

REPORTS

CORRESPONDENCE AND ORIGINAL PAPERS

ON

VARIOUS PROFESSIONAL SUBJECTS

CONNECTED WITH THE DUTIES

OF THE

CORPS OF ENGINEERS

MADRAS PRESIDENCY

ARRANGED AND PRINTED FOR PRIVATE CIRCULATION

BY

CAPTAIN J. T. SMITH, F. R. S.

ASSOC. MEM. CIV. ENGRS. INSTITY.

VOL. I.

MADRAS:

PRINTED BY R. W. THORPE AT THE VEPEY MISSION PRESS, OF THE SOCIETY FOR PROMOTING CHRISTIAN
KNOWLEDGE.

1839.

TO

THE RIGHT HONORABLE JOHN LORD ELPHINSTONE G. C. H.

&c. &c. &c.

WHOSE CORDIAL ANXIETY

FOR

THE ENCOURAGEMENT OF EVERY USEFUL UNDERTAKING

AS WELL AS EMINENT STATION

Constitute Him

THE NATURAL HEAD AND PATRON OF THE CORPS

WHOSE LABOURS ARE HERE COMPILED.

THIS VOLUME

IS IN THE NAME OF HIS BROTHER OFFICERS

MOST RESPECTFULLY INSCRIBED

BY HIS OBLIGED

AND

OBEDIENT SERVANT,

THE EDITOR.

P R E F A C E.

The object proposed in the compilation of this volume will be readily acknowledged by every Officer of the Corps to be one of universal and permanent interest—that of providing a record, for the benefit of all, of the experience of its several members, and thus preventing the fruits of costly experience, or anxious study, being lost with the individuals by whose exertions they have been obtained.

It was under this impression, added to the feeling that the establishment of a free communication on scientific subjects would tend to encourage and keep up a more lively interest in our duties, and promote the real efficiency of the Department, that the commencement of a first volume was attempted; and the result of the experiment has I hope been such, as to hold out every encouragement for the future.

The arguments which apply in recommendation of such a work as this in Europe, plead with tenfold force in this country. Cut off as we are, both from examples for imitation, and authorities for reference, the practical Engineer is at this remote distance thrown entirely upon his own resources in regard to every new undertaking; and in the direction of a difficult enterprise, wherein he alone is called upon to supply information, from the most important principles in theory, down to the minutest particulars in detail, must often feel the want of that readiness of invention, or fertility of resource, which can be acquired only in the hackneyed paths of familiar practice and long accustomed routine.

In the absence of a mutual interchange of the experience which each may laboriously acquire on these occasions, and while a record is still wanting of such information as new circumstances give birth to, or new opportunities of observation discover, it cannot fail to be a source of regret to all, that the same obstacles should oppose themselves with fresh hindrance to each in turn, and that each should have to tread the same path of difficulty and doubt, to arrive at the region already explored by the many who have gone before him.

Instead of enlarging the boundaries of our practical knowledge by our united labours, we have, in fact, all to set out from the same point, and toil up the same rugged ascent often mastered before; and the waste of time and opportunities thus lost in the unnecessary acquisition of known truths puts a complete check to the extension of our labours, and damps the energies which might have been devoted to higher and more important research.

The proposition, therefore, which calls upon every individual member of our service to perform his part in a work of this kind, by communicating the results which his opportunities of experience afford, for the benefit of the rest, meets him in the shape of a duty which he owes to his brother Officers, followed by a recompense which he himself reaps in return; whence it may be confidently assumed, that the emulation which prompts each to aim at the most satisfactory discharge of his own peculiar duties, will stimulate him also to lend his aid, to the utmost of his ability, in raising the standard of professional knowledge, by which may be regulated the general efficiency of the Corps.

It will be observed that a change has taken place during the progress of the volume, in the selection which has been made for its contents. In first commencing to print for private circulation, it appeared to me, that it would have been sufficient to have collected together such public documents as would have given a complete history of the undertakings to be described, and would have embodied all the opinions and facts collected respecting it; but on proceeding to carry this into execution, I found, that so much irrelevant matter was thus necessarily included, and the papers were thus rendered so bulky and tedious, that a perseverance in that principle only, would have defeated both the usefulness, as well the interest of the volume.

With the exception of two or three subjects, therefore, that feature of the original plan has been modified by the substitution of papers expressly written for the occasion; and I am glad to have an opportunity of here expressing my sincere thanks to those friends, by whose kind exertions I have been enabled successfully to make a change involving so much additional labour.

An advantage attends this substitution which more especially marks it as the most suitable course for a collection of this kind—an opportunity is thus afforded for the insertion of minor details which it is the chief object of the volume to record; and the minutiae of practical difficulties, with the methods of surmounting them, which, though perhaps not the most interesting, are by far the most useful results of experience, can thus be communicated along with the accounts of the difficulties themselves. It is with a view to the encouragement of such detail, and with the desire also, that the authors should aim more at making their communications practically instructive, than popularly pleasing, that it has been judged expedient to make the present circulation a private one; and thus, while none may be restricted by any fear of deficiency from free contribution, those who have any further objects may still preserve the copy right of their communications, and after subjecting them by this “rehearsal” to the indul-

gent criticism of their brother Officers, make such further use of them as they may afterwards think proper.

In regard to the nature of the papers of which the work ought to consist, one rule only has been assumed, which it is hoped will be found a sufficient guide in all cases; and this is, that the communications submitted shall be the results of real experience, and therefore relate to some work or experiment *actually* executed; by this means it is hoped that the statements submitted will contain a valuable collection of *facts*, and that whatever information may be offered will be free from those delusive errors, which are too apt to pervade mere opinions, however carefully formed.

It has also been considered advisable that no definite periods should be fixed for the successive appearance of different volumes. In fact, the necessary advantages of position and opportunity are too rarely enjoyed by any member of the Corps, and the frequent mutations in our service render the liabilities to deprivation of them too numerous and sudden, to admit of the possibility of any prospective pledge being undertaken or fulfilled; moreover, the unremitted and overwhelming demand which almost all are subject to in their professional labours, leaves to but few the capability of assisting in a work of this nature, except by occasional efforts.

While, however, a desire shall continue to be felt by all for the encouragement of this endeavour towards our mutual improvement, it may be trusted that individual exertions will not be relaxed; and as long as the supply from the original sources shall continue steady and copious, we need not fear that their united streams will ever be long retarded by the want of an appropriate channel.*

J. T. S.

* It is requested that contributions for an ensuing volume may be addressed to the Secretary to the Engineer's Library.

NOTICE.

The Editor is not to be considered responsible for any of the opinions or statements contained in this volume, with the exception of such as may appear under his own signature.

The following papers are not to be published, or used as the materials for publication, without the express permission of their authors.

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APPENDIX A.

General Summary of Vessels of different descriptions that passed the Paumban Channel during the years 1843 and 1844.

1843.									1844.									Total number of vessels for two years.	Total amount of Tonnage for two years.
Steamers.	Barques.	Brigs.	Schooners.	Sloops.	Cutters.	Dhories.	Total.	Total Tonnage.	Steamers.	Barques.	Brigs.	Schooners.	Sloops.	Cutters.	Dhories.	Total.	Total Tonnage.		
2	1	185	201	13	17	1,220	1,639	98,238	2	0	230	263	13	6	1,645	2,159	115,939	3,798	214,177

A correct Statement of export and import duties connected with the Sea Customs at Paumban, during the years 1843 and 1844.

1843.			1844.			1843 and 1844.		
	Rs.	A. P.		Rs.	A. P.		Rs.	A. P.
Export.....	908	2 1	Export.....	1072	6 10	Export for 2 years.....	1980	8 11
Import.....	612	6 2	Import.....	382	3 7	Import.....	994	9 9
Stamp.....	184	4 0	Stamp.....	464	8 0	Stamp.....	684	12 0
Anchorage.....	2405	0 0	Anchorage.....	2824	8 0	Anchorage.....	5229	8 0
Pilotage.....	5677	4 0	Pilotage.....	6402	8 0	Pilotage.....	12,079	12 0
Total Company's Rupees..	9787	0 3	Total Company's Rupees..	11,146	2 5	Total Company's Rupees..	20,933	2 8

Pilot Establishment Per Mensem.

Head Pilot &c. &c. Rupees per month.....	100	0 0
1 Native Head Pilot.....	15	0 0
4 Native Assistant Pilots at 12 each.....	48	0 0
4 Do. do. do. at 10 ..	40	0 0
1 Gomastah @ 7 Rupees per month.....	7	0 0
6 Custom House Peons @ 3½ Rupees per month each.....	21	0 0
For oil, paper, ink &c. &c.....	0	14 0
Total Company's Rupees..	231	14 0

APPENDIX B.

The following are the dates of the sanction received from Government for the charges incurred from the year 1837.

Vide Chief Engrs. letter to Govt. dated 24th December 1840 Page 137.	} Expenses incurred during the year 1837..... Rs.	5,527	15	2				
4th & 6th Jan. 1841. p. 1-10.		Do. do. 1838.....	6,919	5	2	23,308	1	2
Vide letter to Government 2d April 1842		Do. do. 1839.....	10,860	12	10			
Do. do 18th June 1842.		Do. do. 1840.....	14,098	8	0	14,098	8	0
Do. do 10th Jan. 1844.		Do. from December 1840 to October 1841	12,097	3	0	12,097	3	0
Do. do 27th Aug. 1844.		Do. from November 1841 to April 1842.....	4,233	11	5	4,233	11	5
		Do. from July 1842 to February 1843.....	3,987	12	9	3,987	12	9
		Do. for May and June 1842.....	1,153	3	0	1,153	3	0
		Do. from March 1843 to January 1844.....	5,794	3	10	5,794	3	10
	Do. from February 1844 to June 1844.....	3,158	0	8	3,158	0	8	
	Total.....				Rs 67,830	11	10	
<i>The following are the amounts disbursed but not sanctioned.</i>								
	Expenses incurred for July 1844 by the Superintendent.....	878	14	1				
	Do. do. August.....	1,186	2	4				
	Do. do. September.....	525	7	9				
	Do. do. October.....	510	13	2				
	Do. do. November	100	5	0				
	Do. do. December.....	108	10	0				
	Do. do. January 1845.....	119	11	0				
	Do. do. February.....	667	12	10				
	Do. do. March.....	608	3	7				
	Do. do. April.....	415	7	8				
					5,121	7	5	
May 9th.	Cash remaining in the hands of Superintendent.....				349	7	3	
" 6th	Do. Authorized by Government.....				1,000	0	0	
" 27th.	Do. Remaining still to be drawn.....				3,000	0	0	
	Total.....				77,301	10	7	

APPENDIX C.

Commencing January 1841.	Sand and Mud.	Stones.	Coral.	Sand and Shingle.	Cubic feet	REMARKS.
January. - - - - -	27,920	"	"	"	"	
February. - - - - -	20,440	611	"	"	"	
March. - - - - -	5,630	19,939	9,450	4170½	"	
April. - - - - -	"	21,968	14,239	8,983	"	
May. - - - - -	"	5,963	7,829	10,644	"	
June. - - - - -	"	5,355	2,751	12,730	"	
July. - - - - -	"	3,834	12,306	11,983	"	
August. - - - - -	"	9,915	24,819	18,214	"	
September. - - - - -	"	1,988	10,020	28,033	"	
October. - - - - -	"	4,485	7,772	27,394	"	
November. - - - - -	35,988	"	"	"	"	
December. - - - - -	66,423	"	"	"	"	
Total for 1841. - - - - -	156,401	74,058	89,186	122,151½	"	
January 1842. - - - - -	48,073	"	"	"	"	
February. - - - - -	62,484	"	"	"	"	
March. - - - - -	105,070	"	"	"	"	
April. - - - - -	68,622	"	"	"	"	
May. - - - - -	28,352	"	"	"	"	
June. - - - - -	46,456	"	"	"	"	
July. - - - - -	44,052	"	"	"	"	
August. - - - - -	29,088	"	"	61,488	"	
September. - - - - -	78,412	"	"	"	"	
October. - - - - -	88,051	"	"	"	"	
November. - - - - -	81,963	"	"	"	"	
December. - - - - -	93,234	"	"	"	"	
Total for 1842. - - - - -	773,857	"	"	61,488	"	
January 1843. - - - - -	99,534	"	"	"	"	
February. - - - - -	"	"	"	"	"	
March. - - - - -	"	"	"	"	"	
April. - - - - -	"	"	"	"	"	
May. - - - - -	"	"	14,811	"	"	
June. - - - - -	"	"	"	25,584	"	
July. - - - - -	"	"	"	37,410	"	
August. - - - - -	"	3,043	55,917	"	"	
September. - - - - -	"	3,680	51,040	"	"	
October. - - - - -	72,315	2,440	9,891	"	"	
November. - - - - -	94,475	"	"	"	"	
December. - - - - -	52,920	"	"	"	"	
Total for 1843. - - - - -	319,244	9,163	131,659	62,944	"	
January 1844. - - - - -	65,340	"	"	"	"	
February. - - - - -	75,198	"	"	"	"	
March. - - - - -	89,410	"	4,199	"	"	
April. - - - - -	41,392	3,630	5,382	"	"	
May. - - - - -	42,261	2,007	19,951	"	"	
June. - - - - -	43,001	2,984	17,271	"	"	
July. - - - - -	22,842	7,035	18,088	"	"	
August. - - - - -	38,442	7,960	23,512	"	"	
September. - - - - -	36,281	5,569	13,299	"	"	
October. - - - - -	17,650	9,789	"	"	"	
Total for 1844. - - - - -	471,818	44,974	107,712	"	"	
	1,721,319	128,195	328,557	246,633½	2424704½	{ Total in cubic feet of mud, sand, stone, coral sand and shingle excavated in the Paumban channel during the years 1841, 42, 43, and 44.

APPENDIX D.

Nature of soil in channel, commencing at the Buoy,—Marked A.

From A. to B, a distance of 300 yards, the bottom is a coarse sand having detached masses of dead coral (brain coral) in it.

From B. to C. a distance of 100 yards has also coarse sand and masses of dead coral, together with a very hard conglomerate of sand and shells, occurring in masses of from 10 to 20 yards long and broad, and about 3 feet thick, under which there is again coarse red sand.

From C. to D. the bottom is similar to that from B. to C. but in this part some exceedingly hard masses of Madrepore were found, (they are now removed.)

From D. to E. red sand stone grit, 11 to 12½ feet thick—(from 2½ to 4 feet remaining to be cut through.)

From E. to F. Do. Do. Do. Do. Do. Do.

F. to G. fine grained (compact) sand stone, very hard—11 to 12½ feet thick (from 2½ to 4 feet remaining to be removed.)

From G. to H. the same, but having a good deal of shingle over lying it (this has been removed.)

From H. to the end, soft sand stone, lying in layers of about 8 to 10 inches thick, much broken up, and full of fissures filled with sand, pieces of coral, shingle &c.

APPENDIX E.

Method of carrying on the works.

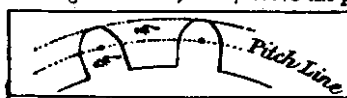
The work in the channel consists of removing sand and mud ; and sand and masses of dead coral, and between the reefs, of blasting and removing sand stone.

A hand dredge of rather a rude construction* worked by prisoners, has been used hitherto for removing the sand and mud, and notwithstanding its many imperfections, it has done a great deal of work ; it cannot be exactly stated what quantity of work is done by it a day, but it may be said on an average to bring up about 1800 cubic feet in a day of 12 hours, worked by two gangs of prisoners, at an expense including 3 boats for removing the soil, (exclusive of prisoners) of Rs. 111 : 9 : 0 per mensem.

There were also two spoon dredges used for removing shingle, but they are now dismantled.

The boulders of coral are first cleared from the circumjacent sand, by working round them with the dredge, when a rope is attached to them by a diver, and from their lightness, they are then easily raised by a common derrick placed in a boat of about 15 tons, called a weighing Dhony—these boats are hired at 6 annas per diem, they generally make one trip a day, the expense of raising the coral is 3 pie a foot for divers (the boat and boatmen are excluded.) When these weighing Dhonies are used for raising the stone blasted out of the reefs, they have a large thick rope net, kept open at top by a hoop attached to the derrick tackle, (the expense of one of these nets is one anna a day), they are filled by the divers who receive 3 pie a foot for filling. For blasting the rock, the holes are bored by jumpers, about 1 inch in diameter, having chissel shaped ends, of about 6 inches broad, tempered with steel—two canoes are lashed together, (forming a jungar) with cross pieces, and the holes are bored by four men, and a diver who guides the end. Sometimes a fifth man is required, it takes from 1½ to 2¼ hours to bore a hole of from 2' 10" to 3' deep, the diver clears out the sand from the hole, and when prepared, inserts the charge of powder for blasting it, he then tamps it by filling up the hole to the top with sand, which he takes down with him in a leather bucket. The charges formerly used were of from 5 to 10 lbs. of powder, inserted in tin cases, with long tin tubes, this was found expensive, and not to answer so well as those now used, which are composed of leather, with bamboo tubes, the leather is formed into a bag, of the diameter of the hole, and sufficiently large to hold from 1 to 2 lbs. of powder, which has been found the best size of charge, (the line of least resistance in feet cubed for the number of ounces of powder), they are made wet, and then filled with sand, when dry the sand is poured out, and the charge filled, a long reed of the bamboo kind, called (Coorukke) is then inserted, which is filled for the priming with coarse powder ground and mixed with conjee water, and rubbed into cotton thread, after this it is carefully bound at the junction of the reed and leather with twine, and served over with country cloth, and dammered, each costs thus prepared, exclusive of powder 6 annas and 1 pice—as follows, skins (sheep) cotton, bees wax, 1 anna and 6 pie, coorukke 2 annas 9 pie, dammer and oil 1 anna 4 pie, country cloth and chatties 1 anna. It has been suggested that a diving bell might be used with advantage. I think perhaps a diving dress might, which would enable the Superintendent to do all that he could with a diving bell, at less trouble and expense, for the currents are so strong, that it could not often be used, moreover the method now used viz. by tying a quantity of boats together, and sounding all across at short distances, and wherever there is a stone or projection, putting down a small buoy, is more speedy, less trouble, and as efficacious a way of ascertaining the nature of the bottom.

* The teeth of the wheels are not properly constructed, the proper way to make the teeth of wheels, is to set off ¼ of the pitch below the pitch line, for the length of tooth, and ¾ above the pitch line thus.



The ladder should be made with three, instead of two longitudinal timbers, and the friction rollers, of much larger diameter, and of cast iron,—the barrel also over which the buckets turn, should be 4 sided, instead of 6 sided, as they are in this, by making them 4 sided the buckets are less likely to slip, and clear themselves better, and the barrel being less, there is more leverage—the wheels and rollers in this are brass, which is a great waste—by selling these, and getting cast iron ones from Porto Novo, a saving would be effected, and a better machine obtained.

DESCRIPTION OF AN ASSORTER'S SCALE, AND WEIGHING MACHINE OF A NEW KIND, CONSTRUCTED FOR THE USE OF THE MADRAS MINT.

BY CAPTAIN J. T. SMITH, F. R. S. F. R. S. N. A. &c. &c. &c.

1. In the peculiar system of adjusting coins to the correct standard weight, which has been practised in the Madras Mint for the last four years, and which will be fully described hereafter, it is necessary that all the pieces on first being cut should be accurately weighed, and separated into classes of equal weight, varying from one another by differences which are suited to the particular description of coin under execution, being for instance, with rupee pieces $\frac{1}{4}$ a grain, and for 2 anna pieces the $\frac{1}{8}$ th of a grain. This operation is required to be done with considerable accuracy, but at the same time with as much expedition as possible, and it has been therefore a matter of great interest to investigate the form of apparatus best adapted to the fulfilment of the necessary conditions; and a number of experiments having been made with that object, the result has been the adoption of the contrivances, which it is the object of the following paper to describe.

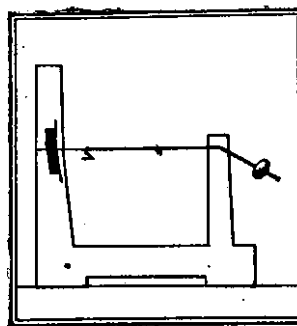
2. On first commencing business, we had no alternative but to use the common hand scales with moveable weights, and the rupee pieces which we were then engaged in fabricating, had to be separated into 12 distinct classes. This as will be readily imagined, was a work requiring no little time and attention, and I was apprehensive at first that mistakes and impediments to business would have ensued, upon the endeavour to separate numerous successive batches of coins into so many classes, by ordinary means; but after a little practice, the steady and experienced sorters soon got into the way of shortening the process, and with very tolerable accuracy avoided the confusion which such a system is liable to; so that in time an expert hand was able in a day of 9 or 10 hours work, to complete the sorting of 1500 pieces; those who were less skilful, smaller numbers, varying from that to 1000.

