, the condensers will not be called upon to raise brine to 25° Beaumé during a great part of the season. They need not, therefore, be as large as they would otherwise have to be. Theoretically, the proportion of condensers to salt-beds to provide the latter continuously with sea water condensed 25° Beaumé should be 5 to 1; but because the condensers get nearly one month's start, and because the residual salt in the bitterns by forcing out salt in the beds supply the place of condensation, they need not, in the system sketched, be nearly so large. The proportion I have provided 3 to 1 I have practically found to be sufficient. This is a clear gain to the manufacturer. He has one-fourth of his ground turning out salt instead of one-sixth. Scraping salt as the natives do, a condensing proportion of 3 to 1 is likewise enough, but only because the beds soften and are thrown out of work, there is no gain in this; it involves a real loss.

36. The best time to gather the salt is in the early afternoon, when the sun is at its hottest, directly the coolies have finished their midday meal. At that time there is the least chance of the salt being adulterated with magnesian sulphate, which is much more soluble in warm than in cold water. The salt cakes when lifted from the sand readily break up. They should be placed in baskets ranged along the pathways, and there left to drain till sundown, when the salt should be carried off and stored. This will necessitate a large number of baskets, but baskets are cheap, and it will be found a real economy to provide them abundantly. The natives use a certain amount of salt each scraping, a large quantity at the end of the season, through heaping it on muddy pathways; and what they do carry away is more or less soiled. The fresh irrigation should always be let on to the beds as the salt is being gathered, partly with a view to wash it, but more especially to dilute the magnesian channels in the mother liquors.

37. Two or three hours' draining at the bedside, and the constant drainage in a well-constructed store shed off from atmospheric moisture, will probably dry the salt better than two or three days' exposure on the ridges. If, as I have made as described, it will not contain any magnesian sulphate except that in the bitterns inevitably in contact with it, and this will drain away in time. If exposed in the open, apart from the chance of its being smuggled away, magnesian sulphate will dry on it in the heat of the day, and reabsorb moisture at other times. According to Mr. Pascoe's report our atmosphere contains about 70 per cent. of moisture during the hot season, and all ordinary salt must suffer from exposure to this. Natives leave their heaps exposed, apparently through carelessness, and after all it is to their advantage to do so, since the heaps catch moisture and gain in weight.

38. The salt should be stored on grooved double-inclined planes within the walled enclosure on the platforms. The roof of each heap should be raised up to an acute or gable angle as is represented with the canvas, for the coverings have been proved to be in every respect the best. Here the salt should be allowed to drain on the platform, for at least three months before being sold.

39. Government has hitherto bought fresh made salt and sold it after its moisture has drained away through wholesale dealers at a net cost for loss of weight. This is hardly fair. A certain percentage for moisture should be deducted from the price paid, or else manufacturers should be compelled to take such ordinary precautions as are described for supplying it dry. When the present native contract is most inferior article must be accepted, and this is I think a very unpropitious precedent giving large contracts to Europeans. If the European merchants who are desirous to do so, are allowed to manufacture and repurchase wholesale their own salt, this

5 per cent. discount will be entirely saved. What the discount loss throughout the Presidency amounts to, I don't know. Last year it was Rupees 1,12,080 at the Madras Kotahs alone.

40. Allowing for irrigation purposes one cooly to every five salt-beds, a salt work of 50 acres will require about fifteen permanent coolies in addition to the men in charge of the pumping machinery. At harvesting time extra coolies will have to be employed to carry off and store the salt. In France skilled workmen on the establishment gather the salt from the beds, contractors take it to the platforms and heap it. An allowance of one salt cooly to five beds will not admit of this being done, but it will give sufficient skilled superintendence to the work. At 3 garces per acre per mensem, there will be every fortnight 75 garces to get into store. About 300 coolies will be required to store this in the course of a single afternoon. If 300 coolies are not procurable in the neighborhood, the arrangements sketched will have to be modified, a larger number of permanent coolies employed, beds scraped on different days, &c.

41. I think I have written enough now to enable any one to lay out and work a salt manufactory as well as can be done in the present state of our knowledge. The arrangements sketched are confessedly imperfect in one very important detail—the stability and permanence of the salt-beds—upon which every thing else depends, and for this reason I have not entered upon the question of cost. The very low estimate of the cost of salt manufacture which I formed in 1872, and published in my first report, was based upon the assumption that the continuance of manufacture depended solely on the weather. Experience has since taught me that this is not the case; it depends also, and to an equal extent, on the stability of the salt-beds. Under the circumstances I would prefer to postpone the consideration of this subject until I had practical experience of clay works on a large scale; but inasmuch as several merchants have lately written to me asking for information on this point, and expressing their willingness to embark capital in salt manufacture, I think I ought to make a few remarks as to its probable cost.