3. The plan they adopted was, to weigh the whole of a lot approximately first, in a rough and quick manner, and with the use of a single standard weight, separating the pieces into their supposed classes by a guess, founded upon the rapidity and extent of the vibrations with that weight. After this, all the classes were separately gone through, beginning with the "standard" one, and on taking up each class successively adding the fraction necessary to make up the coun-

terpoise to the proper weight, setting aside each piece which was found unsuited to the class it was temporarily placed in, for a fresh examination in whatever other class appeared to suit it.

4. In this manner, whatever skill and judgment the sorter might possess, he could not avoid the necessity of weighing all the pieces twice, and many of them four or five times; and it thus happened, that the same men who, in examining finished coins, against a fixed weight and remedy, could complete 6000 a day, failed to do more than one fourth that number, under the conditions particularised above.

5. The advantages which accompanied the system with which this method of weighing the pieces was connected, were sufficient to overbalance the inconvenience of this peculiarity in the sorting, but we were from the first desirous to diminish it as much as possible. It soon occurred to me to try the bent lever balance, as a means of obviating the repetition of weighings above spoken of, and after one or two experiments we succeeded in contriving a beam of this description which was admirably adapted to our purpose. Our first attempts were however made with a beam of the shape

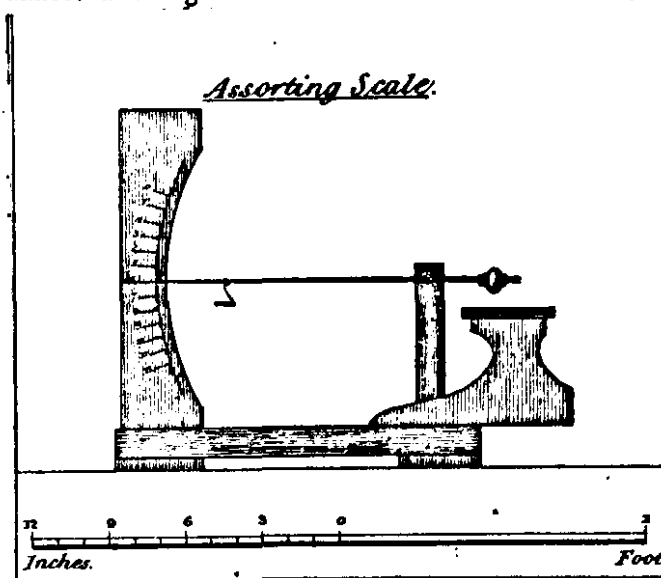


given in the annexed figure, and we were led to abandon the scheme as hopeless, after trial of an instrument of this form, in consequence of finding that for the very minute differences which we had to discriminate, the indications were too small to admit of being practically distinguished with accuracy.

6. It was not till some time after the failure of our first attempt, that I was led to try the influence of the bend of the beam upon the sensibility of the scale, for given differences of weight; or in other words, upon the dimensions of the scale which would indicate given additions to, and subtractions from the standard. This enquiry removed all the difficulties we had previously

experienced, for we immediately discovered, what indeed might have been anticipated from the theory of this instrument, that we had nothing to do but to regulate the scale to suit our convenience, by the easy method of altering the inclination of the two arms, a small angle between the two parts of the beam giving a larger, or very sensible scale, and a larger angle the contrary.

7. The instruments now in use, therefore, for this discriminate sorting are represented by the annexed figure, in which it will be observed that the beam is almost a straight line. The amount of flexure, or



the distance of the centre of suspension above a line $10\frac{1}{2}$ inches long, joining the centre of the counterpoise weight and the suspension point of the pan, being only $\frac{1}{16}$ ths, or about $\frac{1}{16}$ th of an inch. One very great recommendation of them is the great ease with which they are constructed, and the diagram represents one of a number made up in a hurry. The beam is merely a piece of steel forged and filed to the proper shape, and the end tapped to receive the weight, with a couple of adjusting nuts, one in front and one behind it. The stand and scale are made altogether of deal wood, the planks of a rejected packing case, and the centre of suspension is a fine sewing needle.

8. In respect to the suspension just spoken of, it is remarkable that the simplest and easiest of execution proved also to be the best. As it was an important object to make these instruments as accurate as possible, a trial was made of a knife edge suspension, similar to what is used for the most delicate scales, but we were at once met by the difficulty which is inseparable from all accurate weighing of this kind, *viz.* the tendency of the beam to vibrate, and the very great delay occasioned thereby. In the common hand scales which are used for examining finished pieces, and in the use of which the system of weighing is different, this peculiarity forms no objection, because the question required to

be solved by them in regard to each piece, is merely whether it corresponds with the "standard," or not, and the weighing-men or sorters who perform this office, acquire by habit the power of instantaneously judging, by the first movement of the index of the beam, whether the piece is sufficiently true, or otherwise; and if the latter, it is set aside for re-examination against a fresh standard of greater or less weight, corresponding with the utmost deviation, either way, which can be allowed. But in the peculiar method of assortment required by us, wherein not only a knowledge of the truth or error of the blank, but the exact amount of its deviation is sought for, it is evidently necessary to wait till the beam is brought to rest in equilibrio, and this with ordinary instruments, if of delicate construction, would be altogether unsuited to the despatch of business. On this account I found that some retarding agent, such as friction, was indispensable, and after experimenting upon a variety of different means of effecting this, we at last found that a simple needle, passing through a circular hole drilled in the beam, was the most practically useful. With it, the beam was sufficiently sensible to answer all the purposes we required, and it vibrated very little, if at all. In the course of work, in order to bring the index to its point more quickly, and to obviate any error arising from the friction of the pivot, the sorter taps the foot of the stand with the piece next to be tried, and in this way gets through his business with considerable expedition.

9. The extreme simplicity of these instruments has constituted their greatest value for our purposes, for the construction of them is so very easy, that a dozen of them may be made by a carpenter and a blacksmith in two or three days. When finished, the scales are marked off, and the beams adjusted to them by the Superintendent of the sorting department, and before beginning each day's work it is proper to examine each beam by testing it with pieces of the highest and lowest denominations comprised by the scale, to guard against any accidental injury or alteration of the beam.

10. By the adoption of this form of instrument we were enabled very much to simplify our system, and in consequence of this a twofold economy ensued. As the index points at once to the true weight of the piece, it was easy also to make it designate the class to which it belonged; and thus marking off the scale into divisions of classes, instead of weights, we at once freed the operation from a part of its difficulties and chances of error. Accordingly, the divisions were merely distinguished numerically, and all that the sorter has to do in separating pieces (or *disks* as we call them) is to note the number the index points to, and remove the disk to the corresponding division of a series of compartments chalked on the floor close beneath the low table on which the weighing instrument stands, whence they are removed for use by other parties.

11. The operation thus carried on is so intelligible and easy, that the number of disks assorted has been increased from 1500, the greatest number above stated to have been accomplished previously, to 4000, per working day of $8\frac{1}{2}$ hours; and what is of more importance, we have been enabled to employ upon it young apprentice boys, whose salaries are only one half of what it was necessary to pay to experienced weighing men. On our first beginning work the expence of assorting every lac of pieces was upwards of 20 rupees, the pay of each sorter being $7\frac{7}{8}$ rupees per month; but by the introduction of the beam above described, this charge has been reduced to 4 rupees, boys upon that salary being quite competent to do the business, and easily completing a lac of pieces within the month.

12. It will be seen by the description which will be presently given of a mechanism for doing the work of the sorters, that this charge is capable of being further reduced, but before closing the account of these comparatively humble, but most useful little instruments, I must observe, that in the absence of the more elaborate apparatus just alluded to, the Mint has derived the greatest benefit from the use of the bent lever balances, and the whole of the work of the department since September 1842, has been performed by them, with the exception of that of rupee pieces, which, since the construction of the larger machine have been assorted by it.

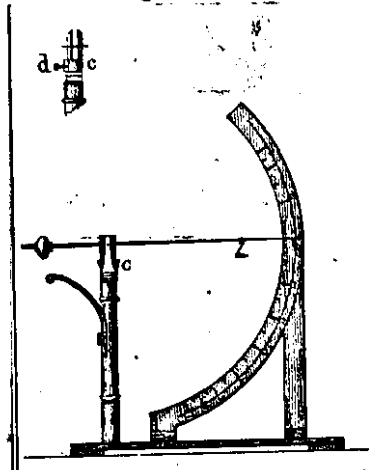
13. As the operation of these instruments is peculiar, they may perhaps be of less interest where the system of manufacture is different from what it is in this Mint.* They are however available for one species of work which is common to all Mints, and may probably be found to be of great advantage in it. I refer to the examination of finished coins previous to issue. I am not quite certain that this duty is always performed elsewhere, but in Madras, not a single piece is issued without examination after stamping, and as the remedies are very small in some coins ($\frac{1}{16}$ ths of a grain in 2 anna pieces), and are rigidly adhered to, it would be impossible to carry on business without it.

14. We have lately made some experiments as to their adaptation to this duty, but have not brought them to a final issue. It was found that a boy could examine 6000 pieces daily with one of these beams, when the object was merely to ascertain whether they were within certain limits or not, but although this result affords a very satisfactory prospect of future success, we have not had sufficient time since the experiment was made to obtain data whereon to speak with certainty. Should the result just mentioned be confirmed on the large scale, the expence would be reduced nearly 50 per cent; the same duty being performed by boys as would be otherwise executed by men on double their

pay. The only doubt which suggests itself as to the general introduction of the plan is, whether in making the alteration, it would not be best at once to proceed to the construction of the larger instrument about to be described, by which the expence would be reduced to the minimum.

15. There is another use for which the bent lever beams are peculiarly suited, and for which they have been exclusively employed in this Mint ever since they were first successfully tried, and this purpose is one in respect to which they will be found equally valuable in all Mints. This is in the examination of the test pieces cut from the straps after the last rolling in the finishing mill, which, as will be readily understood, it is a very great convenience to weigh by an instrument which at once indicates the exact amount of deviation, either way, without the troublesome addition or subtraction of fractional weights.

16. We have found it most conducive to accuracy in rolling, not merely to test the straps by single pieces, but to judge of their average condition by the average weight of three pieces cut out of different parts; and the finishing mill is furnished with a couple of instru-



ments of the accompanying form, finished in brass, one of them supplied with a counterpoise suited to the weight of three pieces, and the other suited to the weight of one. The beam is swung between two cheeks, one of which is moveable round the pillar, which supports the beam, by means of the collar *c* which is fixed by the thumb screw *d*. The needle

is passed through holes drilled through the two cheeks and secured in one by a deal wedge, and in consequence of one of the cheeks being moveable, the needle is easily adjusted to a position exactly at right angles with the plane of the face of the instrument, and the beam can be made to travel at a greater or less distance from the surface of the scale.

17. The same scale suits any description of coin, but a different beam and counterpoise is required for each. It is necessary therefore to have a beam suited to each different description of coins, and to make use of them as required. It is also advisable, upon every occasion of mounting a new beam, to test the accuracy of the scale at its medium and extreme points, to make sure that no change or injury of its shape has occurred, which has affected its accuracy.

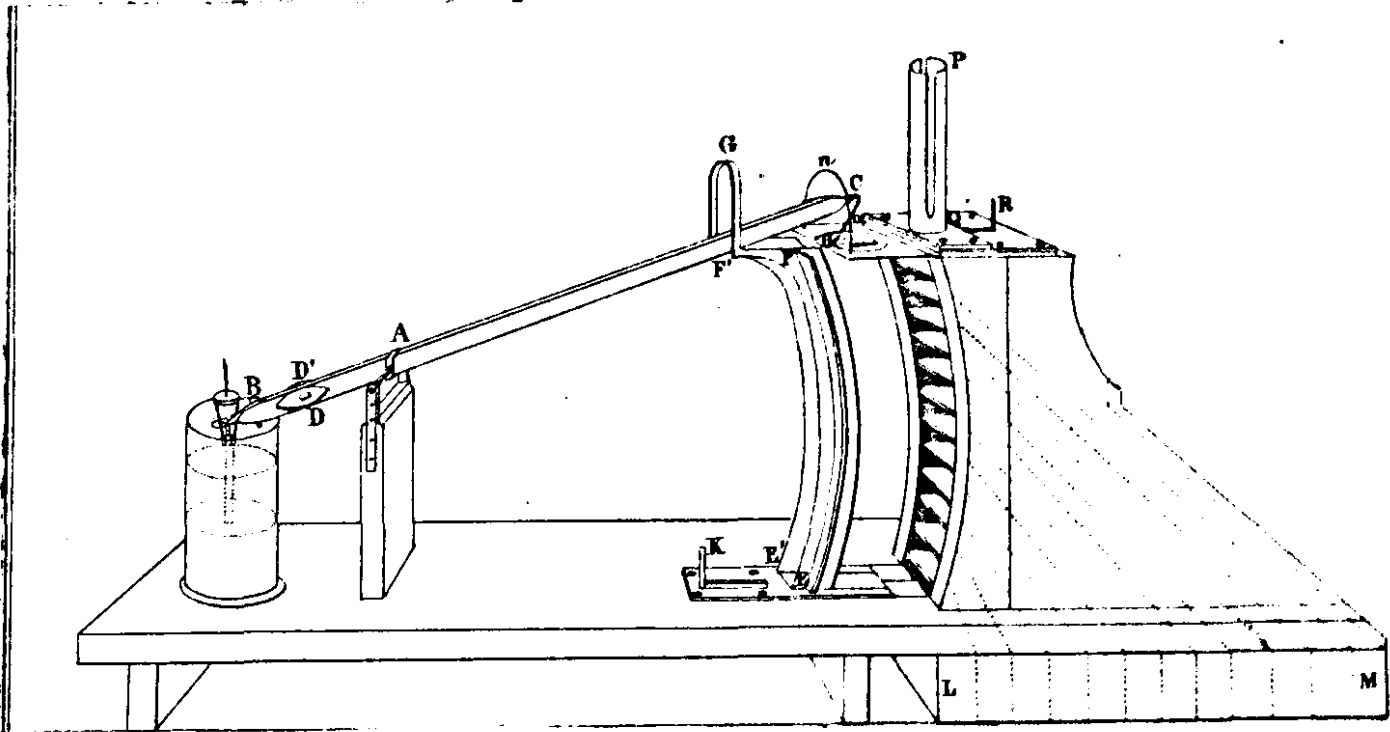
* Even where the file is used for adjustment, I should think these instruments would be very valuable, for an expeditious classification in a rough way, of the pieces to be operated on.

18. When this preliminary has been settled, the pieces as they are handed from the blank cutting machine are successively weighed in one or both of the instruments. If the average deviation of three pieces be required, then the three blanks are placed in the larger scale, and the index will point to the average difference at once; If the discrepancy of only one is to be tested, the smaller instrument is used, which shows the same result as applied to it.

19. *Sorting Machine.* This instrument was made up in order to test the possibility of performing the weighing and sorting of coins by machinery, and the result has been completely successful; nearly the whole of the rupee disks being now assorted by it. The principle is that of arranging a number of beams side by side, and attaching to them an apparatus by which the pieces are mechanically placed upon the pan swung from the end of each, and after equilibrium has been attained, removing each piece to its proper compartment in a series of cells, which are appropriated to the different classes into which the pieces are to be assorted. The

idea naturally suggested itself in connection with the use of the simple bent lever beams, before described, in considering the possibility of obviating any chance of the pieces, after their true classes had been pointed out by the index, being misplaced by the sorter. It occurred to me, that as the pan is raised by the end of the beam to a different height for each class, and it was in our power to regulate the distances between the different marks on the scale to any dimension most convenient, by altering the length and flexure of the beam, it might be possible to arrange a series of shelves at the exact heights marked by the divisions; and then, by merely giving the pieces a sudden horizontal movement, they would be at once carried to their proper places, and might be conveyed by means of partitions, down to any receptacles most convenient for the accommodation of large numbers.

20. Before proceeding to make any experiments upon a large scale, it was first thought advisable to test the main principles of the scheme, and this having been done by a rude model, with a satisfactory result, the



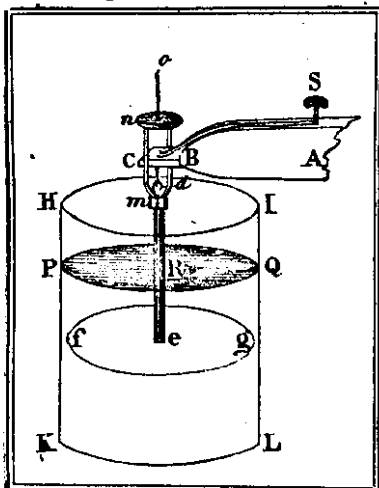
model of a single beam of the full size was accurately made, and the following description of this will be the best introduction to the study of the compound machine.

21. In the above figure the letters *A. B. C.* show the beam, which was made of a piece of seasoned fir, which had been baked to thorough dryness, and varnished. It was altogether 30 inches long, the arm *A C* being 24, and *A B*, 6 inches. This was poised upon the ordinary knife edge suspension pivots, in the usual way, the only difference being, that they were placed rather widely apart, in order to ensure steadiness in the direction of the beam, and to obviate any lateral vibration.

The points *C* and *B* are also provided with pivots, in the manner represented in the figure, the former a knife edge for the support of the pan for the reception of the pieces, the latter a silken loop passing through two holes in a steel plate holding the weight, which will be presently described. Great pains were taken in making the edges of the three suspension pivots in exact line, in order that the equilibrium of the beam might not be in any way affected by the amount of the weights opposed to one another; and equal care was bestowed in adjusting the centre of gravity of the beam itself, to the point marking the position of the edge of the central pivot, to effect which it was found necessary to attach counter-

poise weights *D. D.* on opposite sides of the short arm *A B*, to balance the weight of the larger arm *A C*. These counterpoises were made of lead, and fixed in the manner represented.

22. These conditions having been attained, the test of accuracy was, that the beam rested in any position in which it might be placed; or to speak more correctly, it had no tendency to assume any particular position, for although it was in perfect equilibrium at every angle, the fineness of the pivots, and the length of the arm *A C* totally prevented its assuming a state of rest; the mere motion of the atmosphere being quite sufficient to keep it in constant oscillation. This circumstance was one of the reasons which induced me to make an alteration, which will already have attracted notice *viz.* the adoption of a new kind of weight. It has already been mentioned, that in the small bent lever scales it was found absolutely necessary to sacrifice in a small degree their sensibility, to get over the difficulty of their constant motion, and that this had been done by making use of a pivot which was not without a very trifling degree of friction. In constructing the model now under description, the idea suggested itself of introducing a retarding agency, which might be effective in preventing motion, but incapable of exerting any influence when the beam was at rest. This condition naturally points to the use of a fluid, and it being at the same time very desirable to devise a plan by which the spaces between the different shelves intended for the classes of "disks" might be made equal to one another, those of the bent lever balance being rather smaller at the limits of the scale above and below the zero point, it was determined to attempt the combination of a retarding plate with a fixed wire, on the principle of the hydrometer, the whole weight of the plate and wire being so adjusted in the first instance, as to exactly balance a disk of the medium weight, when the beam was horizontal, and the pan opposite to the middle opening *O P*.

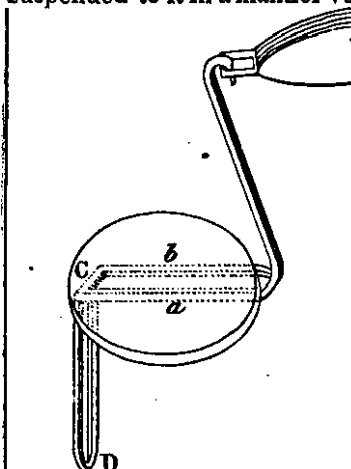


23 The annexed figure represents this part of the apparatus, as it was constructed on that occasion. *A B* is the end of the short arm of the beam, to which the plate *B C* was attached. In this plate a couple of very small holes were drilled, through which passed the two ends of a silken thread, which form a loop at *d*, in which the circular stem *d e* is suspended by means of the hook *d*. The ends of

this thread are secured by means of the pin *s* round which they are wrapped, and by screwing or unscrew-

ing which, an adjustment of the distance of the plate below the point *B* may, to a small extent, be made. The bottom of the stem is fixed to the circular brass plate *e f g*, and by the motion of the beam the plate rises and falls in the cylindrical vessel *H I K L* in which it is placed. The diameter of the cylinder was 3.2 inches, and of the plate 2.9, thus leaving an interval of about 1/4 tenths of an inch all round, between the edge of the plate and the inner surface of the cylinder; that is, when the former is in the middle of its track as regards height; for as the motion of the end *B* of the beam is circular, it follows that at the highest and lowest points of its rise and fall, the edge *g* of the plate is drawn nearer to the side *I L* of the cylinder, and the edge *f* further from the side *H K*. The level of the surface of the water is shown by the letters *P R Q* the wire passing through it at the point *R*. *m n o* is a light cup of thin brass, supported by a couple of thin wires bent into the form of the letter *Y*, and attached to the upper part of the stem *d e*, the object of the cup being to contain the fractional grain weights which might be required in finally adjusting the weight of the stem and retarding plate &c. to perfect equilibrium with the standard disk, in relation to which all the remainder of a series were to be assorted.

24 The other end of the beam merely carries a pan suspended to it in a manner very similar to that of a letter balance, the width *a b*



of the frame upon which the disk is supported being much less than the width of the piece, to allow the two cheeks which are employed to remove the piece, to pass freely without carrying the pan with them. The same object is intended by the skeleton plate *C D*, which is a continuation of the pan frame *a, b*, at right angles to its face, and serves as a stop to prevent the latter being carried into the inside of the shelves, within which the piece is to be projected.

25 It has already been stated that the whole beam is poised upon knife edge suspension pivots in the ordinary manner, the only thing at all unusual in the arrangement, being, that the pivots are sharpened to a point outwards, the point being on a line with the knife edge, and a plate being attached outside beyond the circular cups in which the knife edges work, and touching these points on each side, so that any lateral motion of the pivots is prevented, and they are thus kept in their proper places.

26 If we now consider the action of the beam, we shall

see that the principle of its operation is different from that of balances in general. It has been remarked above, that great pains having been taken to bring the three points of suspension into exact line, and also to cause the centre of gravity to coincide with the centre of suspension, the result was, that previous to the introduction of the fluid in the cylinder, the beam would rest equally in any position in which it was placed, whether bearing weights or not, excepting as regards the motion produced in it by the currents of the air. As the suspension pivots were delicate, a very trifling weight would disturb the equilibrium, and thus the sensibility of the instrument and its capability of marking slight differences was secured, irrespective of any difference in its action brought about by the use of water.

27 When one of the weights consists of a plate suspended in water by a wire or stem of any given thickness, two changes take place. The first of these is the resistance of the water to the surface of the plate, and the difficulty of its motion, in consequence of the inability of the water to pass quickly from the lower to the upper side of it, and *vice versa*, owing to the plate nearly filling the area of the cylinder, and also the friction of the fluid, these being the retarding effects which were aimed at by the use of the plate; The second, that even supposing these resistances to be overcome, the beam once being in equilibrium, can not change its position without destroying that equilibrium. Indeed, it will be evident on a little reflection, that if the piece at the other end of the beam were exactly balanced against any solid body, part only of which was immersed in water, any movement which caused a further portion of the body to rise out of the water, would add to the effective weight of the whole mass, by a difference equal to the weight of the mass of water which was previously displaced by the part now raised out of it. In other words, the increase of weight which would be required to lift it out of the fluid, and by which it would act against the disk in the opposite scale, would be equal to the buoyancy of the part lifted out of the water, supposing it to be itself intrinsically of no weight. And this last supposition is true in regard to the parts of the stem and retarding plate now under consideration, because, as their actual weight is counterbalanced, and neutralised by the equilibrium previously existing, it ceases to have any power of interference in respect to the differences in that equilibrium effected by alterations of the position of the beam.

28 If we could possibly conceive that the stem attached to the retarding plate were, like the mathematicians definition of a line, absolutely devoid of the dimensions of breadth and thickness, then the above conditions would not arise, till the retarding plate itself came to be lifted out of the fluid. If the wire stem could be supposed to displace *no fluid at all*, the equilibrium would not be disturbed by any change which did not effect the uncovering of the plate. As had been ascer-

tained with respect to the action of the beam in air, so in the water, the equilibrium would be perfect; and, owing to the resistance to the plate, more stable, in every position in which it might be placed; and the plate would act simply by preventing the vibrations, which have been above spoken of as occasioning so much delay in delicate weighing.

29. In the above case, we should require a series of weights, to counterbalance the differences in the various disks to be assorted; and then, as before, the beam would rest equally in any point in which it might be placed (the plate not being exposed) but the required conditions would not have been attained, one of these being, that each position should be one of equilibrium for a different weight, which should rest stable at that point and no other. It thus appears that apart from the influence of a sensible dimension in the wire stem carrying the retarding plate, the necessary conditions are not fulfilled; but the moment we take into consideration the consequences of a certain thickness of it, we perceive that its motion into and out of the fluid has precisely the effect which is desired, by its requiring a different weight at every point to bring about equilibrium.

30. One of the first ideas which suggested itself in connection with the attempt to weigh mechanically, was that of attaching to the pan containing the counterpoise weight, a silken thread, having fixed to it, at regular distances, weights corresponding to the differences which should exist between the different classes of disks; so that, as a heavy disk descended on the one side, it might, one by one, raise the successive weights on the other, until equilibrium was established. After the use of water was resolved upon, this idea was superseded, because it will be perceived that a balanced stem rising and falling in the way the retarding plate stem does, has the very same effect, though in an infinitely more regular and perfect manner, as the gradual addition or subtraction of weights; its operation being indeed precisely similar to that of the hydrometer, with this exception, that the latter is sustained by its own buoyancy, and the former by the counterbalancing effect of the disk upholding the stem.

31. The most important advantage, however, which was gained by the use of the water and the stem was, that it enabled me to fix upon any size most convenient for the openings between the shelves or partitions for the reception of the coins, without any reference to the length of the beam, and without diminishing its accuracy, by merely regulating the dimensions at my own convenience. Like the hydrometer, the sensibility of the instrument, that is, as affected by the immersion of the stem, is obviously dependent altogether upon its sectional area. If the immersion to any given depth, say an inch, of a wire of 2 tenths of an inch diameter, caused an effective diminution of the weight at the short end of the beam of 8 grains, corresponding with

a difference in the weight of the disk of 2 grains, any other wire of greater or less sectional area would produce a greater or less difference with the same degree of immersion, or an equal effect with a greater or less immersion, and consequent rise of the longer arm through a larger or smaller space.

32 Hence it followed, that after the adoption of any given height as that most convenient for a series of shelves, it was merely necessary to regulate the thickness of the stem of the retarding plate, to suit the difference of weight which it might be desired should exist between the different classes of disks to be assorted into the distinct compartments. In the model, we determined upon having a set of 12 shelves, each one inch above the next below it, and it was determined also, that the difference of weight between the disks belonging to each shelf or compartment should be half a grain. To fulfil these conditions, a wire of the above mentioned diameter, viz. 1/16ths of an inch, was found to be necessary, and the beam thus fitted up answered every expectation. After the weight of the whole counterpoise, stem, plate, &c. had been adjusted to the weight of one of the disks in any position, for instance at the top of the series of shelves, the addition of any number of half grain weights, successively, would carry the piece down with great regularity, from partition to partition, in exact accordance with the weight applied to the piece, which on their removal would with equal regularity rise to the proper height, bringing the disk opposite to the compartment suited to the weight which belonged to it. Thus, so much of the contrivance had been fully realized, and the only remaining steps were to adapt to the beam instruments for the laying on and removing the disks, as they were successively weighed.

33. The removal of the pieces was effected by means of the apparatus shown in the figure given at para 20 *E F* and *E' F'* and *G* represent a sliding frame composed of two upright brass cheeks *E, F* and *E', F'* curved to suit the form of the face of the shelves, (which is necessarily circular to adapt it to the motion of the pan *H*), standing on, and firmly fixed to a bed plate sliding in groves cut in a plate of brass, secured to the floor of the stand, and moved backwards and forwards by the pin *K*. When the disengaging frame is moved forward to the utmost, the face of the two cheeks coincides with the front face of the shelves, and the disk is separated from the pan, and projected to within the interior of the shelves, whence it is carried, by the partitions represented in the figure, down to its appropriate compartment in a drawer *L M*. The beam on being released, rises quickly, (but not too suddenly, on account of the retarding plate) till it is arrested by the stop *o, n*, which is so adjusted, that when the beam is held in that position, the pan *H* is exactly suited to receive a fresh disk, which is carried forward and lodged upon it by means of a tongue, or feeder, working beneath the hopper *P, Q*, which is kept filled with a supply of the disks to be assorted.

34 It will be observed, that at the point *F F'*, the upper part of the upright cheeks of the disengaging frame is filed flat and horizontal; and after a disk has been projected into its partition, the frame remains in the forward position close to the face of the shelves, the horizontal surfaces at *F* lying immediately under, and in the middle of, the circular opening where the disk is delivered; and they support it until, after the delivery has been effected, the disengaging frame is withdrawn, and the disk is left upon the pan *H*, and descends by the force of gravity till it finds a suitable position of equilibrium corresponding with its weight; and thus having been brought to rest, it is in its turn removed by the frame, and the feeder is made to supply another, and so on.

35 The working of this model is carried on as follows. First the disengaging frame is advanced close to the shelves, the feeder is next made to deposit a piece, the frame is withdrawn, and in a short time, when the beam has become quite steady, the frame is quickly brought forward again, by the pin *K*; after this a new piece is delivered, and so the operation continues. The time taken for the beam to come to rest, is found, with an instrument constructed of the above stated dimensions, to be about 20 seconds; so that three pieces could be weighed per minute, in a single machine. In working a number together, a longer time is allowed, in order to make sure that the slowest shall have quite settled. It is worthy of notice in connection with this point, that a curious fact was observed in the use of this model, which seems to depend upon the friction of the fluid, as distinguished from its resistance to the retarding plate; and this was, that there was found to be a trifling difference between the position of equilibrium at which the beam settled, when it descended from a high elevation, or when it ascended from a lower point, (although in each case it vibrated backward and forward past the settling point) being in the former case always a trifle higher than the latter. This difference is small, and it has no effect whatever upon the accuracy of the indications of the beam, as the pieces all descend from the same level.

36. In assorting a series of disks by this model apparatus, the middle cell of the series was appropriated to the medium or "standard" weight, in reference to which all the pieces were to be classified. A disk of that weight having been selected and placed in the scale, the weight of the counterpoise was adjusted until the disk hung opposite the middle of this cell, and the whole were then worked off. In case a second series of disks should be brought for assortment, and another standard, slightly varying from the first; then an adjustment required to be made in the first instance, by adding fractional weights to the counterpoise at *B*, till it balanced the standard disk opposite to the middle compartment, as before.

37 When a new species of disks or coins, not only varying in weight, but requiring to be classed in a series

varying by a new set of differences from one another, require to be assorted, it is necessary to apply a new stem, of a thickness corresponding with the difference of weight required between each class; and in some cases a new pan at the other extremity of the beam, and in almost all a new hopper are necessary. This will be remarked upon more at length, in speaking of the construction of a compound machine on the principle of this model, for as this was found to have completely answered its intended object, in proving the correctness of the principle upon which coins or other pieces might be mechanically assorted, it was not considered necessary to do more than apply it to those it was first prepared for, and the next step was the construction of the compound machine itself.

38. It will have been observed on reading the description of the mode of using this model, that after it has been once adjusted to any given series of pieces, which are intended for classification, all the remaining work to be performed is merely mechanical. Nothing whatever is to be done, but at certain regular intervals, to move backwards and forwards the two pins *R*, and *K*, as follows; first, *R* forward and back again, 2d *K* backwards; then, after an interval of 20 seconds, *K* forwards, then *R* forwards and back again, then *K* back, and so on. In all these movements no discretion, or intelligent operation of the mind is necessary, and if a little longer allowance of time be made, to avoid the necessity of observing when the beam comes to rest, the whole of the motions could as efficiently and well be performed by a steam engine as a man's hand.

39. Upon the encouragement afforded by the satisfactory performance of the model above described, I resolved upon attempting the construction of a compound apparatus consisting of a number of them, to be worked by one man. To avoid the length of time which a large set would consume in construction, and in consequence of the uncertainty which existed as to the amount of mechanical force which would be called for, it was resolved to restrict the first attempt to a set of 20 beams, and after some time, this was accomplished. A general idea of the apparatus will be obtained by consulting plates 18 and 19, and if it be borne in mind that the whole apparatus consists simply of a set of 20 of the instruments which have been above described, arranged side by side, with some few additional parts necessary for working and adjusting them together, the drawings will be found, I trust, not unintelligible.

40. It was the fear of some derangement happening to any one of the beams, the repair of which might be an impediment in the use of the whole, on actual duty, which led to the plan of their being constructed quite independently of one another, and afterwards placed together upon a frame suited to accommodate the whole; but the lengthened experience we have now had of it has proved that there was no necessity whatever for this precaution, and that in the construction of others,

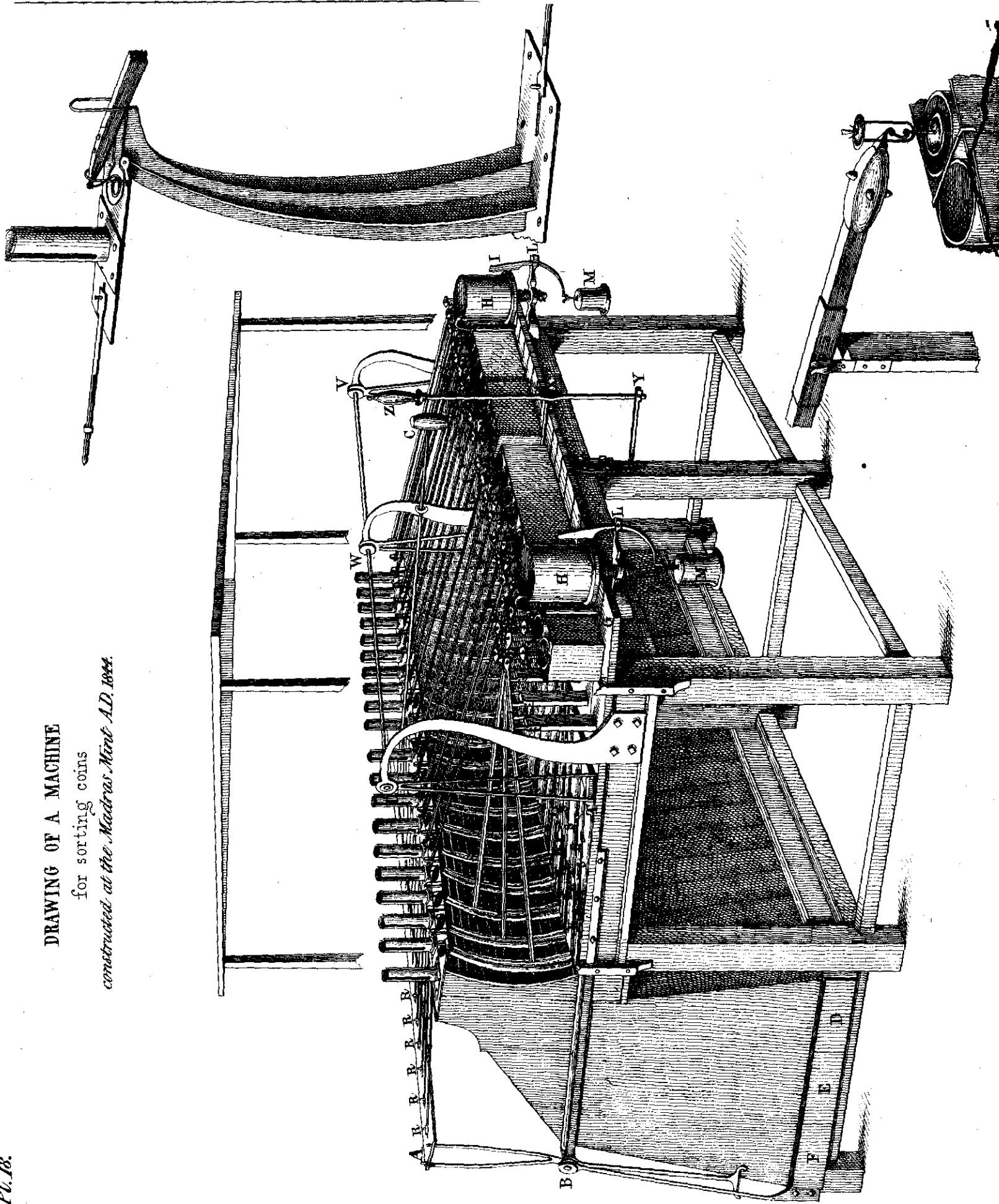
it will be quite safe, as it will also be much more convenient and economical, to frame the whole of the largest series in one system; as the beams are not liable to any derangement, after once being properly made and adjusted.

41. For greater convenience of reference, the two plates above referred to have the same letters attached to the same parts in each. The only parts which it will be necessary now to describe particularly, are those which are added to enable a number of the motions which were stated to be necessary to work the simple machine, to be united in the compound one, so as to be effected by one effort. Those motions it will be recollected were merely of the two pins *K* and *R*. It will be observed, then, that in order to unite the series of motions of all the pins *K* into one, they are all joined by means of connecting rods *s, s, s*, to a wooden bar, of which only one end, marked *T*, is visible, in either plate; which bar is suspended by means of three stirrups of iron *T, U, W*, and *V*, to a long arbor which turns in sockets at the points *U, V*, and *W*. These stirrup frames are firmly rivetted to the arbor, and cannot be moved without carrying it round with them. The consequence is, that any small motion given to any one of them is communicated to the others by means of the arbor, and all the three frames, being thus made to move simultaneously, the bar *T* is carried forward in a direction always parallel with itself, and by means of the connecting rods, or couples *s, s, s*, the whole of the pins *K, K, K* &c. are moved uniformly together.

42. As it would not be convenient to move the bar *T* by the hand applied to it, a rod passes from it to an upright lever *Z Y* which turns upon a pivot *Y*, attached to an arm projecting from the body of the frame. This rod is seen in plate 18 joining the lever at the point *X* where the handle *Z* by which it is worked is also clearly shown. Before quitting the notice of this part of the apparatus, it may be useful to explain what is the use of the connecting couples *s, s, s*, and why it would not answer to have simplified the machine by applying the moving power directly to a bar fixed upon the tops of the pins *K, K, K*, themselves. The reason is, that in all machinery of this kind, it is indispensably necessary to provide against the risk of any obstruction accidentally occurring to prevent the movement of one of the series of parts, which in default of such provision might be injured. In these beams, for instance, it occasionally happens that the piece is carried by the disengaging machine precisely upon the *edge* of the partition, and though this accident very rarely produces a stoppage, owing to a contrivance which was made use of for the purpose of preventing it, still it even now does occur, and but for the use of the connecting rods would most probably occasion the fracture of some parts, an accident which by their intervention is entirely prevented.

43. This is done by making the rods of two parts

DRAWING OF A MACHINE
for sorting coins
constructed at the Madras Mint A.D. 1844.



joined together longitudinally, like a split cane, and connecting them together by a sliding ferule, moving along the rod with sufficient friction to prevent its becoming accidentally displaced, when once fixed. The two parts of the rod are made of steel, with a slight temper, and they are joined at the end *T* and fitted, by means of a hole drilled through it, upon the pin which rises out of the bar *T*. The loop which fits upon the pin *K* is of course drilled through the junction of the two halves of the connecting couple, and as these are not united together at this end, they are free to separate and release the pin, on the occasion of any jirk or violent movement, or in the event of any obstruction, such as the striking of a piece against the partition, in which case the pin remains unmoved, and the two halves of the couple open out from one another and pass on without it. The use of the ferule is to adjust the degree of force which shall be required to detach the couple from the pin, which is of course easily effected by passing it closer to, or removing it further from the point *K*. By this means the adhesion of the two jaws is increased till it is just sufficient to move the pin backwards and forwards and perform its work with certainty, and a little more.

44. The other row of pins *R, R, R,* &c. is moved in a manner very similar to what has just been described, with the exception only, that the bar *A* to which all their connecting couples are linked, instead of being suspended by three stirrup frames, in this case stands upon them; but exactly as in the former case, the motions of all the three frames are connected together by an arbor *B*, to which they are firmly joined. The bar *A* is moved backwards and forwards by a plain rod passing from the back of the machine to the front, where the assorter stands who works the machine, and it is there provided with a handle *C* in a convenient position for use in reference to the other one *Z* before described. It is almost needless to mention, that the connecting rods, are precisely similar in this set to those just described, and the necessity for it is much greater in this part of the apparatus; as it not unfrequently happens that amongst the feeders pushed forwards by the motion of the bar *A* one may be prevented from doing its duty by the pieces contained in the hopper sticking fast, and being immovable for the moment.