42. I will assume that we have to deal with a plot of 50 acres, though the larger the site the better. The embankments, platforms, supply canals, masonry works, pathways, and condensers, inasmuch as they endure practically for ever, are a sort of real estate, and salt manufacture is only chargeable with the interest on the capital sunk in them. Government has hitherto undertaken the construction and maintenance of the first four items, incomparably the most expensive. Whether this assistance, which has been invariably given to natives, will be extended to Europeans is a question. The fact that, under existing rules, Government retains to itself the power of closing the salt pans without compensation would, I suppose, affect the decision of this question. Machinery likewise being of a permanent nature, the interest on its cost would alone be debited to the salt. Now it is simply impossible for me to make a correct estimate of the outlay on these works; it will depend so much on the figure or shape of the area and on the levels, but any one who has a mind to manufacture salt can select a site and calculate the cost for himself. The annual charge for repairs will be less than Rupees 30 an acre, or Rupees 1,500. The monthly expenditure on labor will be less than Rupees 200, or in four months Rupees 800. The total annual outlay will thus be less than Rupees 2,300. The produce will be at the rate of 3 garces an acre a month for four months, that is 600 garces at the end of the season, which valued at Rupees 12 gives Rupees 7,200. Deducting the annual outlay we have Rs. 4,900 profit balance to set against the capital invested. A fair practical knowledge of the amount of capital invested may be had by examining the accounts of the Sevandakulam pans opened last October near Indrapur. The area of the Sevandakulam swamp was 81.74 acres. It was surrounded by a very embankment and a deep canal; another canal about half a mile in length was cut to supply it with sea water; a bridge, shore-race, and pathways, &c. were built. In fact it was provided with every requirement for a salt station at a cost of Rupees 18,733-11-9. Supposing that only 50 acres are worked out as much, we have Rupees 4,900 interest on a capital of Rupees 12,733-11-9, which at the rate

of 35 per cent. If Government undertook half the cost of permanent works, the manufacturer would get 70 per cent. on his money, and Government would yet escape half the expenditure which ordinarily devolves upon it. If the manufacturer were led, as natives now do, within Government enclosure, he would get Rs. 7,200 interest on Rs. 2,500 expended. This is a small matter no doubt, but there is no reason why a firm or a company should not work hundreds of acres as they do in France. By way of checking the foregoing, I may state that at a rate of evaporation equal to one-third of an inch per diem, and supposing that only 2 per cent. of the 2.6 per cent. of sodium chloride contained in common sea water was crystallised out, we should get 932 gallons of salt from 50 acres in four months, valued at Rs. 11,184. At Sevandakolam in the first season, although all of the site was not cultivated for salt, and work began very late, 377 gallons of salt were produced. It should be stated that with a condensing reservoir containing brine at 0° Beaumé, we should get double the quantity of salt obtainable from sea water, and that with subsoil brine at 12° Beaumé we should get four times the amount, and these conditions of brine are often met with in practice. Mr. Cammells had brine at 6° Beaumé in his reservoir this season, and a reference to my salt-works reports will show that at many places subsoil brine from 0° to 12° Beaumé is abundantly used in manufacture. At one place, Velandiam, in the Tanjore District, the brine in the wells sometimes registers 25° Beaumé, showing that it is saturated with salt.

44. It will be evident from what has been said that the quality and condition of the salt beds is a matter of vital importance in salt manufacturing. Whilst at Buncce this year I tried with six different compounds to make artificial salt-beds which would satisfy the requirements of manufacture in the country. The first bed was made with bricks laid down on a clay flooring, prepared as in paragraph 27, and covered with shell lime cement, finished off in the way that varanah, Roosa, and masonry baths are commonly finished. This bed was given out on a tract and completed at the rate of 4 Annas 3 Pies a square yard. It was scraped for salt from the beginning of August until the end of September, during which period it was scraped ten times. It was not hot, and salt was scraped up freely with great ease, and it was of unpassable quality. But after the third or fourth scraping, the surface became so rough, and towards the end of the experiment it was beginning to break away in patches. I was not favorably impressed by the behavior of this bed, but on the other hand it was got ready during the prevalence of showery weather, and was not, therefore, at any time, a first-class one. Its area was 76 square yards. It cost Rupees 20.

45. The next bed was made with a quarter of an inch in thickness of Portland cement, finished with a thick "jelly" foundation, laid down on a prepared clay site. It cost Rs. 1.3-8 a square yard, particulars as under:—

|                             | Rs. | A. | P. |
|-----------------------------|-----|----|----|
| Portland cement             | 16  | 14 | 0  |
| Carriage, that is cart-hire | 0   | 10 | 0  |
| Making the bed.             |     |    |    |
| Carrying the cement         | 0   | 8  | 0  |
| Bricks                      | 1   | 8  | 0  |
| Carrying bricks             | 0   | 8  | 6  |
| Do. sand and water          | 0   | 6  | 0  |
|                             | 2   | 14 | 0  |
| Total                       | 20  | 6  | 0  |

This bed was under observation for a little more than a month during which period it was scraped seven or eight times. It gave the maker a fair trial, and did not at the end of the season show any signs of wear. Area 154 square yards.