45. The mere handle which is shown in the plates as attached to this movement is sufficient for the limited number of 20 assorting beams, working with rupee disks, but as it performs the work at no mechanical advantage, the force required in the way of a direct pull would be too great were that number much increased; for although there is generally no actual obstruction whatever, and it therefore ought, theoretically, to take little or no power, to move the feeders, still practically it is found that the friction of even twenty, when all the hoppers are loaded with 100 disks each, becomes something considerable; and when the workman has to apply this force a thousand or twelve hundred times a day, is quite as much as he can manage. It would be therefore necessary in constructing a machine

combining a larger number, to make this handle differently, and to give it a mechanical aid by means of a lever, in a manner somewhat similar to the arrangement of the handle *Y Z*, which would be very easily done; for the space through which the handle *C* now moves is only about 2 inches, and this, if necessary, might with ease be increased to 10 or 12, thus diminishing the force necessary to be applied in the ratio of 5 or 6 to one.

46. I before mentioned that a contrivance had been applied to obviate the risk of the pieces under assortment, on being disengaged by the frame, striking against the edge of the partition adjoining the cell into which they were to be thrown. This was effected by merely arming the edge of each partition with a roller, and thereby presenting to the piece about to be projected a circular and moveable, instead of a fixed obstacle to strike against. These rollers are about a quarter of an inch diameter, and accurately fixed upon steel pivots; and the slightest force is sufficient to turn them, so that nothing but the circumstance of the piece striking it with the utmost truth in the direction of its centre, can prevent its turning round and giving it admission into one or other of the compartments above and below. It comparatively seldom happens that the piece strikes it with so much truth as to fix it, but when this does occur, it is rectified by the workman drawing back his hand and repeating the stroke, by causing the disengaging frames to recede partially and advance again. This liberates the piece, which by the vibration of the beam assumes a new position, whence it is sure to be carried into its proper place by the forward movement.

47. The section given in plate 19 will show very distinctly the partitions, by means of which the pieces, after being thrown into the proper cells, are carried down to the drawers where they are kept separate from one another, and removed from time to time as they are required. Each single beam is, as before stated, mounted separately, and standing on the horizontal platform *B G* may (with the exception of its water cylinder) be removed and separated from the rest. Thus the upper half of the series of partitions is distinct from the lower, the junction being at the horizontal line, where they meet at a considerable angle. This is no doubt a defect, which will be remedied on the occasion of constructing a second machine of this kind, as it would be obviously so much better that the partition guides should be formed in continuous curve lines instead of meeting at an acute angle, which is apt to occasion a lodgement of the pieces, if they should be very large in comparison with the breadth of the spaces. We have not, however, been troubled with this accident since the first construction of the machine, although we at first met with it from another cause, namely owing to the upper and lower partitions not being fitted exactly to one another, and a projection being left which caught the pieces as they fell.

48. As the large machine, was merely experimental, it was constructed as economically as possible, and

owing to that, the upper partitions were made of tin plate from old packing cases, the lower partitions were of wood. The pieces fall into drawers, of which there is a double set of three, opening on each side of the bottom of the frame, each set of drawers thus answering to ten beams. Each drawer is divided into four partitions, so that the three drawers which belong to ten beams, afford 12 spaces for the accommodation of the 12 classes into which all the disks assorted by them are separated.

49. The only parts which now appear to require description, are the cisterns containing the water, and the apparatus for regulating the height at which it stands in them. In regard to the former, it was found advisable to alter the system of using a separate cylinder for each beam, partly on account of the greater neatness and substantiality of larger reservoirs, and partly also for the purpose of regulating them with greater facility, according to the plan which will be presently described; but it was necessary still to retain the cylinder, for after a variety of changes and experiments upon different forms of retarding plates and cisterns, no plan was upon the whole found to be so good as the simple vertical cylinder and circular plate. In order to retain the advantage of this form, therefore, and still to unite the cisterns together, troughs were made of sufficient size to hold five cylinders, and the latter were fixed in their proper places in them, but were not provided with bottoms; there was therefore a free communication between the fluid belonging to all the five cylinders contained in each trough, and the two troughs on each side of the centre *Z X* were also made to communicate freely with each other by means of a syphon, so that the water should always stand at the same level in each. By this arrangement, the height of the fluid in all the ten cylinders belonging to the beams on one side could be regulated at once; a point of some importance.

50. The circumstance which made it desirable to effect with facility a uniform change in the level of fluid in the whole series of cylinders, was the frequent necessity for very slight changes in the weight of the "standard" disk, in comparison with which the whole of a large number were to be classified. In the course of business, the disks are usually brought in bags containing about 1000 or 1200, and each bag is provided with its own standard piece, which forms the middle or zero point of the scale, above and below which, all the rest are regulated. I have before stated, that on first construction of the beams, the counterpoise at the end of them is adjusted by the addition of fractional weights, till the standard piece is made to rest opposite to the centre of the middle shelf, or zero point in the system, and this must of course be done for each beam individually. But if, in the course of business, this had to be done for every new bag of pieces, and all the ten beams had to be accurately adjusted individually, it would not only occupy a great deal of time, but would introduce great risk of error, in consequence of the probability that delicate adjustments so frequently and hastily made would have but little accuracy, a difficulty which is completely surmounted by adjusting by means of the fluid.

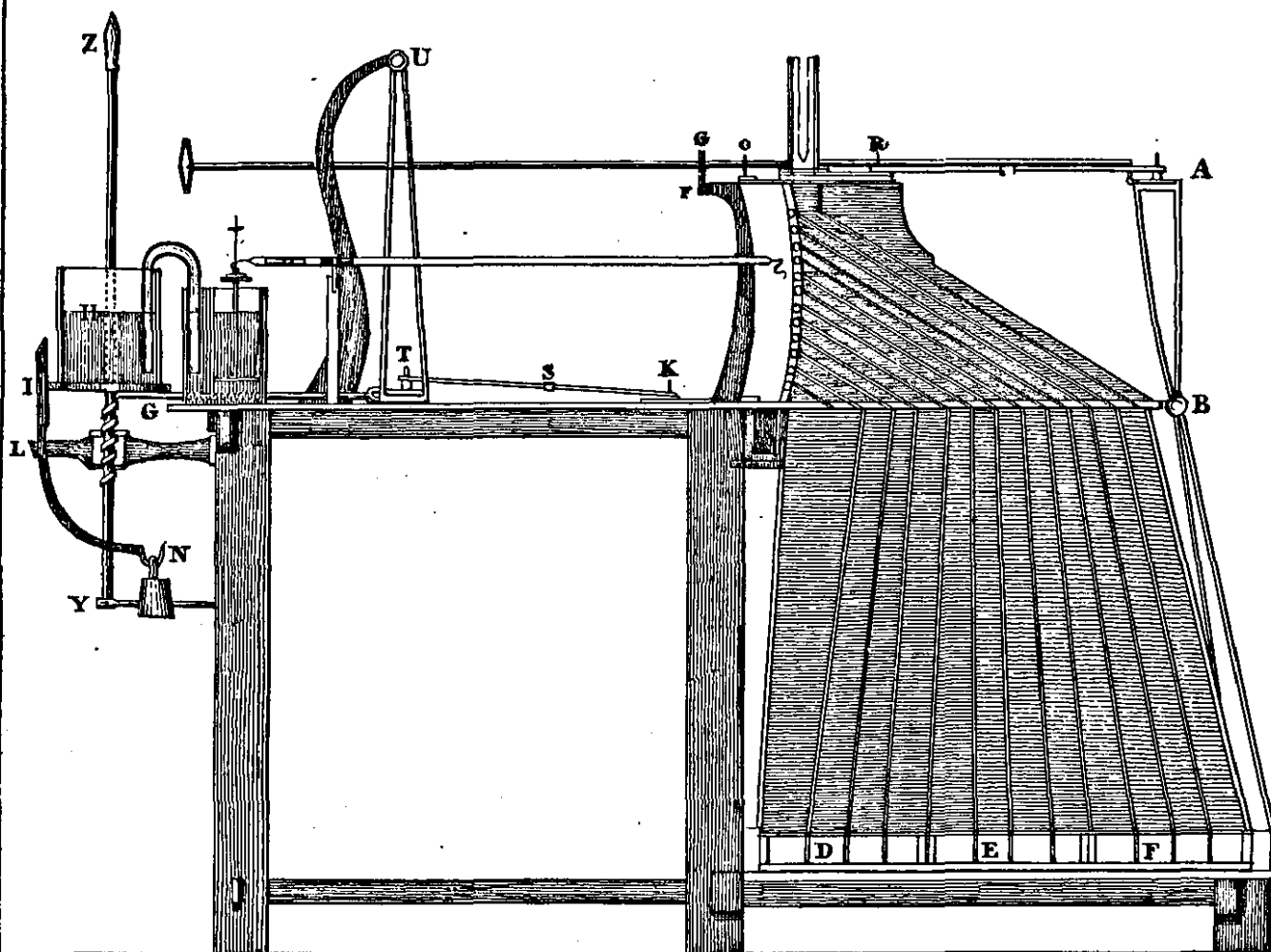
51. How this is done will be easily understood. It has been before explained, that the weights on both sides of the beam having been settled, the piece will cause its end of the beam to sink till so much of the wire stem attached to the retarding plate has been drawn up out of the water, as by its additional weight to balance it. If we suppose equilibrium to have been obtained, at the time that one inch of the stem is uncovered and 5 inches are immersed, it is proved by that circumstance, that the weight of the counterpoise minus the buoyancy of the immersed part is exactly sufficient. And the same would be the case, with the same degree of immersion, at every inclination of the beam, which it will be remembered was tested and proved to show the same results in every position. If therefore a standard piece on coming to equilibrium should be higher or lower than the zero point, nothing more would be necessary to rectify this, than to raise or lower the cistern containing the water, which would immediately produce the desired effect.

52. The same end would be attained also, of course, by allowing the cylinder to remain fixed, and altering the height of the water in it; and as this, within certain limits, can be so much more easily done to the whole series at once, this plan of regulating the zero point for different weights was the one decided on, and it was carried into effect by establishing a communication between one of the troughs and a rather large reservoir marked *H* in the drawings, by means of a syphon, and fixing the reservoir in such a manner that it could be easily elevated and lowered at pleasure. It will be observed that in plates 18 and 19, the two reservoirs belonging to the troughs of the two sets of beams, are represented as standing upon circular wooden trays, which are supported by a central stem which is tapped to enable it to fit into a female screw held by an arm projecting from the body of the frame of the machine. Near the position of each of these reservoirs there is a projection in the side of the trough next to it, a circular well of about an inch diameter, and of a depth equal to the depth of the trough, having been made and attached to it in free communication with its contents. This well is for the purpose of holding one arm of a syphon, the other being inserted in the reservoir; and as the latter is cylindrical, and moves round a centre coinciding with its axis, whenever the reservoir has to be raised or depressed by means of the screw, no change takes place in the position of the syphon, which continues to act uninterruptedly whatever height the reservoir may be set to.

53. By this means, on every occasion when it is found that the standard piece belonging to a new set of disks does not exactly correspond in weight with that which preceded it, the necessary alteration to bring the whole of the beams on one side to point to zero is made in a moment, by raising or lowering the reservoir *H* to such a height as to make a compensation; which it does by the immediate alteration in the level of the fluid in the troughs attached to it, by the agency of the syphon. The reservoirs are kept steady in their places, and immovably fixed in the positions assigned to them, by the

PL. 19.

A SECTION
of the
DISK ASSORTING MACHINE.



Inches 12 9 6 3 0 1 2 3 Feet

pressure of an arm *I* which turns upon the pivot *L*, and is kept in constant contact with the circular tray by the action of a weight *M* attached to it. It is usual to assort two sets of disks at once, by allowing each half of the machine to be occupied with work distinct from the other, so that the adjustments in the two halves are made separately, and have no connection with one another, though all the beams are worked at once.

54. The only thing which now remains to be mentioned is, that during the hot weather, to avoid the disturbance which might be caused by flies settling upon the beams, the whole apparatus is enclosed by a light frame with mosquito curtain gauze stretched upon it, the upper part of which is exhibited in plate 18, the lower parts having been broken off to prevent their interruption of the view of other parts. In this form, the machine has now been in use for many months in this Mint, and during that time has performed nearly all the sorting work in regard to rupees which has been executed. Had it not been constructed in parts, for the reason above stated, so that each beam is separate, carrying its own hopper and feeding apparatus, it would have been easy to have made it do more duty, by applying it to sort other coins. As it was however, as this would have required the removal of the twenty feeders, and addition of new ones, it was determined that it would be best instead of undertaking that work, to reserve this machine for large coins only, and hereafter make a new one capable of being used for every description of coins.

55. The quantity of work which may be executed in a day by the use of even this machine has of course been much augmented. It has been found that as a general average of all the work done, the proper days duty is 20,000 pieces. This is a large increase upon the best performance which had ever been attained previously, but far short, it may be presumed, of the utmost that may be done. It has been before remarked, that in consequence of the doubt which attached to the whole scheme, and the uncertainty as to the number which could be conveniently managed by one man, only twenty were at first arranged together: but from the experience we have had of the very easy and satisfactory working of this, I have little doubt but that with the improvements which may be made, it will be possible to combine from 50 to 80 or perhaps even 100 so as to be within the power of a single assorter.

56. Until the above experiment has been tried, it is not possible to form a certain judgment as to the economy which is attainable by the use of the instrument, because what has already been done is quite an insufficient criterion. We find it best to employ a man and boy together, the former to work the machine, and the latter to feed the tubes or hoppers containing the pieces. The first of these receives the pay of an experienced assorter viz. 7 Rs. 14 As. per month. The boys who are entertained in this department receive from 2 to 4 rupees per month each. I therefore think that if an allowance of 11 rupees be made for both it is

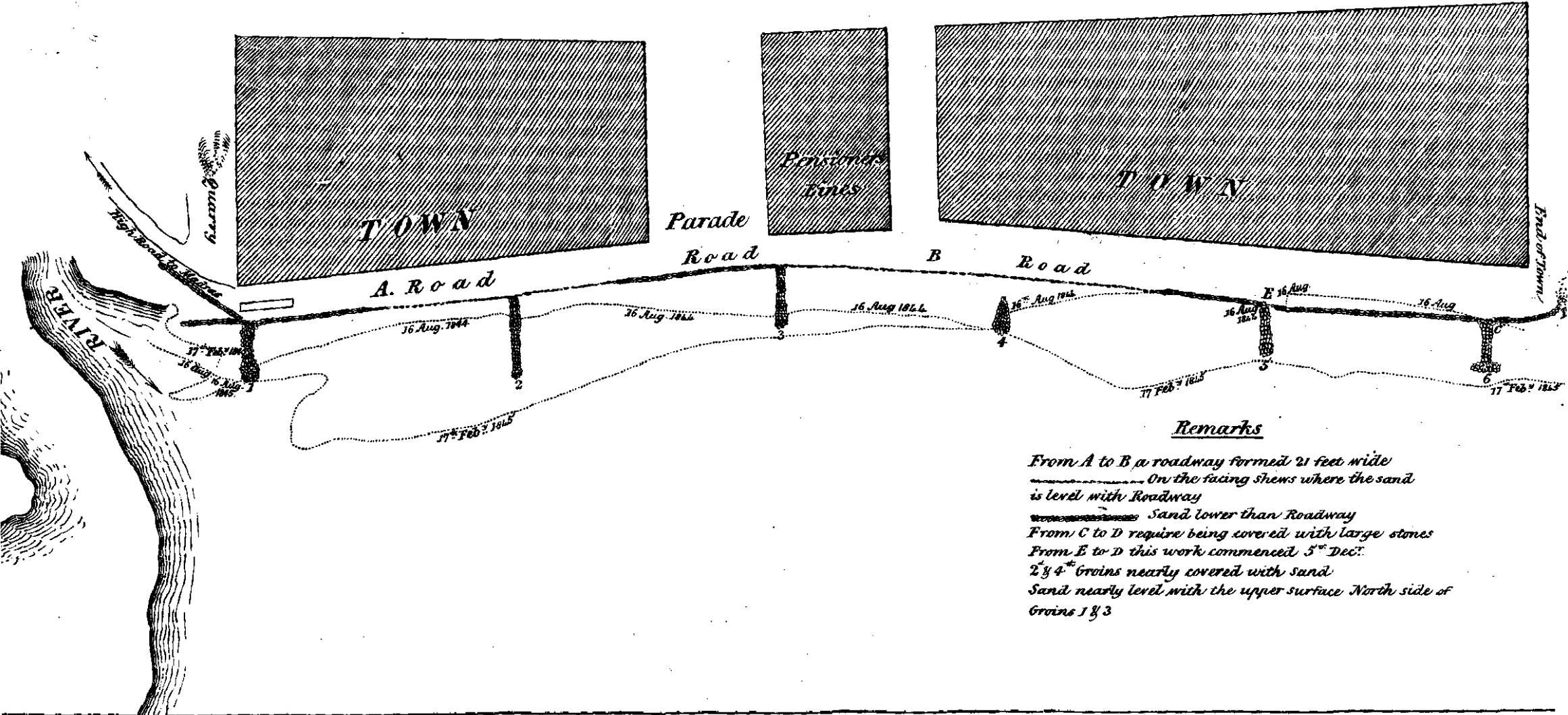
amply sufficient. Reckoning 25 working days in the month, the number of pieces which would be assorted during that time would be five lacs, or at the rate of 2 Rs. 3 as. 2 pice per lac, with an instrument of 20 beams; and if the same calculation be made for sets of 50, 80, and 100 beams, the results would be the rates of 0,, 14,, 1 in the first 0,, 8,, 9 for the second, and for the third the trifling sum of Annas 7,, 0½ per lac as the cost of the work. We cannot of course speak with certainty as to this last reduction until the practicability of working so many as 100 beams together shall have been tested, but with the improvements which I am aware may be made, both as to diminution of friction and economy of space, I think there is reasonable ground to think it quite feasible, and almost certain in regard to small coins.

57. It may be useful that I should mention one alteration which would be necessary were any large number of beams worked together, as it seems to me the easiest method of overcoming what would be the chief difficulty in the undertaking, viz. the difficulty of close approximation. In the case of an instrument of 40 or 50 beams being made, for example, it would be desirable that some of the parts should be made for sets of ten, instead of for single beams, as in the one I have described. This might with advantage be applied to the feeding apparatus, the troughs, and the shelves. There would be no difficulty, then, in bringing the beams close together, so much so that I think they need not to occupy more than 1½ inches in breadth for the largest coins, but in this case there would be a remaining difficulty, namely that of providing for the accommodation of the cylinders and retarding plates, which could not perhaps be conveniently reduced very much below their present size.

58. It will be recollected that the size of the cylinders has above been stated to be 3.2 inches, and this dimension applies to the interior. But we might safely calculate upon such a reduction as would make the whole space occupied by each cylinder equal to 3 inches; but even this would be twice too large. If however we pay attention to the circumstance that it is only at the surface of the fluid that the hydrometric part of the apparatus comes into operation, and that in so far as this is concerned, it is immaterial what the length of the stem, or depth of immersion of the retarding plate is, we shall arrive at a solution of the difficulty.

59. In such a case as the above, where it is very desirable to economise space as much as possible, the breadth of room occupied by the cylinders might be reduced one half, by placing a double series, one over the other. There would be a double series of cylinders but only a single trough, and all the cylinders immersed in the same body of fluid, the upper series of cylinders being so placed on the tops of the lower series, that the points of junction of the former should stand over the centres of the latter. A small opening would require to be left between the upper cylinders, so that they

Viragapatam Beach
Low Water Mark of the 17th Feb^y 1845
as compared with that of the
16th Aug^y 1844.



Remarks

From A to B a roadway formed 21 feet wide
On the facing shews where the sand
is level with Roadway
Sand lower than Roadway
From C to D require being covered with large stones
From E to D this work commenced 5th Dec^r.
2 & 4th Groins nearly covered with sand
Sand nearly level with the upper surface North side of
Groins 1 & 3

EXTRACTS FROM LETTERS AND REPORTS BY MAJOR ARTHUR T. COTTON ON
THE SUBJECT OF THE BULWARK CONSTRUCTED FOR THE DEFENCE OF
THE TOWN OF VIZAGAPATAM.

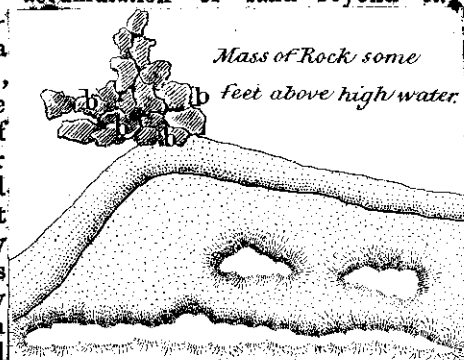
Extract from a letter to the Secretary to the Military Board.

SIR,

I have the honor to transmit a rough plan, showing the state of the Beach of Vizagapatam, which I have prepared in reference to the orders of the Board, contained in their letter No. 1238, dated 12th May last, to consider the mode of constructing the proposed Bulwark.

The point therein especially referred to me was the substitution of detached masses of bulwark for the continuous line proposed by Captain DeButts. As this plan shows the position and effect of a remarkable natural bulwark of this kind, situated about 2000 yards from the fort, it might be expected that if duly examined and considered, a very sound judgment may be formed by that means of the effect of the artificial works suggested.

Nothing can be more distinct and marked than the effect of this mass of rock on the line of coast, the outermost point of it is about 500 feet from the general line of the high permanent sand drifts, which are covered with mud. But about 80 feet from the outer point, the rocks are disconnected, so as to allow a passage for the water, marked in the plan *b b b*, which seems to prevent the accumulation of sand beyond it. Within it however, there is a solid bank of sand, level with the wash of the surf at high water spring tides, and extending about 1100 yards. By this the sea seems to be effectually prevented from encroaching all along that part of the beach. About 1200 yards from these rocks, the town commences, and the sea is washing quite up to the houses along its whole length, having carried away the front line for a considerable distance near the fort.



This accumulation of sand is found only on the south

side of the rocks. On the north side, immediately beyond them, the sea washes up to the high sand drifts. I should account for this by supposing that the principal current is from the southward. * * * * *

From these considerations I conclude.

1st. That projecting stone groins would certainly cause the sand to accumulate to the southward of them.

2nd. That they would affect a great length of beach; the rocks at *A* extending about 420 feet from the line of sand hills, seem evidently to collect the sand from a distance of 1100 yards. I should rather say the rocks are situated about 420 feet from the sand drifts, for it is not certain that they extend to them, as there are no rocks visible above the sand. A groin extending 50 yards would, according to this proportion, affect the bank for 400 yards, in which case *3* would protect the whole town.

3rd. That a very slight line connecting the outer point of the groin with the shore would be sufficient, as it would immediately collect the sand, the outer end alone being exposed to the force of the sea. * * * * *

It is evident that those works, though intended only to protect this town, will be of very considerable general importance, as an experiment which, if successful, may greatly facilitate the protection of any other part of this extensive line of coast, and on this account it is well worthy of much consideration.

24th June 1843.

Extract from a letter to the Secretary to the Military Board.

* * * * *

The first groin now contains about 3000 cubic yards of stone, and as it has been repeatedly exposed to very severe surfs while in progress, I do not think it would sink much more. We have on the spot and in the quarries, about 800 or 1000 cubic yards of the largest stones, which I think will be sufficient to complete the groin. The outer stones will be from 8 to 15 cwt., but by continuing the rails to the sea, we could easily convey stones of two tons.

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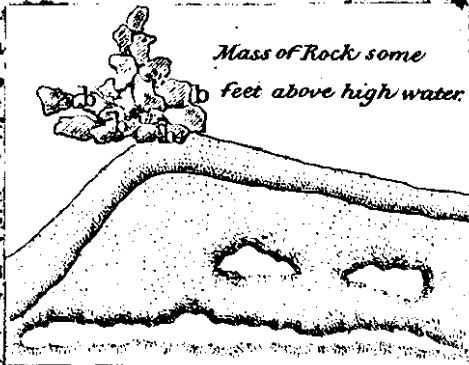
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3rd. That a very slight line connecting the outer point of the groin with the shore would be sufficient, as it would immediately collect the sand, the outer end alone being exposed to the force of the sea. * * * * *

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The second groin is commenced at the western

end of the Pensioners lines, 270 yards north of the first, so that, if necessary, a third may be interposed between them. This work may be carried on more rapidly than the first, as there is now a great number of persons ready to contract for any quantities of stones.

The cost of the first groin of 70 yards will have been almost 3500 rupees, if completed to 80 yards, including all the preparations, viz. making roads, purchase of stones, tools, rail-waggons, iron for rails &c. The second will cost almost 1800 rupees if made of the same length, which I conclude would certainly be advisable. The second point which I beg respectfully to bring before the Board is the effects of the first groin; I am happy to be able to state that they are already highly satisfactory. The last three or four spring tides have been very high, and accompanied with very stormy weather, producing a severe surf. The consequence has been a great encroachment of the sea along almost the whole line of the town (protected by the groin) by which a great number of houses have been washed down, both north and south of the groins, and at the southern end of the town a very solid mass of prickly pears forming the last barrier to the sea, has been almost totally swept away. But so complete has been the effect of the groin in accumulating sand to the southward of it, that the sea has not touched the shore for full 150 yards, that is, from the groin to something beyond the southern end of the parade, and its influence was so extending, that in the last two springs the sea did not encroach on the shore nearer the groin than about 200 yards. The residents have all expressed their assurance that the groin has effectually stopped the encroachment on the parade, and that but for its construction a considerable breadth of ground there would have been cut away by the spring tides of the last two months. I thus felt satisfied that the first object, the preservation of the parade, is already attained. I transmit a section of the beach on the north side of the groin, and also that on the south side, both taken on the 13th September, from which it will be seen that near the inner end of the work, the sand is $6\frac{1}{2}$ feet higher on the latter side than on the former. The plan contains also, a section taken before the work was commenced, showing that while all along the outer point of the town great encroachments have been made, there has here been a considerable accumulation. The full effect of the groin can scarcely be seen yet, having been so short a time under construction; but as its influence already extends upwards of 150 yards, I should judge that it would ultimately protect full 3 times its length; and hence it may be hoped, that if the groin just begun is extended to 80 or 85 yards, it would not be necessary to construct one between the two now constructing, which are 270 yards apart. But at present I do not feel inclined to lengthen them beyond 70 yards, as I shall not be able to observe their further effects for some time to come, in consequence of the change of the monsoon, which will at all events prevent any accumulations on the south side of these works. I am informed that the currents in the north

east monsoons are so weak, that the accumulations are never removed from the south sides of the rocks on the coast, nor any considerable accumulations formed on the northern sides * * * * I beg to call the attention of the Board to the great excavation of sand immediately beyond the end of the groin, as shown by the section, the water there being 6 feet deeper than it is a few yards farther. The reflow of the surf causes a strong current along the sides of the groin, which is continued beyond it, so that a man cannot swim from seaward to the end of the work. I think this particularly worthy of notice, because it would seem at first to show that a communication across the surf might be effected by a simple groin or jetty, for if there is so strong a current at the point of such a work, it seems probable that by carrying the jetty beyond the break of the surf, and sinking a short break water at right angles with it, and little detached from it, there would be always both deep and smooth water between the end of the groin and the break water, where boats could lie safely. This subject seems to be worth examining, with reference to the improvement of the port of Madras. Should it be thought worth while to make any experiment on this point, I would observe that no place on the coast would be more suitable than this, where it could be done so cheaply, both on account of the low cost of labour, ($1\frac{1}{2}$ anna for the highest rate of cooly) and also the facilities of carrying, and the short distance from the rocks to the beach, for the southward groin will be only 300 yards from the quarry. The cost of stone per cubic yard at that point will not exceed $2\frac{1}{2}$ annas, so that per 1000 rupees 6400 cubic yards might be added to that groin, making 11400 cubic yards, sufficient to extend it to 150 yards, and make a small break water opposite to the end of it. I only give this calculation to show at how small expence some experiment could be made here, if the subject is considered worth prosecuting.

1st October 1843.

Extract from a letter to the Secretary to the Military Board.

I stated in a former letter that the backwater rose to a level of from $1\frac{1}{2}$ to 2 feet above the highest spring tides, but I had mistaken the water mark, and I have since found that it rose exactly 5 feet above the level of the highest springs; and as the greatest height was at 2 A. M. on the 25th, the hour of low water, and the tide rises nearly 5 feet at springs, it is evident that the backwater was at that time nearly 10 feet above the level of the sea, from which a judgment may be formed of the vast body of water that came from the interior. The point of sand on the north side of the river was entirely swept away, making its mouth much wider than it was before.

With respect to the effects of the hurricane on the beach, it should be observed, that just at the previous spring tides, there had been a severe and continued storm, which had washed away most of the sand that

accumulated near the groins, and this gave the hurricane a great advantage, and caused the encroachment where otherwise there would have been none. On the other hand, most providentially, the strength of the storm was from half ebb to half flood, had it blown in its force at the time of high water, when the sea would have been two or three feet higher, the destruction in the town must have been far greater. As it was, an encroachment of from 6 to 10 yards in breadth, took place throughout the whole length of the town, (taking away a complete row of houses) excepting near the groins, that is from 100 yards south of the first groin, to 100 yards north of the second, where the encroachment was less, that is from 1 to 4 yards in breadth. Since that time, there has been a very great deposit of sand, both north and south of the groins, but especially between them, so that at low water, a person can walk straight from the outer end of one to that of the other on the dry sand, that is at 70 yards from the shore. I am therefore of opinion, that had the two groins been completed long enough for the sand to have collected between them, the hurricane would not have cut away the beach there. I have not yet however sure grounds for judging of this, I feel confident that no great deposit of sand can take place during the stormy part of the south-west monsoon, that is, nothing like that which occurs during the fine weather. From constant observation of the changes in the beach at this place, I have satisfied myself of these points respecting the sands.

1st. They are always carried away as the strength of the surf increases during stormy weather, and deposited as the sea subsides.

2d. They are always carried away as the spring tides advance, and deposited as they go off.

3rd. They are always carried away during flood tide, and deposited during the ebb.

4th. The effect of the current upon them is very small, probably quite insignificant in comparison of that of the wind. In whatever direction the surf strikes the beach, (which will almost always have some slight degree of obliquity), in the same direction the sand will be carried forward, even though the current may be the opposite way; thus if the wind is from east by north, on a coast lying north and south, the sand will be carried to the southward even though the current may be running to the northward. If at any time the surf should strike quite directly on the beach, perhaps the sand might be carried forward in the direction of the current, but I think it would scarcely move either up or down the coast, because the current close in shore is extremely slight. Just within the mouth of this river the progress of the sand inwards by the action of the surf is plainly seen, while there is a strong ebb tide, until there is a large body of water coming down from the country, producing a current of several miles an hour.

I have now commenced a facing of stones along the beach, in addition to the groins, for the following reasons.

1st. The storms of the last monsoon, and especially the hurricane, have now cut so far into the town, that to obtain a road for conveying the stone to the groins, a vast number of houses must be removed, and the expense would be so great, that it seems out of the question to carry the stones that way; to convey them along the sands would be a most laborious and expensive work, and there therefore seems no alternative, but to make a road outside of the town, on a level a few feet above high water mark, and securing it by a slight facing of stones. It will not require much stone, because the whole fine season is before us, and the force of the surf now is nothing compared with what it was in the south west monsoon; and also before the strength of the next monsoon, we may expect that a much greater deposit of sand will have formed.

2nd. There is now no communication along the beach at high water, and this was before one of the principal roads from north to south of the town; this communication will therefore not merely answer for conveying the stone, but it will be of great use afterwards.

3rd. I am not yet certain respecting the distance between the groins, and should they be too far apart, I think it will be as effectual and easy to make a slight bulwark, as to interpose additional groins. It should be observed, that I consider the groins at their present distance, will at all events effectually resist the main force of the sea, so that the facing of stone I am now forming, need not be of more than an eighth of the section that a regular bulwark would be, and I hope that it will always have a large deposit of sand outside of it.

Part of the wooden railroad has now been worked with waggons on wooden wheels, bearing loads of 2½ tons and under, for more than two months, and it has thus far answered admirably, but it takes a long time here to collect any quantity of materials, and to construct the waggons &c.

A third groin has been begun 250 yards south of the first, and a railroad is under construction from the end of the hill south of the town to it, a distance of only 300 yards. On this line, the waggon works with perfect ease on a curve having a radius of only 19 yards. When the works now in hand are completed, there will therefore be three groins 70 yards in length, including between them 480 yards, and protecting, I should hope, 800 yards of beach, along which also there will be a road with a facing of stone. They will require about 9000 cubic yards of stones, of which 1000 are ready.

The actual expenditure about the beginning of this

month was 5500 rupees, of which about 1700 rupees had been expended on stores, railroads, waggons, the removal of huts at the quarries &c. The quantity of stone deposited, or ready for deposition, was about 9000 cubic yards, which gives an average of 10 annas per cubic yard, including every thing, and deducting the cost of preparatory work, about 7 annas per cubic yard, including native superintendence.

* * * *

The length of railway already laid is 1100 yards, the cost about 10 annas per yard of road, including laying; the material is dammerwood, the waggons cost about 50 rupees each, and it requires about 2 men per ton of load to work them on a level. From their cheapness, I think they would often be useful in public works. We have no difficulty in working a curve of 19 yards radius, and one with radius of 12 yards is now constructing, which upon trial appears to answer. To cover the rails with an iron plate of $1\frac{1}{4}$ inch by $\frac{1}{4}$, would cost $\frac{1}{2}$ rupee per yard of road. It costs here about 2 pice to convey a cubic yard of loose stones 200 yards on the railroad, and about 1 anna for the same if conveyed by coolies.

13th November 1843.

To the Secretary to the Military Board.

* * * *

Since my last report I have continued to cover the north groin with large stones and it is now nearly completed. The 3d or south groin is also carried on, extending 32 yards. An embankment of sand faced with rough stone now extends along the beach from the new quarry on the Mosque Hill at the south end of the town to the north groin, but it requires yet to be raised and much additional stone to be thrown against its face, which work is in progress; the smaller stones being thrown on this line, while the larger ones are taken to the groins along this embankment, the rails are laid from the new quarry to the south groin, and they will be continued along it to the first groin.

* * * *

The deposition of stone at the south groin, has been considerably retarded by a sudden and strong set of the surf upon the southern point of the town, which has obliged me to throw a large quantity of stone down there for the protection of the railroad, and also of the common road beyond the end of the former. This encroachment of the sea is very remarkable, as there is now little surf, and also the main level of the sea is near a foot lower than in the south-west monsoon, on which account the sea usually makes no encroachment. All along the remainder of the town, there has been a continual deposit of sand since the stormy part of the monsoon terminated; and of late, the accumulations have been very great between the groins, where we had made a raised embankment 3 or 4 feet high only a month ago, the sands are now nearly level with the

top of the bank, and there is a prodigious deposit of sand against the groins. Yet the set of the sea upon the southern part of the town was so decided, that there is no doubt it would have washed away all the ground up to the Mosque Hill, and have cut off the communication from the town to the river, had it not been for the stones thrown down for the protection of the railroad; and beyond the end of those stones it cut away the ground with such rapidity, that I could not prevent it from destroying part of the common road, though I threw down all the stone I could obtain. As this is a very important point, being the only line of communication from the town to the river, and the great road to Madras, it seems absolutely necessary to protect it by the construction of a groin of 30 or 40 yards in length. As the distance for the conveyance of stone would be only a few yards, the cost of this would be very small, about 3000 cubic yards at 5 cubic yards per rupee, would probably be sufficient.

* * * *

There has been no encroachment at all at any part of the beach, excepting the southern point, since the hurricane. But there are several reasons for this; 1st, at this season of the year there is no surf of any consequence, 2nd; from the continuance of fine weather and lightness of the surf for a long time, the sand has gradually accumulated; so that instead of a steep beach, as there is towards the middle and end of the south-west monsoon, there is now a broad flat of sand extending to upwards of 50 yards in breadth, and opposite the groins it is upwards of 100 yards in breadth, 3d; the mean level of the sea is nearly a foot below that in the south-west monsoon. There is thus always a cessation of encroachments during the fine part of the north-east monsoon, and the effect of the sea upon the southern point of the town lately seems to be quite unusual, it may be in a great measure owing to the retention of the sands by the groins, but it seems not to be entirely attributable to that, because there has been no such encroachment immediately south of the first groin, from which part the sand coming from the north is as much cut off as it is cut off from the south point.

But while there is this general accumulation of sand along the face of the town, the effect of the groins is most distinctly seen, both in the height and breadth of the sand in their neighbourhood.

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27th December 1843.

To

W. U. ARBUTHNOT Esq.

Collector of Vizagapatam.

SIR,

In reply to your letter of the 27th instant, desiring me to prepare an estimate for the extension of the works now under execution, for the defence of the town from the encroachments of the sea, I have the honor to state that, from the experience of the progress

of the sea of late years, and especially during the season that I have been here, there seems no ground to expect that it will not continue to advance and destroy any part of the town that is left unprotected by stone work. The original estimate was intended to provide for the protection of 350 yards in length only, viz. the parade and the pensioners lines, but I have reason to hope that it will be found quite sufficient to protect the beach from the river as far as the present northern groin, and I have therefore prepared an estimate for the remaining 500 yards of the town lying north of that point. This additional work can be executed at a lower rate than was before estimated, on account of the apparatus, viz. rails, waggons, and cranes already provided, the rails are sufficient to reach from the quarry lately opened to the north extremity of the town, but two or three additional waggons would be desirable, that the work might be hastened. The estimate now forwarded provides for the construction of two additional groins, and a raised road with a slight facing of stone between them, which would complete a good line of communication along the whole sea face of the town; this is very much needed, especially on account of the encroachments having compelled the people to build in the most crowded manner along that line. It is of course most desirable that this work should be done now; besides the cost of apparatus, it has of course cost much time and money to get the present arrangements organized, to get the people accustomed to the quarrying work, the rail-waggons, cranes &c. and if the works are not completed, it will cause much additional expense to begin entirely anew at some future time. It is also of great importance to press on the work as much as possible during the present season of the year, for two reasons; first, because that there is now no interruption from storms, which caused much additional expense in the south-west monsoon; and secondly, if the groins are constructed before the stormy part of the year, the sand now accumulated along the beach will be retained, whereas, if they are not constructed till after May, the sand will be carried away, and considerable encroachments will again be made in the stormy months.

With respect to the necessity for the completion of these defences, I should mention that about 15 yards in breadth of the whole surface of the town, excepting about the parade, has been washed away since I came here, the whole of this entirely covered with houses; and as the sea advances the buildings that will be destroyed by it are increasingly valuable. At the southern end of the town the sea has cut away part of the high road to the landing place and to Madras, and but for the stones lately deposited there this communication would have been entirely cut off, considerable work will be required to secure this point.

* * * *

28th December 1843.

Estimate of the Expense of extending the Bulwark now constructing at Vizagapatam, for the protection of the Town.

2 Groins 70 yards in length containing 10,000 cubic yards.			
5000	Facing 500 yards length of beach north of the present northern groin at 10 square yards of section.		
Cubic yards 15,000		Rough stone, at 3 cubic yards per rupee....	5000
	Additional apparatus.....		500
			Total C. Rs. 5500

Vizagapatam, 28th December 1843.

Extract from a letter to the Secretary to the Military Board, under date 6th May 1844.

* * * *

The bulwark has been completed to the northern end of the pensioners lines, that is, so far as it can be, till the effect of the south-west monsoon upon it can be seen. The southern groin, at the southern part of the town is 30 yards in length; the other three 70 yards each, and the facing between them is in all 800 yards long and 7½ feet above the level of the highest spring tides. There remains of the estimate about 750 rupees, which would be sufficient to cover the expense of depositing about 4000 cubic yards of stone, and this would be available for raising the points of the groins or any part of the facing which might sink during the monsoon. We have already had some considerable surfs, and a great part of the sand deposited during the north-east monsoon along the whole face of the town has been carried away, but much more at the northern end than between the groins. Though the points of the groins have been exposed to the surfs now for several weeks, they have not yet sunk at all perceptibly. The total quantity of stone deposited is about 24,500 cubic yards, besides some ready in the quarry, and the cost 12,560 rupees, being at the rate of just 8 annas per cubic yard, including railways, cranes, purchase of houses, forming roads, and every other item.

We are now proceeding with the railway, and facing, north of the northern groin, upon the estimate sanctioned in the Civil Department, and have completed nearly half of it, but the beach is there now so steep, and the sand still washing away so fast, that we shall scarcely be able to make good our line of communication the whole length, and secure it before the moonsoon.

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6th May 1844.

Extract from a letter to the Secretary of the Revenue Board, Department of Public Works, under date 25th May 1844.