46. The third bed was made by floating over a similar foundation half an inch thickness of General Morgan's patent hydraulic cement. It cost 11 Annas 2 Pies a square yard, as per account:—

|                                 | Rs. | A. | P. |
|---------------------------------|-----|----|----|
| General Morgan's cement         | 12  | 8  | 6  |
| Carriage, that is cart-hire     | 2   | 8  | 6  |
| Making the bed.                 |     |    |    |
| Carrying cement to the bed      | 0   | 10 | 0  |
| Bricks                          | 1   | 12 | 0  |
| Carrying brick, sand, and water | 0   | 12 | 0  |
| Cooly women                     | 0   | 10 | 0  |
|                                 | 3   | 12 | 0  |
| Total                           | 19  | 13 | 0  |

This bed was also at work for about a month, and was scraped six or seven times. It gave a slightly pinkish tinge to the salt, and showed considerable signs of wear at the end of the experiment. It does not seem to be well adapted to salt works. Area 28 square yards.

47. The fourth bed was formed of artificial stone made with magnesite on the French plan, as follows:—Magnesite or magnesian carbonate was calcined in a kiln just as calcite or marble is to drive off the carbonic acid. It was then mixed with half its bulk of coarse sand and spread out to a thickness of half an inch on a "jelly" foundation similar to that in the other beds. It was then submerged in mother liquor at 25° Beaumé taken from an adjoining bed, and allowed to rest until it hardened, which took about twenty-four hours. The theory of the process is this. Magnesite is reduced by heat to magnesian oxide. This is mixed with coarse sand to any shape required, and thoroughly drenched with a strong solution of magnesian chloride, such as the mother liquor of salt manufacture: the magnesian oxide and chloride combine to form magnesian oxy-chloride, which crystallising compacts the mixture into a hard firm stone. This bed cost 6 Annas 5 Pies per square yard as per account subjoined. Area 16 square yards:—

|                              | Rs. | A. | P. | Rs. | A. | P. |
|------------------------------|-----|----|----|-----|----|----|
| Railway charge               | 4   | 4  | 0  |     |    |    |
| Cart-hire to Chinnam factory | 0   | 6  | 0  |     |    |    |
| Boat-hire                    | 0   | 10 | 0  |     |    |    |
|                              |     |    |    | 5   | 4  | 0  |
| Making the bed.              |     |    |    |     |    |    |
| Bricks                       | 0   | 12 | 0  |     |    |    |
| Carrying bricks              | 0   | 3  | 0  |     |    |    |
| Do. sand and water           | 0   | 3  | 0  |     |    |    |
|                              |     |    |    | 3   | 2  | 6  |
| Total                        |     |    |    | 8   | 6  | 6  |

The great hopes of this magnesite bed, and have faith in it still, although this particular bed reported upon was decidedly softening towards the close of the month it was to use. But this bed was made with brine at 25° Beaumé, whereas it should have been made with brine at 28° Beaumé, which makes all the difference, inasmuch as the latter is a strong solution of magnesian chloride and the former is not, so that the conditions for the manufacture of artificial

stone were not in the case fulfilled. Brim at 38° Brim was not procurable in July owing to the rains. Perfectly pure magnesite can be obtained in abundance in the neighborhood of the Salem Railway Station, and I would recommend this rock for further trial. The construction of this bed might be cheapened by burning the magnesite at Salem before sending it by rail to Madras.

48. The fifth bed was made with gypsum. Globular fibrous crystals of gypsum are to be found in the soil about many salt stations. In fact calcareous plate is contained in sea water, and gypsum is a bye-product of salt manufacture. I drew attention to the presence of gypsum at the Channarayana Salt pans, South Arcot, and I had that similar crystals are plentiful at Ennore. At 275° Fahrenheit gypsum abandons its water and changes into anhydrous, often called plaster of Paris, which again on the addition of water readily recrystallises into a solid mass. Such is the explanation of its action. Inasmuch as gypsum, if heated to redness, melts and changes into anhydrite, which will not take up water, I had to burn the crystals in chuties under my personal supervision, and the resulting anhydrite was ground to powder, in detail, in stone mortars. The expense of preparation was in consequence very great, greater than that of producing the material. In practice this would not be the case, and the cost per square yard would be very much less than it is shown in the following account. Area 15 square yards:—

|                                 | Rs. A. P. |
|---------------------------------|-----------|
| Gypsum .....                    | 8 14 0    |
| <i>Making the bed.</i>          |           |
| Preparing gypsum .....          | 1 8 0     |
| Bricks .....                    | 0 12 0    |
| Carrying bricks and water ..... | 0 7 0     |
|                                 | <hr/>     |
| Total .....                     | 9 0 0     |