* * * *

The bulwark however will certainly require the Superintendence of an officer during the monsoon without

intermission, to observe its effects, and be ready to press on the work in case of any point being endangered; the extension of the bulwark to the northern end of the town especially, is in a very exposed state, there being only a weak facing, and the first of the new groins being but just begun. During these months I suppose a Civil Engineer cannot do much in this Division, the rains being so constant, and the country so impassable from want of roads, yet it is extremely desirable that he should be at liberty to do whatever circumstances will allow. I have not yet been able to see much of the division, but from what I saw in my late tour to Gangam and Kimedy, and all that I have learnt of Rajahmundry, it is quite evident that three active Officers are most urgently required in it, the expenditure in it hitherto has been so utterly inadequate &c. &c.

Extract from a letter to the Secretary to the Military Board.

I have continued the roadway and facing to the northward as fast as we could obtain stone for it, but it proceeded very slowly on account of the great quantity of sand which had been swept away by the first surfs we had in the beginning of the month, which yet were comparatively light, the southerly winds evidently still blowing along the coast only. We had continued it 400 yards from the northern groin, when on the 24th instant, the heavy bay swell indicating that the southwest monsoon had commenced in the bay, set in with considerable force, and in two days swept away all the remaining sand from the foot of the facing, leaving the work exposed to the full force of the sea. It was evident now that there was no hope of continuing the extension of the roadway, as every stone that could be obtained would be required to secure what had been already constructed. Since that date therefore, we have been adding to the stone facing, and the sea every day causing the stones to sink as fast as we could bring them, we have now employed coolies in addition to all the rail bandies to convey stones to this part of the work, by which means we are now throwing in about 200 cubic yards a day, we are now rather gaining ground, and the surf having a little diminished in the last two days, the sand has again risen there. No time however must be lost in strengthening this facing as there will be in future no complete intermission of the heavy swell, and in the course of next month we must expect severe surfs.

Had the work been one month in advance of what it is, the groin would have been carried out some distance before the sand was washed away, and much of it would have been retained. At present we cannot spare any stone to carry on the groin which had been just begun.

It will be evident, that in this state of things, we shall be compelled so to strengthen the facing that much smaller groins will be required.

I had before come to the determination in this new part of the work to make the groins shorter, and at smaller intervals, for the following reasons; first, so far as I can at present judge from what I have seen of these works, I am inclined to think less favourably of the very long groins than I did at first, that is, I think it probable that short groins at shorter intervals would protect the beach with less stone; chiefly because it does not appear that nearly so much stone would be required at their points as I had thought; secondly, it seemed very desirable to obtain as much information from this work, as possible, and that therefore it would be better to make a trial of short groins as well as long ones, if it could be done without the probability of a waste of stone. I had consequently commenced the two first groins of the new work at intervals of 150 yards, purposing to make them 30 or 40 yards long. As matters however now stand, I must be guided entirely by the effects of the surf upon the work, purposing however, that, if we get the facing well secured, I would proceed with the groins as begun.

With respect to the effects of the groins already constructed at present, they are very striking, as will be seen on inspecting the accompanying plan and section of the beach; throughout the whole length of that part of the work, there is a high and broad bank of sand outside the road-way, while north of the groins, the sand is 14 feet below the top of the road-way, and the surf breaks with its full force on the facing. This, so far as it goes, is highly satisfactory, but we must wait for the heavy and continued surfs of July and August, before we can properly judge of the effects of the groins. There is not yet the least appearance of any sinking of the ends of the groins, though for the last week the surf has broken on them very heavily.

There is every proof that the surfs would have already made a further cut into the town, and destroyed many houses, but for the new work, so that it was of great importance to extend that work as far as possible. There is however still about 100 yards of the town exposed, beyond the end of the work, and I am afraid it will be impossible to save it from encroachment this season.

30th May 1843.

Extract from a letter to the Secretary to the Military Board.

After my last report dated the 30th May, I continued for some time to struggle against the heavy surfs, which broke upon the new work towards the northern part of the town, but I was unable to supply stone fast enough to maintain the whole extent of facing; (400 yards) I was obliged therefore to abandon 100 yards of it, and as soon as I had sufficiently strengthened the remainder, for the time, I ran out a new groin at the end of it, 300 yards from the next southern groin. This

5th groin is only 55 yards in length measured from the bank, that is 15 yards shorter than the other; I left it thus short in order to see whether it might not be sufficient, as the other groins appear now to be longer in proportion to their intervals than is necessary. I also covered this groin and the new facing with large stones. During these 3 months the sea has broken frequently with great violence upon this new facing, as it was quite unprotected by sand, and I have had constantly to raise it in consequence of its sinking. The surf has repeatedly broken over it, and thrown up volumes of spray 7 or 8 feet above it, though it is 8 feet above high water spring tides, especially during the late springs when we had the heaviest surfs this year; we had then again to take up the rails in consequence of the stones having sunk so much. During the monsoon no sand of any consequence accumulated here, some collected at times and again washed away, excepting in the angle formed by the next groin, where the sand soon formed sufficiently to protect the facing; and its effect in this way was remarkably seen in the last heavy surfs; where the sand had risen to within 4 feet of the top of the facing, not the least injury was done to the railway, while further on, where the sand was 4 or 5 feet lower, the stone work was so deranged that it was necessary to take up the rails.

Since the turn of the springs the sand has deposited with extraordinary rapidity, and where it was $14\frac{1}{2}$ feet below the top of the facing about 6 weeks ago, it is now only $4\frac{1}{2}$ feet. This last new moon is generally the end of the stormy part of the south-west monsoon, so that it is not probable that any severe surfs will break on this work till the setting in of the north-east monsoon, when there may be expected one or two gales, but in the interval probably a large quantity of sand will be deposited.

On the 14th of this month, there remaining nothing of any consequence to do to the work already done, and it being impossible to extend the bulwark to the northward from want of space to convey the stones, I reduced the establishment to the lowest that I safely could, keeping only one or two bandies at work, in case of stones being required at any point. There will not probably be sand enough to the northward till November, to enable us to proceed and complete the line to the north end of the town.

I will now remark upon the state and effects of the old work beginning at the south end. The short groin marked No. 1 in the sketch, sunk a little on the south side during the monsoon, but not so as to lower the work, some of the stones on that side only having slid down a little; it has not been necessary, nor is it now, to add any stones to it. The surf washed away the sand south of it, and the facing there sunk a little. Between Nos. 1 and 2, the sand was washed away gradually during the last two months, principally, of course, in stormy weather and at spring tides, till a part

of the facing was laid bare, to 6 or 8 feet below the rails; during the last springs this part sunk a little, the surf breaking very heavily on it, and flying over the roadway, and it has been necessary to add a small quantity of stone to the facing. The difference between the quantity of sand in this part of the work, and that further to the northward is very remarkable, it is also to be observed that the quantity is greater between the groins Nos. 3 and 4, than between Nos. 2 and 3. There appear to me to be two reasons combined for the sand being so washed away between Nos. 1 and 2 viz. first, that the surf leading round the Dolphin's nose strikes here nearly directly on the beach, in consequence of which it does not carry the sand along and lodge it against the south side of the groin No. 2, but draws it back into the sea; 2nd, in consequence of the failure of the monsoon, there has not been a single fresh in the river to sweep away the bar, and all the sand that has been brought round the Delphin's nose has collected in front of the mouth of the river, leaving, instead of a narrow bar 5 or 6 feet deep at low water spring tides, an extensive flat of sand covered with only 1 foot of water at that time, and forming a most serious obstruction to the trade, so much so that I believe the large donies will hardly be able to leave the port this year, unless there is a fresh in the north-east monsoon. The usual supply of sand for the beach north of the river has thus been almost entirely cut off. Had the usual freshes taken place, they would have swept the sand away from the mouth of the river, and it would have been carried on shore by the surf. If there should be a fresh at the setting in of the north-east monsoon, it is probable that a very large quantity of sand will be deposited along this part of the work. It seems probable, however, that it will be necessary to strengthen this part of the facing a little more.

The groin No. 2 has also sunk a little at the end, but far less than I had expected, and it has required no additional stone. Between Nos. 2 and 3, there is even now, at the end of the monsoon a large mass of sand, and instead of the facing having been laid bare, it has been covered with sand to within a few perches of the roadway. The sand here continued to diminish in breadth, though it was thrown up higher, till lately; but it has now begun again to accumulate.

The groin No. 3 has not undergone the slightest change. At the end of it, where at this time last year there was 11 feet of water, at low water, the sand is now bare, as it is also at the ends of the other groins, excepting the north one; shewing I think, that there is a permanent change in the line of the beach. Between No. 3 and 4 the quantity of sand is enormous, extending nearly to the end of No. 4, on a level with, and in some places higher than the groin, and even than the roadway; no where are more than a few inches of the facing uncovered. As this is the time of the year when the sand is usually most swept away, or nearly so, it seems a very satisfactory state of things. North of No. 4, and

immediately adjoining it where there was time for sand to accumulate between the construction of the facing and the setting in of the monsoon, it has never been swept away, being protected from the force of the surf, in a great measure, in consequence of its striking obliquely on the south side of the groin. At this time last year the surf washed up on the north side of No. 4 to within the line of the battery. If we were now to have a heavy gale, it would doubtless wash away a great deal of the sand all along the work, but I doubt whether it would remove any part of the facing from the groin No. 2 to No. 4, there would be some sinking of the facing south of No. 2, but a little additional stone would probably repair the damage. Excepting a short interval of bad weather at the setting in of the north-east monsoon, we have now a prospect of 8 months of smooth water, during which time the sand will accumulate all along the town.

The following points seem worthy of being remarked, in addition to what has been said.

1st. It has not been nearly so stormy a season as the last, nor have we had any decided gale, so that the work has not had so severe a trial as it might; but on the other hand, as most part of the work was executed during the fine weather, it had not had time to accumulate any thing like so much sand about it, as there will be another year; and also the part that was then finished stood the storm and hurricane of October without injury.

2nd. The ends of the groins have scarcely sunk at all, even No. 2 and 4 which were thrown out in fine weather, and consequently did not sink to any considerable depth at the time, though they have been exposed to heavy surfs almost all the monsoon. Even No. 5 which was constructed only 6 weeks ago, has not sunk perceptibly. Thus, No. 3 the first constructed, which was carried out 70 yards in the height of the monsoon, has a foundation of probably about 6 yards at the end, while Nos. 1, 2 and 4 can scarcely have more than 2 yards, showing how much stone would be saved by carrying out the groins immediately after the monsoon, or as soon as the sand is thrown up.

3rd. The surf has not the slightest effect on the stones themselves; not a stone has been moved at the ends of the groin, though the slopes are not near so great as I at first proposed. And even on the facing, where the water was about 7 feet deep at high water, and the surf broke so violently as to fly 7 or 8 feet over the top of the roadway, though the slope was quite steep, and many of the stones were not large, the largest being under $\frac{1}{4}$ a ton, the slope was scarcely altered, standing probably at about $1\frac{1}{4}$ to 1.

4th. A slight facing seems to be useful, at least at first, in case of the sand being washed away, but I am almost inclined to think that with groins extending as

these do, or 55 yards beyond the line of facing, when once the sand is accumulated, the facing stones might be taken away.

5th. From an inspection of the plan, it seems as if with this length of groins much larger intervals might be allowed, especially on a straight line of coast, where the surf breaks obliquely. Even at No. 4, the direction of the surf is, in consequence of the Dolphin's nose, more perpendicular to the beach than it would be at Madras, for instance. It appears as if it would not make any difference if the groin No. 3 were removed. There is no doubt that where the evil had gone so far as it had done here, and no time was to be lost, so many groins were useful, as they formed a better protection to the beach at first, but from what yet appears, I rather think that one groin at each end of the town, and one in the centre, would have been sufficient.

6th. It seems evident that a small number of long groins, are preferable to a greater number of short ones, in this respect, that they inclose a greater breadth of sand, and in case of a succession of storms, it would take so much longer to sweep it away. And if they are constructed in the fine season, the quantity of stone in them would not be very greatly disproportioned to their length.

7th. I have made the groin No. 5 only 40 yards long beyond the facing, that is 15 yards shorter than the others, and at 300 yards from No. 4, in order to see whether a shorter groin will not be sufficient for the intervals.

There has not been the least danger to any part of the town behind the bulwark, but I regret to state that to the northward of it, many houses have been washed down, which I could not find any means of preventing. The quantity of stones in the northernmost part of the facing near No. 5, is very great indeed, we have had to add to it almost throughout the monsoon; in consequence of this, the cost of this part of the work has been greater than its due proportion of the last estimate, on the other hand I hope that from past experience we shall be able to do the remaining portion of it below the estimated cost, by postponing it till the sand is accumulated there.

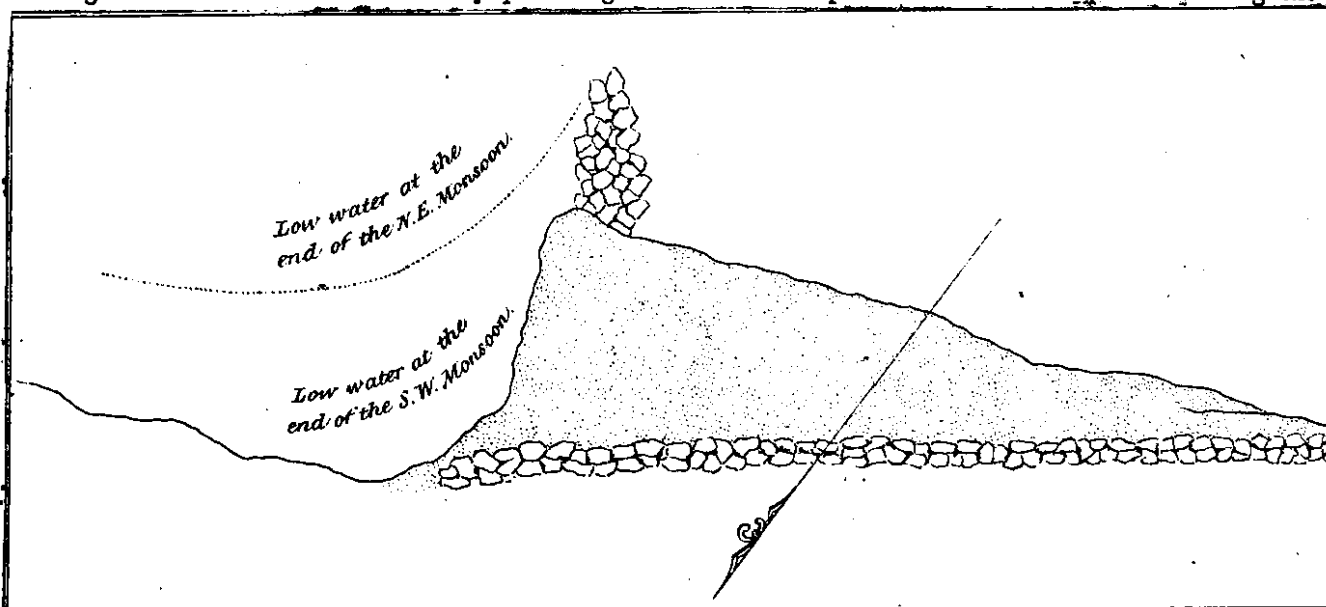
* * *

In the sketch, the low water mark of the 16th August shows its state at spring tides, the low water marks of the 17th and 19th are added, to show the rapid increase of sand as the springs subsided, a greater breadth of sand being exposed though the water on the last day did not fall so low as the 16th. The high water mark of the 21st is inserted, to show how far the high part of the sands extends towards the end of the groins, this was an ordinary tide between the springs and the neaps. At spring tides, with a heavy surf, the water washes up to the facing almost throughout.

Upon the whole, the quantity of sand along the work is far greater than I at all expected; I thought that by the end of the monsoon, the whole line of facing would have been more or less exposed.

I think I omitted to mention at the time of the setting in of the south-west monsoon, what had been the effect of the north-east monsoon upon the sands, generally, along the coast. Its effect upon the sand in moving it to the southward was evidently quite insigni-

ficant, in comparison of that of the south-west monsoon in the opposite direction. At the ledge of rocks forming a natural groin between the town and Waltair, which was particularly mentioned in my first report to the Board, there was then a hollow in the beach on the north side. This was not filled up in the north-east monsoon, that is, the line of high water was scarcely at all altered; but it became shallower, so that the line of low water was further-out, in the way here shewn. But this deposit of sand takes place all along the



straight line of the coast, as well as in this hollow, during the fine weather. Hence it appears, that though there is some little time during which there is a heavy surf from the northward, just at the setting in of the north-east monsoon, which must move some sand to the southward, yet that this effect is very slight, and that there is consequently a very great balance in favour of the sand moved by the south-west monsoon, so that upon the whole the sand is continually carried to the northward, and consequently where there is a promontory like the Dolphin's nose, which in a great measure cuts off the supply of sand from the southward, the sea must necessarily encroach on the shore north of it, unless stonework is thrown out to prevent it. I have no doubt that this preponderance in the effect of the south-west monsoon is also found at Madras, (though not to so great an extent) as the surfs produced by the southerly winds continue much longer than those of the north-east monsoon; and I am convinced that the movements of the sand depend solely upon the direction and force of the surf, and are entirely unaffected by the current, simply because the force of the current along the shore is nothing, when compared with that of the surf. As respects Madras, I should draw this inference from what I have seen here, that stone groins would protect the beach for a considerable distance, probably 5 or 6 times their length, and that it will make an enormous difference in the cost of such works if they are executed during the fine season, for the reasons mentioned above.

26th August, 1844.

Extract from a Letter to the Secretary to the Military Board, under date 18th June, 1845.

Since my last report on the progress of the bulwark at Vizagapatam, I have several times expected to have an opportunity of personally inspecting the work, and on that account I have postponed sending any further statement hitherto. I have, however, had such important duties in this district, the works have gone on so well, and Serjeant O'Hara's reports have been so entirely satisfactory to me, that I have not again visited Vizagapatam. What I have now to report, therefore, is merely what I have learned from the reports of Captain Shaw, (late in charge of the division during my absence) who inspected the work, and of Serjeant O'Hara.

The 6th or northernmost groin was completed, and the facing carried about 100 yards to the north of it, that is, to the western extremity of the town, before the change of the monsoon, but not early enough for the sand to collect about that part of the work to the extent that was desirable, though still a large quantity had formed against it. At the first commencement of the strong southerly winds, the sand was rapidly removed from that end, and the extremity of the groin and the adjoining facing sunk a good deal. A good quantity of stone had been deposited near each groin previously, to be ready to apply to any point that might require it, and this was immediately used to repair the facing.

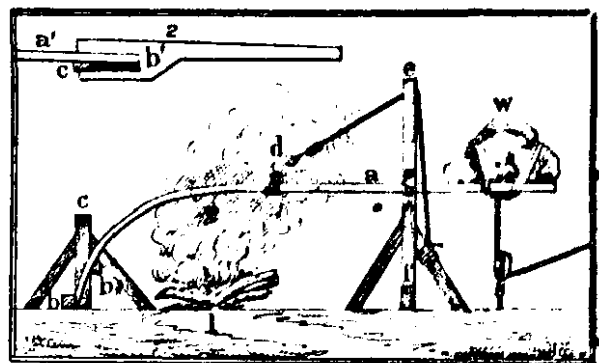
Since then the sand has again rather increased at that part of the works, and the late accounts state that the whole work is well covered with mud. This is exceedingly satisfactory, as the season has been more stormy and the surfs higher than has been known for many years. As a considerable part of the work had not had a whole fine season to collect sand about it, it was to have been expected rather, that the facing would have been laid bare, and have required additional stone from time to time. The mass of mud in front of the older portion of the work is so solid, that in these severe surfs and at the spring tides, the wash of the sea at high water has scarcely reached the stone facings. There are yet two stormy months, the effects of which remain to be seen, but thus far the work has answered completely. Part of the town has now been protected one whole season, and part of another extremely stormy one, without a house having been endangered. There is still a little money in hand, and the old materials are of some value, there being upwards of a mile of wooden

raile, &c., but I purpose keeping the accounts open till towards the end of the year, in case any additional work should appear necessary.

As I propose hereafter, when I have had an opportunity of visiting the place, drawing up a more complete report on this important experiment, I will only here observe, that near a mile of coast has thus been protected, at an expense of about 18,000 Rs. including all items, such as construction of railroads, and cranes, cost of tools, powder, &c., subordinate superintendence, and office establishment, the purchase of many houses, &c. I think if the necessary allowance is made for the difference of distance of transport of stone, and of the cost of this work with that of the Bulwark at Madras, it will put in a very striking light the superiority of loose stone groins with a light stone facing, to a solid continuous bulwark with a wall of masonry behind it.

Extract from a Letter from Captain G. C. Collyer, on the Subject of the Mode of bending Planks.

I suppose you are well acquainted with the method used in this country for bending planks for ship-building purposes. I had never seen it before I went to Cochin, where I was constructing a Steam Dredge. It is a simple, cheap, and very efficient method, and as others may not have seen it, like myself, perhaps a slight description may be of assistance to some one similarly employed. Planks for all sizes of craft from boats to vessels of the largest class are thus bent. The plank *a* to be bent is wetted all over with a solution of cow-dung in water, tolerably thin, and mixed with sand; it is then put in between the two transverse timbers *b*, *b'* (as shewn in the accompanying sketch), attached to the upright *c*, and is bent over *b'* by attaching a weight *w* or any other contrivance, (a rope and pulley purchase) at *d* a chain is attached, thence a rope goes over a pulley at *e* on the upright *f*, by which the plank can have a little more curvature given to it if required. Sometimes a peg is inserted at *o* as the case may be, by which an additional strain upwards can be borne at *a*—all this time a plentiful dose of the above mixture is applied underneath, and at top, to prevent burning from the fire, &c. &c. It is taken down and fitted occasionally to the part of the vessel to see if the curvature is right. It may sometimes happen that the plank is too short for the frame; when this is the case, the end of the plank *a'*, fig. 2, is inserted into another piece *b'*, and confined by a cleat *c'*; this is perhaps a very rude way, but it is a very cheap and efficient one—and I have seen planks bent by its means, without a flaw being produced in them. Perhaps the above not very elegantly worded description, and still worse diagram, may, when put by your master-hand into shape, be of some use in the Transactions—a hint sometimes helps a man who would otherwise be thinking about boilers, steam-boxes, and all the other contrivances European ship-builders require.



ABSTRACT OF SOME EXPERIMENTS ON THE STRENGTH OF WOODS TRIED AT GUNTOOR IN 1840, AND AT SINGAPORE IN 1843—FURNISHED BY CAPTAIN S. BEST.

No.	NAMES.	Length.	Breadth.	Depth.	Cubic Inches.	Weight.	Specific Gravity	Length between supports.	Weight sustained before breaking.	Corresponding deflexion in the middle.	Deflexion corresponding to	Weight sustained.	REMARKS.
		Inches.	Inches.	Inches.		oz.		Inches.	lbs. oz.	Inches.	Inches.	lbs. oz.	
1	{ Mimosa Arabica, Baubool (Hindoostany) } { Toomakurra (Telooogo)	62-625	1-375	2	172	96	964	59-156	539-2	1-8125	{ 0-5 1-094	{ 155-12 346-0	{ The weights were removed and the wood became again perfectly straight.
2	{ Borassus Flabelliformis, Palmyra, } { Tar (Hindoostany)	62-625	1-375	2	172	96	964	59-156	255-14	1-1875	{ 0-5 1-0	{ 104-0 217-4	{ This specimen was cut partly across the fibres.
3	Do. do.	62-625	1-375	2	172	96	964	59-156	474-14	1-71875	{ 0-5 1-0 1-5625	{ 117-2 230-2 423-4	{ Cut parallel to the fibres, but $\frac{1}{2}$ was of the pithy internal wood.
4	{ Bambusa Afundinacea, common hollow bamboo, } { Bāns (Hindoostany) } { Moongil (Tamil)	62-625	D. 1-625 to 1-875	Δ 1	136-5	19	of the solid part 620	59-156	423-4	3-375	{ 0-531 1-0625 1-5 2-0625	{ 88-8 168-10 255-14 320-4	{ D. exterior diameter. Δ inner diameter.
5	Dāboo Dāgoo (Malay)	73	2-	1-469	214-0	130	1050	66	0	0	{ 0-6 1-2	{ 141-8 497-0	{ The weights were removed and the wood became again perfectly straight.
6	Do. do. (do.)	73	1-469	2-	214-0	130	1050	66	953-8	3-40	{ 0-51	{ 240-8	
7	{ Moorubboo } (Malay) { Marbow	73	1-42	2-	207-5	114	949	66	728-8	3-02	{ 0-78 1-52	{ 228-8 478-8	
8	Krānjy (Malay)	73	1-45	1-8	190-5	152	1379	66	1103-8	3-95	{ 1-8 1-28	{ 978-8 803-8	
9	Dāmalāut (Malay)	73	1-3	1-9	180-33	124	1188	66	753-8	3-2	{ 0-6 0-8	{ 403-8 228-8	
10	{ Sirīya } (Malay) { Poon	73	1-35	1-95	192-0	84	756	66	503-0	2-67	{ 1-7 0-4	{ 478-8 103-0	
11	Do. (two pieces, one on the other,)	73	1-23	{ 1- 1- 0-277 0-277 0-277 0-277 0-277 0-277	179-5	78	756	66	278-8	6-10	{ 2-48 3-40	{ 153-8 203-8	
12	Do. (eight pieces, one on the other,)	73	1-5	{ 0-277 0-277 0-277 0-277 0-277 0-277 0-277	243-0	80	568	66	0	0	{ 3-12 5-58 8-16 10-64 12-02	{ 16-13 33-8 50-3 64-1 70-10	
13	Do. one piece,	73	1-45	1-95	206	85-33	709	66	547-0	3-33	{ 1-0 1-5 1-75 1-25 2-0	{ 155-0 322-0 220-0 372-0	{ The deflexion originally 1-5 increased in 24 hours to 1-75. This was borne 4 days without further deflexion.

The four first experiments were tried by J. Goldingham, Esq. and myself. Having no other convenient weights, and the public Treasury being close to the spot where we were trying them, we made use of bags containing each 500 Rupees, and weighing with their contents each 12 lbs. 4 oz. The pieces of wood were laid on the supports not fixed. The deflexions were measured in the middle after each bag was added, but it would not serve any useful purpose to show them all in detail. The remaining experiments were tried at Singapore by Lieut. C. M. Elliot, of the Engineers, and myself, and with great care. We used as weights on this occasion bricks, of which 9 weighed 25 lbs. The 11th and 12th experiments were tried in order to test the formula $W = \frac{b d^3}{l}$

The general results of these experiments are shown in the subjoined table, in which for the sake of comparison are entered (Nos. 14, 15, 16, 17,) experiments by Professor Barlow, and (Nos. 18 and 19) by Lieut. Brown, U. S. Engineers, quoted in Mahan's Elementary Course of Civil Engineering, pp. 47 and 48.

No.	Names.	l	b	d	W''	f	$\frac{W''^2 D}{4 b d^2 f \text{ or } E}$	W	$\frac{3 l W}{2 b d^2 \text{ or } R}$
1	Toomakurra,	58.15	1.375	2.0	350	1.125	1300312	539	8546
2	Palmyra, No. 1	58.15	1.375	2.0	170	.875	868436	—	—
3	Do. No. 2	58.15	1.375	2.0	0	0	—	474	7517
4	Bamboo,	58.15	D = 1.75	$\Delta = 1$	270	1.625	1030406	423	7706
5	Daboo Dago,	66.0	2.00	1.41	141	0.6	3023361	—	—
6	Do.	66.0	1.41	2.00	378	0.78	3047872	953	16728
7	Marbow,	66.0	1.42	2.00	303	1.0	1917066	728	12888
8	Kranji,	66.0	1.45	1.80	603	1.28	5335333	1103	23243
9	Damalaut,	66.0	1.30	1.90	203	1.12	2180683	753	15885
10	Poon,	66.0	1.35	1.95	228	0.87	1881695	503	9700
11	Do. 2 pieces,	66.0	1.23	1.00	139	6.10	1331535	139	11167
12	Do. 8 pieces,	66.0	1.50	0.277	8	12.02	1641136	—	—
13	Do. 1 piece,	66.0	1.45	1.95	322	1.75	1230034	547	9821
14	English Oak,	84.0	2.0	2.0	200	1.28	1447026	637	10032
15	Pine,	84.0	2.0	2.0	150	0.931	1492019	—	—
16	Cast Iron (soft gray)	78.0	1.5	3.0	410	.075	17185533	—	—
17	Forged Iron (English)	36.0	1.0	1.0	560	.025	261274700	—	—
18	Pine,	85.2	2.75	5.55	0	0	0	5189	7429
19	Cast Iron,	36.0	1.0	1.0	0	0	0	800	4380

In the above table *l* is the length between the supports, *b* the breadth, *d* the depth, *W* the breaking weight, $R = W \frac{3l}{2bd^2}$, *W''* is the weight answering to *f* the deflexion, and $E = W'' \frac{R}{4bd^2f}$. Δ is the interior diameter of the bamboo, and *D* the exterior. For it, $R = W \frac{3lD}{2D^2 - \Delta^2}$ and $E = \left(\frac{W''^2 D}{3.6f \times D^2 - \Delta^2} \right)$.

$\frac{E}{8} = E$ and $\frac{R}{6} = S$ in the table of data, page 150, in the edition of Professor Barlow's work, published in 1837.

The following particulars I obtained from an intelligent Chinese Carpenter at Singapore, named Ah-See-Ah.

Daboo, Dāgoo, or Dāwoo is used for beams in houses, piles, &c. It is a strong durable wood, and grows to a large size.

Marbow is used for furniture, windlasses, handspikes, ship gun-carriages. It is a very fine wood, but does not grow so large as the preceding.

Krānji. The strength of this wood is very remarkable, being more than double that of oak. The Chinese use it for the sternposts of their junks and for anchors, and they export it from Singapore. A log 24 feet long and 1½ foot square is worth ten dollars.

Dāmalāt and Tampeenus are used for beams and posts in houses and for joists. Dāmalāt cracks and shrinks, lasts long except in water, where worms destroy it. It grows to 90 feet in length by 2½ feet square. Piles 24 feet long and 1 foot square, cost at Singapore four dollars each. The Chinese exchange the masts they bring from China for Singapore Dāmalāt. A mast worth one hundred dollars at Singapore will sell for five hundred in China.

Tampeenus is very difficult to saw, but is a good wood, lasting long, not injured by exposure, and not so liable to crack as Dāmalāt.

The Sirāya or Poon is the most abundant wood in Singapore. Small spars are called Bintāngo. The best sort of Poon is grown on the hills and called Bātū Sirāya. It is distinguished by white threads running lengthwise. The Sirāya grows to 100 and 130 feet long squaring 3 feet at the butt. It is easy to saw and work up, used for all building purposes, but not capable of enduring exposure or moisture for a long period. Planks 20 feet by 1 foot by 4 inches are worth a dollar—16 feet by 11 inches by 1½ inch about a quarter of a dollar each at Singapore. Masts 90 feet long and 2½ feet in diameter may be procured for forty dollars.

NOTICE OF SOME FURTHER EXPERIMENTS UPON THE INFLUENCE OF JAGHERY IN CHUNAM, BY CAPTAIN J. T. SMITH, F. R. S. F. R. S. N. A.

In the first volume of our transactions an account is given of some experiments made by me, for the purpose of determining the value of jaghery as an ingredient in the composition of chunam. The result of those experiments was, that there could be no doubt of its beneficial influence on its first setting at least; the strength of a mortar composed of two of sand by measure to one of lime, mixed with pure water, being upon the average of a number of trials about 1½ lb. per square inch, and that of a precisely similar mortar mixed with a solution containing 1 lb. of jaghery to every gallon of water 3.62 lbs. or more than double as much as the first.

These mortars were only a month old, and I had no means at that time of giving any facts relative to the influence this ingredient might have on the final induration of the compounds; that change being a tedious one, which it might take months or years to accomplish. As the inquiry was an interesting one, however, both with respect to the influence of the jaghery after the cements had undergone the hardening effect of combination with carbonic acid, derived from the atmosphere, and the durability of its action throughout a course of years, I took an opportunity some time afterwards to set aside a series for future examination, and have now the pleasure to give a statement of the trial of five specimens of each kind, which have been three years exposed to all the influences of the weather.

The experiments given in volume 1st had been made, as was stated in the notice given of them, with common mortar taken from a heap prepared for a public building, and which having been exposed to the weather, was thereby probably much deteriorated. It was impossible to procure any of exactly similar quality with which to compose a new series which could be strictly compared with them, and a different mixture was therefore prepared, containing a smaller proportion of sand than before; namely, in the ratio of 1¼ to 1 of lime; and with this mortar the experiments about to be described were made, and with the exception of the difference in the quality and proportion of the ingredients, they were in all other respects precisely similar to those described in volume 1st; the compositions prepared for trial being common mortar made up with pure water, on the one hand, and on the other precisely similar mortar worked up with a solution of jaghery containing one pound to one gallon of water.

From the fact of the impossibility of exactly matching the quality of the ingredients first experimented upon, it is evident, that it would have only led to error had a series of experiments of like proportions (¾ to 1) with them been set aside for trial and comparison

with them; but the truth is, that the adoption of a different ratio of the ingredients was accidental, and the mistake was not found out till long afterwards, so that although the original intention could not have been carried out so as to have elicited the truth, and the change of proportions was in that respect harmless, yet on proceeding to make trial of the specimens which had been set aside for three years, it was found that we had no data with which to compare them, and we were afterwards obliged to prepare and set aside a third small series of each kind, precisely similar to the second, as far as could be remembered, which last were operated on after a month's exposure only.

To make the comparison altogether satisfactory, it would have been desirable that the whole of the two series compared together, namely, those exposed for one month, and those exposed for three years should have been prepared at the same time and under the same circumstances, so as to be, as far as possible, precisely identical; but this was prevented by the accident above-mentioned. I have no reason, however, to believe that there was any difference, as the series exposed for the single month, though cemented together at the close of the three years during which the other series had been exposed, was prepared by the same individual, and with every endeavour to make them identical in every respect.

With these observations I shall now proceed to give the tables of results.

TABLE I.

Experiments upon the cohesive force of bricks cemented together with common shell lime mortar, worked up with plain water, after one month's exposure to the weather.

No. of experiments.	Area of surface of the joint.	Total weight* which caused separation.	Average depth of induration by the carbonic acid of the air.	Whether the cohesion or the adhesion failed.
1	36 inches.	124½ lbs.	¾ths inch	Cohesion totally
2	36 do.	152 do.	¾ths inch	Cohesion totally
3	36 do.	128 do.	¾ inch	Cohesion ¾ adhes. ¼
4	37 do.	144 do.	¾ inch	Cohesion ¾ adhes. ¼
5	37 do.	128 do.	¾ inch	Cohesion ¾ adhes. ¼
6	36 do.	117 do.	¾ inch	Cohesion totally
7	36 do.	148 do.	¾ inch	Cohesion totally
8	36 do.	137 do.	¾ inch	Cohesion totally
9	37 do.	138 do.	¾ inch	Cohesion totally
10	37 do.	137 do.	¾ inch	Cohesion totally
Average.	36.4	135.35	.31	Cohesion .9 Adhes. .1

Nearly 4 lbs. per square inch.

* Including scale pan, &c. &c. &c.

TABLE II.

Experiments upon the cohesive force of bricks cemented together with common shell lime mortar, worked up with jaghery lime water, containing one pound of jaghery to each gallon of water, after one month's exposure to the weather.

No. of experiments.	Area of surface of the joint.	Total weight* which caused separation.	Average depth of induration by the carbonic acid of the air.	Whether the cohesion or the adhesion failed.
1	37 inches.	193 lbs.	$\frac{1}{8}$ to $\frac{3}{16}$ in.	cohesion totally very regular.
2	36 do.	189 $\frac{1}{2}$	$\frac{1}{8}$ to $\frac{3}{16}$ do.	do. do. do.
3	36 do.	196 $\frac{1}{2}$	$\frac{1}{8}$ to $\frac{3}{16}$ do.	do. do. do.
4	37 do.	203 $\frac{1}{2}$	av.	do. do. do.
5	36 do.	179	av.	do. do. do.
6	36 do.	204	av.	do. do. do.
7	37 do.	296	to $\frac{3}{16}$ do.	do. do. do.
8	37 do.	226		do. do. do.
9	35 do.	199		do. do. do.
10	35 do.	209 $\frac{1}{2}$		do. do. do.
Average.	36. 3	209. 6		Cohesion totally

Nearly 6 lbs. per square inch.

These two tables present a remarkable contrast to those of similar character in volume I. It is to be observed that the proportions of sand and lime are different, but this seems hardly sufficient to account for the very great superiority in the cohesive power of those lately experimented upon. In the trials formerly given the average cohesion of the plain water mortars per square inch was about 1 $\frac{1}{2}$ lb. and of the sugared ones 3. 62. In these which have been lately made, it has been for the former nearly 4 lbs. and the latter nearly 6 lbs. for the same area.

The comparison also of these later experiments with those upon the mortars exposed for three years presents some remarkable phenomena. I shall therefore proceed to give the tables of the latter, merely repeating, as above explained, that as far as could be remembered they were precisely similar in character and composition, and that the only difference between them was their age.

TABLE III.

Experiments upon the cohesive force of bricks cemented together with common shell lime mortar, worked up with plain water, after three years' exposure to the weather.

No. of experiments.	Area of surface of the joint.	Total weight* which caused separation.	Average depth of induration by the carbonic acid of the air.	Whether the cohesion or the adhesion failed.
1	35 inches.	123 lbs.	Total.	coh. $\frac{1}{2}$ adhesion
2	36 do.	210	do.	coh. $\frac{1}{2}$ adhesion
3	39 do.	163	do.	coh. $\frac{1}{2}$ adhesion
4	38 do.	123	do.	coh. $\frac{1}{2}$ adhesion
5	35 do.	125	do.	coh. $\frac{1}{2}$ adhesion
Average.	37	148 $\frac{1}{2}$		5.3 4.7

4 lbs. per square inch.

* Including scale pan, &c. &c. &c.

TABLE IV.

Experiments upon the cohesive force of bricks cemented together by common shell lime mortar, worked up with jaghery lime water, containing one pound of jaghery to each gallon of water, after three years' exposure to the weather.

No. of experiments.	Area of surface of the joint.	Total weight which caused separation.	Average depth of induration by the carbonic acid of the air.	Whether the cohesion or the adhesion failed.
1	39 inches.	205 lbs.	Total.	coh. $\frac{1}{2}$ adhesion
2	36 do.	218 $\frac{1}{2}$	do.	coh. $\frac{1}{2}$ adhesion
3	39 do.	263	do.	coh. $\frac{1}{2}$ adhesion
4	36 do.	123	do.	Adhesion totally.
5	38 do.	129	do.	coh. $\frac{1}{2}$ adhesion
Average	37 $\frac{3}{4}$	183. 7		5.2 4.8

Nearly 5 lbs. per square inch.

These two tables when studied in connection with the two first seem to show the unexpected result that mortars are not improved in hardness by continued exposure to the air, after the first month. This conclusion is so much opposed to the general opinion derived from experience, that I can only account for it by supposing that there may be other influences which materially affect the cohesion of cemented masses which may have been overlooked. It appears by Colonel Pasley's experiments upon various mortars taken from the best brick walls within the Chatham lines, that the strength of the plain water cements contained in Table I. only a month old is equal to the average of those whose age was 30 years, being about 4 lbs. per square inch; and the close correspondence between the cohesive strength shown by Tables I. and III. seems to corroborate this inference. On comparing Tables II. and IV. still stronger evidence seems to be adduced, for the jaghery cement of three years' standing is even less cohesive than the recent compound. I can therefore only say, while presenting the facts as they have been experienced, and which I greatly regret my inability to confirm or explain by other experiments, that unless there be some other elements of cohesion which have not met with proper attention, it seems to be shown by what we have now before us, either that age does not improve the strength of mortars after they have once been fully set and dried, or that the experiments we have made cannot be taken as accurately showing the results upon the large scale.