Had an inch in thickness of the anhydrous powder was spread over the brick concrete bed as in the last case and watered. It set with such rapidity that in ten minutes the coolies walked upon it, but I found that the upper surface in crystallising had in many places formed a crust, which prevented water from percolating through the whole thickness of the material, and these crusts subsequently breaking spoiled the bed. The powder should have been first thoroughly mixed into a paste of plaster with water and then laid down. Knowing how quickly it set, I did not think my coolies could do this and lay it level and smooth in time. Further experience of this material for salt beds is desirable.

|      |      |
|------|------|
| C.S. | 7530 |
| R.D. | 1877 |
| C.S. | 7531 |
| C.S. | 1878 |
| C.S. | 1879 |
| C.S. | 1880 |

49. The sixth and last bed was made with hydraulic cement of my own design, containing 50 per cent more lime and Portland cement, manufactured at the Government Kilns with Rangoon carbonaceous clay, containing 25 per cent of sand, supplied by me. The Superintendent, Northern Range, states that it was made in the following manner:—

The clay was broken up into cubes of about half an inch, dried, weighed, and ground, to which was then added one and a half times the weight of sieved sand lime and thoroughly mixed. This mixture was then made into a thick paste, ground in a mill, made up into balls of about three inches in diameter, dried, burnt, and then ground into a fine powder. This bed was 18 inches thick, and was made of material from Rangoon to and from the Government Kilns, Madras, as per estimate. Area 15 square yards.

|                                            | Rs. A. P. | Rs. A. P. |
|--------------------------------------------|-----------|-----------|
| Digging clay and boat-hire to Madras ..... | 2 6 0     |           |
| Boat-hire from Madras .....                | 1 4 0     |           |
|                                            | <hr/>     | 3 10 0    |
| Chunnam .....                              |           | 7 0 0     |
| <i>Making the bed.</i>                     |           |           |
| Bricks .....                               | 1 12 0    |           |
| Carrying brick and water .....             | 0 12 0    |           |
| Do. cement .....                           | 0 8 0     |           |
|                                            | <hr/>     | 3 0 0     |
| Total .....                                | 13 10 0   |           |

This hydraulic cement was applied to the formation of a salt-bed precisely in the same way that the Portland cement had been, but it was received so late in the year (1st October) that I was unable to test it in salt manufacture. It formed, however, as far as could be judged, a hard enduring salt-bed. The clay for this bed was sent to the kilns on the 21st of August. Beds of this material could be made for much less than 8 Annas 7 Pies per square yard if the clay and lime were procured and prepared on the spot, as both might be at Ennore for instance.

50. Such, briefly, were the experiments made to determine the possibility of making solid and lasting salt beds. They were not very successful, even as experiments, for reasons connected chiefly with the weather, and, like all first attempts, they are capable of being improved upon. The Portland cement, the hydraulic cement noticed in the last paragraph, and the magnesite seemed to me to offer the best chances of success. One drawback which ran through the whole series of experiments must here be mentioned. The clay walls and paths surrounding the beds were left untouched, and these gradually crumbling away dirtied the beds and allowed water to get under them and soften the clay floorings, so that the beds sank and cracked after they had been abandoned during the north-east monsoon. This shows the necessity of making the sides of the beds as solid as the floors, and of taking measures to prevent the access of water to the clay foundation.

51. Owing to a fear of its costliness I made no experiment with wood as a material for salt beds, although I know it is so used in America, and I have long considered it to be the most suitable substance we possess for the purpose. Planking has many advantages. It could be pegged down so quickly at the beginning of the season, removed and replaced at any time if necessary, and taken up and stored during the monsoon. It is precisely the sort of material we want for a salt flooring, and owing to the antiseptic action of saturated brine which arrests natural decay, it would probably last an indefinite time. Should my connexion with salt manufacture continue through another season, I will give it a trial. I have great hopes of it, and do not think that it would cost more than 1 Rupee a square yard.\*

52. The salt work I laid out at Ennore this year was made solely for the purpose of showing the West Coast Deputy Collectors how to turn an acre of ground to the best advantage. I commenced it on the 19th of May, too late in the season, to look for any profit from it. For this reason, and because the acre model can be applied, by magnifying all its parts proportionately, to the construction of ulums ten times that area, I did not think it advisable to spend money on a larger work. It is a model adapted to small native holdings, devised, in case of

\* In estimating the cost of laying down wood and other materials for salt beds, it must be remembered that the beds with their paths and channels occupy but one-fourth of the whole area. Thus, the work of bed flooring in a 30-acre site would be less than 60,000 square yards.