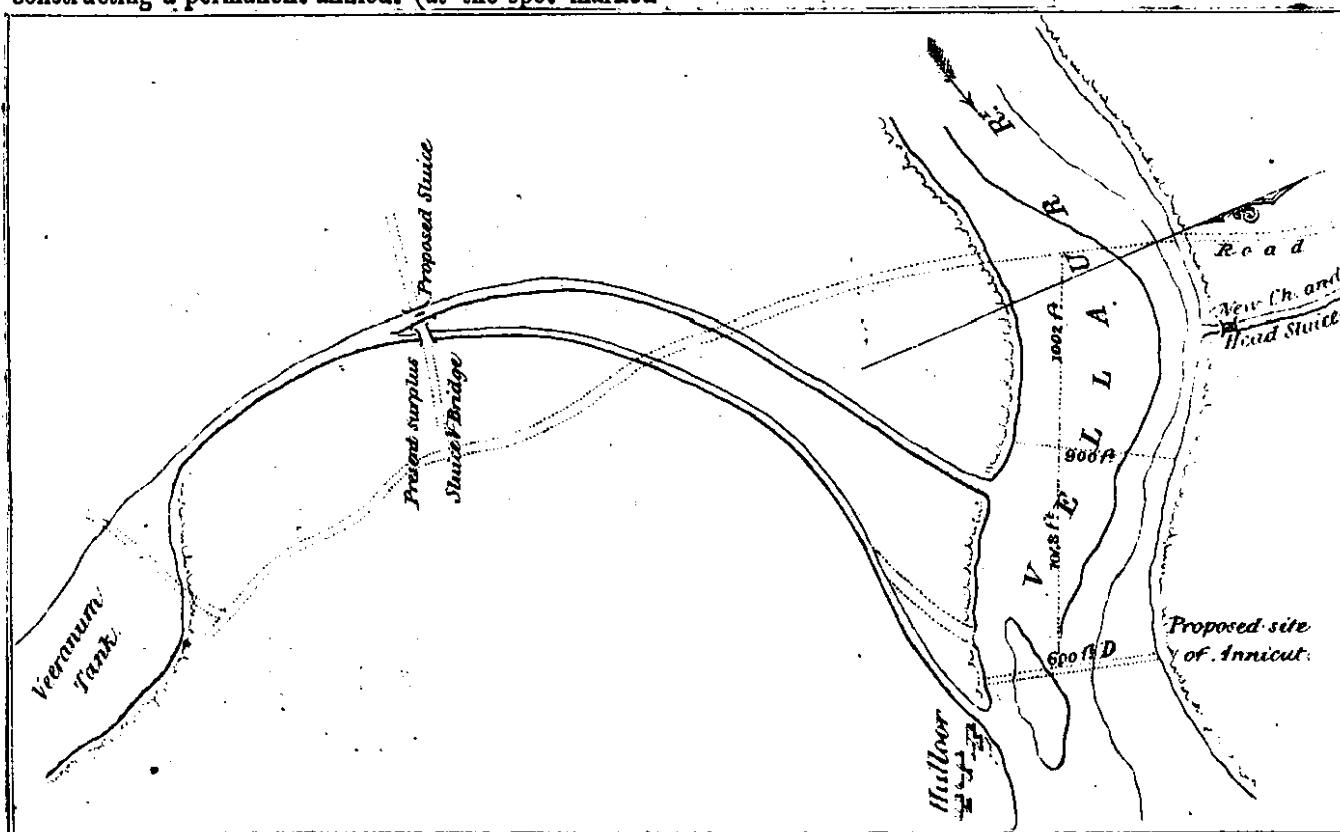
I am inclined to think, that if it be not true that the effect of age upon mortars such as those referred to in the above tables is less than it has been supposed to be, the cause of the results which have been arrived at must be some inaccuracy in the trials which has escaped my observation, as the bricks were not in either instance cemented together under my own eye; but whatever may be the truth on this point, it may be satisfactory to be possessed of a datum in the way of an approximate measure of the tenacity of mortars in this country, which when compounded in the proportions given in the above tables, and applied with care, seem to be capable under favourable circumstances of exhibiting a strength of 3 or 4 lbs. per square inch with plain water, and 5 or 6 lbs. when applied with solution of jaghery of the strength before mentioned.

J. T. S. Nov. 1845.

REPORT UPON A PROJECT FOR ERECTING AN ANNICUT ACROSS THE VELLAUR, FOR
THE BETTER SUPPLY OF THE LAND UNDER THE WALLAJAH, PERMAUL, AND
MANAMBATTAN TANKS, AND THE KINNANOR AND MEERALOOR
CHANNELS IN THE SOUTH ARCOT DISTRICT.

The want of a sufficient supply of water for the irrigation of the large tracts of land under the Kinnanoor and Meraloor channels, as well as those under the large tanks of Wallajah, Permaul, Manambattan, and others below them, has long been severely felt, and it was proposed in some measure to remedy this deficiency, by constructing a permanent annicut (at the spot marked

A in the accompanying sketch) across the Mannumootahnuddy at the head of the Kinnanoor channel, for which an estimate was transmitted to the Board of Revenue upwards of 4 years ago, by the Civil Engineer of the former 3d Division, Major (then Captain) H. C. Cotton.



The Board in their letter to Government under date the 4th of May, 1837, stated that there appeared to be ample proof of the necessity of the work, but did not at that time recommend it for sanction, in consequence of their requiring further detailed information regarding the work from the Civil Engineer.

Subsequent to this period, the then Sub Collector, Mr. Pycroft, in a letter to the Principal Collector under date the 28th February, 1839, after remarking on the very great advantages which would accrue from the speedy execution of the work, and regretting the delay which had taken place in its construction, suggested,

as an improvement, that the annicut should be thrown across the Vellaur, instead of the Mannumootahnuddy, as by this means advantage would be taken of early freshes in either river, and a more copious and certain supply obtained.

The site selected for this work is near the village of Audinoor, and 3,200 yards below the junction of the Vellaur and Mannumootahnuddy, and is indicated by the letter **B*, in the accompanying sketch. The report

* The points *B* and *C* could not be inserted in the sketch, and they are of no consequence for the purposes of illustration.

of Assistant Surveyor Oliver upon the relative merits of the two sites proposed has been already laid before the Board, the Assistant Surveyor giving a decided preference to the work across the Vellaur, but the site proposed by him was at the point *C*, which is 1600 yards higher up than *B*, and near the village of Arsocondanuttum.

After Mr. Oliver had completed his survey and report, it was suggested by Major Cotton, that if it were found practicable for the supply of the tanks and channels above enumerated, it would be expedient to place the annicut at the site *D*, which is nearly 4 miles lower down the Vellaur than Audinoor, and a little below where the surplus water of the large Veranum tank enters that river, in order that this water might be made available for the purposes of cultivation: by which plan a much more certain and copious supply might be obtained at a time long anterior to that in which the freshes occur either in the Mannumootahnuddy or Vellaur, and the ryots, by this desirable arrangement, might commence sowing their crops at a much earlier season.

The advantages of this last plan, should it be found practicable, are at once apparent, and are noted in a general manner in the letter of the Acting Civil Engineer of the 5th Division, to the address of the Acting Collector under date the 15th October last.

The only point of importance in the project which was at all doubtful, was, whether the relative height of the works would admit of the free passage of the water, and in order to test which, as well as to consult with Major Cotton on the expediency of the scheme generally, I met that officer in the neighbourhood of the proposed work, as directed in the proceedings of the Board of Revenue, under date the 18th November last.

After a careful examination, in company with the Acting Collector, of the localities, and ascertaining the levels of the ground, we came to the conclusion that the work would be highly expedient, and agreed upon the following plan of operations, viz.

To throw an annicut across the Vellaur, nearly opposite to Shatitape, and about 250 yards below the spot where the surplus of the large Veranum tank discharges itself into that river. This work will throw the water down a new channel, directly into the large Wallajah tank, whence the surplus will pass off by a head sluice to be constructed in the bank of the Wallajah tank to the large Permaul reservoir below it.

About 1½ mile below the head of the main channel, it is proposed to take off a branch for the better supply of the Meeraleer vaikal, where that cut intersects the proposed new line, by which the numerous villages dependent on the Meeraleer channel, as well as those watered by the Manambattan tank, would receive an ample supply; the surplus of the Manambattan again

passing off, as at present, to water the lands belonging to several villages situated lower down.

The proposed position of the annicut is the most favourable one which could be selected, and the ground on both sides are high; wells have been sunk along the proposed line of the work, and although no very stiff soil has been met with, the foundation is as favourable as that on which the Colleroon annicut was built.

It is proposed to make the work 9 feet in height, which will keep up an almost constant supply of water in the Wallajah tank, to a depth over the lowest level of 11 feet, certainly from June till the end of October, and probably even from an earlier period, when freshes sometimes occur in May, and the tank is thus partly filled before the north-east monsoon sets in, may be supplied to any extent deemed expedient from the Vellaur freshes, by which means an ample supply considered desirable, may be furnished to the Permaul and Manambattan tanks, and the Meenambattan channel.

It will be necessary to regulate the supply of the main channel by means of a head sluice, and to keep the bed of this cut free from accumulations by means of a surplus sluice, a head sluice is required to the Meenambattan, &c. main channel, for the irrigation of lands at present watered by the Meeraleer vaikal branches from the Vellaur at a point much lower down, and a small under sluice for the Kinnanoor cut, which will then supply the two small tanks of the Meenambattan and Pinnaloor.

A head sluice will also be required in the Wallajah tank bank, as was mentioned above, for the supply of the Permaul reservoir, and it will be necessary to construct a bridge over the surplus from the Veranum tank to the Permaul reservoir; in addition to the above works, it will be necessary to construct a small earthen embankment along the northern bank of the river, to widen and deepen the Meeraleer channel, to increase the size of the channel leading to the under sluice, and to excavate a small branch cut to supply of the Meeraleer tank.

The several positions of these works are indicated in the sketch, and plans and estimates of them are annexed; the latter amounting in the aggregate to Rupees 44,883 7 10.

The enclosed statement will show the number of names of the villages, as well as the quantity of land under the several works proposed to be benefited, and the amount of the increase which may be anticipated.

From this it will be seen that there are nearly 1000 cawnies of nunjah land under the Wallajah, Permaul and Manambattan tanks, and the Meeraleer and Kinnanoor channels, which should, if properly supplied with water, yield a revenue of no less than Rs. 79,208; but, on an average of the last 20 years, only realized Rupees 35,181, showing an annual

of no less than Rupees 44,027; or, after all deductions for land which is of an inferior quality, of Rupees 39,747.

Considering that the proposed works will bring down the waters of the Coleroon as early as the month of May in some years, and always in June, the tanks and channels, instead of being dependent, as hitherto, wholly on the local rains, which frequently do not commence before the middle of October, will have a certain supply for the greater part of the year, and it is not too much to suppose, with these advantages, that the whole sum exhibited in the column of increase, will in the course of a few years be realized; and that at least half of that amount may be calculated upon as the immediate return the works will yield.

There is more confidence in the present anticipated increase, from the circumstance of the quantity of water thrown off by the lower annicut being much more than can be made use of in the cultivation of the two Talooks of Manargoody and Chellumbrum, and that the main object of the present works is to extend the Coleroon waters, which are so certain, and abundant; so abundant indeed, that the water has been passing over the calingalas of the Veranum, and out by its surplus channel into the Vellaur, with little intermission from the month of July to the present time, in quantities quite equal to that required for the use of the lands belonging to the works under report.

I need not however allude more particularly to the advantages to be derived from the execution of the works proposed, as they have been explained in communications from Messrs. Thomas,* Dent,† Pycroft,‡ Major Cotton§ and Mr. Hallett,|| and recognized by the Board of Revenue.

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I must not omit to state that I have availed myself largely of the advice and experience of Major Cotton in projecting and in drawing up the plans of the works under report, and annex transcript of that Officer's diary on the subject. In conclusion, I have only to recommend that sanction may be granted at an early period for the execution of the works, which there is no doubt will be attended with highly beneficial results, viz. a return of no less than 73 per cent. on the outlay, besides preparing the way for vastly extended improvement in cultivation situated still lower down.

(Signed) STAFFORD VARDON,
 Civil Engineer 4th Division.

ABSTRACT OF ESTIMATES.

No. 1	Annicut, - - - - -	29,217	0	10
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" 7	Bridge, - - - - -	1,498	12	4
"	For Channels, &c. - - - - -	10,620	1	1
	Superintendence, - - - - -	500	0	0
		<u>46,929</u>	<u>15</u>	<u>7</u>

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	For Channels, &c. - - - - -	10,620	1	1
	Superintendence, - - - - -	500	0	0
		<hr/>		
		46,929	15	7

Vellour Annicut.

Statement of Tanks and Channels, &c. which may be benefited by the construction of an Annicut across the Vellour River, near Shattah-top, in the Bowengherry Talook, of the Southern Division of Arcot.

Name of Tanks, &c.	NUMBER AND NAMES OF VILLAGES.	Ayacut Revenue.			Highest Revenue ever realized.			Average Revenue realised during the last 20 years.			ANTICIPATED INCREASE OF REVENUE.																					
											From present Ayacut Nunjah land.				From Poonjah into Nunjah.				From Poonjah land at present dependent, on ruin.				Total.									
		Cawnies.	Rupces.	Annas. Pice.	Cawnies.	Rupces.	Annas. Pice.	Rupces.	Annas. Pice.	Cawnies.	Rupces.	Annas. Pice.	Cawnies.	Rupces.	Annas. Pice.	Cawnies.	Rupces.	Annas. Pice.	Cawnies.	Rupces.	Annas. Pice.	Rupces.	Annas. Pice.									
Wallajah.	1 Cottavachang																															
	2 Vurthumput																															
	3 Auloor Agaram																															
	4 Kistnapoaram																															
	5 Cusbahampaudy																															
	6 Pinnaloor																															
	7 Ambaupooram																															
	8 Prisinarampooram																															
	9 Oolootoor																															
	10 Murdoor	3,991	61	32,003	2	7	2,785	54	21,644	11	0	13,423	3	9	2,075	15	16,215	14	1,277	143	1,686	2	0	15	21	48	9	0	17,996	9	9	
	11 Kolacoody																															
	12 Jaumcondan																															
	13 Gomdemoolay																															
	14 Yellacoody																															
	15 Ollayoor																															
	16 Boothumpaudy																															
	17 Thalacolum																															
17 Total																																
Permaul.	1 Sevakolinden Pettah																															
	2 Cooppayacandoo																															
	3 Thunnoor																															
	4 Poovaneecoopum																															
	5 Vullevaday																															
	6 Agaram																															
	7 Vengatampooram																															
	8 Cumbelemoode																															
	9 Yadacanduputto																															
	10 Coondeyamelloor	1,758	34	13,830	1	11	1,600	0	11,167	6	3	6,753	9	7	408	124	5,590	13	10	161	31	93	7	6	13	91	22	10	6	4,597	15	6
	11 Musrahkillaivalle																															
	12 Karevampoondy																															
	13 Seeroopaulayoor																															
	14 Pareyaput																															
	15 Theyagavullee																															
	16 Aundaramullepullom																															
	17 Theerthanagay																															
	18 Anookuput																															
18 Total																																
Manambattian.	1 Thirkoothla																															
	2 Sundapettah																															
	3 Moollepullum																															
	4 Cooreamungalum	585	94	6,232	15	3	525	1	5,399	7	6	3,324	7	2	246	54	2,877	9	7	115	5	693	0	0	0	0	0	0	0	3,570	9	7
4 Total																																
Meeraloor Channel.	1 Chittairy																															
	2 Thombeckennettamput																															
	3 Villeanelloor																															
	4 Keelamanacoody																															
	5 Vullum																															
	6 Chuderkellay																															
	7 Pereaput																															
	8 Aremoolahaven																															
	9 Pareacoormootty																															
	10 Munjacoory																															
11 Audeveraga Nelloor	2,206	104	17,429	15	4	1,253	104	11,321	6	2	7,275	11	5	224	152	7,095	10	2	208	24	1,282	3	6	0	0	0	0	0	0	8,384	13	8
12 Tachacandoor																																
13 Samadim																																
14 Chumacoormatty																																
15 Ramavadacoopum																																
16 Yalungalumput																																
17 Pauluantoovunnan																																
18 Manycollay																																
19 Yayepooram																																
19 Total																																

Total Anticipated Increase. 24,180 0 2

Extract from the Official Diary of the Acting Civil Engineer of the 5th Division, for part of the month of December, 1841.

SOUTH ARCOT DISTRICT.

14th to 18th.

Bowengherry Talook.

“Project for extending the benefit of the Coleroon annicut to irrigate lands on the north side of the Vellaur river.

“In company with the Collector of South Arcot, and the Civil Engineer of the 4th Division, I examined the country on both sides of the Vellaur, and got such levels, &c. taken as enabled us to make a complete plan for carrying the surplus waters of the Veranum tank across the Vellaur river by means of an annicut, and carrying it by a new channel to the Wallajah Yairy.

“The whole project proves easily feasible, all the required works will be constructed at a moderate expense, and the effect such as to make it one of the most valuable improvements undertaken since the construction of the Coleroon annicuts. The Civil Engineer of the 4th Division has prepared and will submit the estimates for the works which we have planned, with the statement of expected increase of Revenue, and a general description of the project.”

(Signed) H. COTTON, Major,
Acting Civil Engineer 5th Division.

To

The Secretary to the Board of Revenue
in the Department of Public Works.
Fort St. George.

From the Collector of South Arcot.

Recommending that the project for constructing an annicut across the Vellaur in the Bowengherry Talook, may be taken into consideration at an early date.

SIR,

When the Civil Engineers of the 4th and 5th Divisions lately met on the bank of the Vellaur, with the intention of examining into the merits and practicability of an annicut, which was the subject of my letter of the 29th October, 1841, I made a point of accompanying them in their inspection, during several days, of the spot proposed as suitable for the work, as well as of the whole country which it was considered would derive advantage from the new irrigation.

I have paid great attention to the subject, and have no hesitation in most fully concurring in the views formed by Major Cotton and Captain Vardon, as expressed in the report forwarded by the latter officer to your Board.

The entire cost of the annicut, and the necessary additional works, will be fully covered by the outlay of Rupees 44,883,* which it is calculated will yield a return of 77 per cent.

The Bowengherry Talook will reap the benefit of this work if carried into execution, and its inestimable value is strictly pointed out this very season, for in consequence of a failure in the north-east monsoon, the crops

have not sufficient water, whereas, had this irrigation been in force, much land on the eastern side of the talook would have been receiving the water from the Coleroon, which, as is well known, is certain.

I beg most earnestly to request the Board's favorable view of this project, and strong recommendation to Government. I also have the honor to point out that an early sanction will enable me to do so much of the work this year, as to render its completion in time for the season of 1843 a matter of certainty, which is of course of very great importance.

I have the honor to be, &c.

(Signed) C. HALLETT,
Collector.

Cuddalore,
Collector's Cutchery.
31st January, 1842.

To

G. D. DRURY, Esq.
Chief Secretary to Government.

SIR,

Min. cons. No. 7.
October, 1842.
Do. No. 5.
May, 1841.
Paras. 4 & 5.

1 Estimate.
6 Plans.
1 Report 28.
January 1842.
2 Letter with 2
Enclosures dated
29th Oct., 1841,
with letter and
report from Civil
Engineer 4th Di-
vision, dated 28th
January, 1842.
Cons. 28th Fe-
bruary.

Para. 1. I am directed by the Board of Revenue, with reference to the orders of Government, as per margin, and to the Extract of a letter from the Court of Directors accompanying the first, on the subject of improvement to the irrigation of the Western Talooks of South Arcot, to forward for the purpose of being laid before the Most Noble the Governor in Council, the accompanying Plans and Estimates for the construction of an annicut across the Vellaur river, and of auxiliary works designed to conduct the surplus water of the Veeranum tank across the river to other considerable reservoirs on its north bank, the Estimate amounting to Rupees 56,877 1 6.

2d. The sources of the Vellaur being not affected by the south-west monsoon, its supply of water for irrigation is precarious, and many dams are necessary to retain it in different situations. These are commonly constructed of rough stone, and are found only in situations where there is a natural foundation of rock or hard soil, high up the river, in the lower parts of which the bed is composed uniformly of sand or mud, in which a permanent dam would have been a work of immense cost to the Natives, while the temporary dams or corumboos occasionally used are swept away by every sudden flood, must be as often renewed, and under the most favourable circumstances only partially answer the required purpose.

3d. A permanent dam has been consequently proposed, to collect the waters for distribution to the tanks and lands of numerous villages now supplied partly by channels taken off at different points in the bank of the river, and partly by local rains, and the project has been strongly supported by several gentlemen who have by turns had charge of the district.

*As particularised in Captain Vardon's report.

4th. Considered simply with reference to the natural supply of the Vellaur, the proposed annicut was thought to be well worthy the attention of Government, and different sites were suggested for its construction; but Major Cotton, then Civil Engineer of the 5th Division, having declared his opinion that by means of the new work, if properly placed, the surplus waters of the Veeranum tank might be conducted across the Vellaur to the lands suffering from the uncertain supply above described, that officer was requested in concert with Captain Vardon, the Civil Engineer of the 4th Division, to investigate the subject.

5th. The result of their joint labours is now submitted, and the Board cannot but believe it such as to deserve the most favourable consideration and support of the Most Noble the Governof in Council.

No. 523. 6th. His Lordship in Council has been made aware by my letter of the 26th October last, of the greatly increased body of water poured from the Coleroon river into the Veeranum tank since the construction of the lower Coleroon annicut, and enlargement of the Vuddavar. This was so apparent in 1841, immediately after the execution of the latter work, that 29th October, 1841, para. 6. Cons. 5th No. vember 1841. Mr. Hallett, the Collector, visiting the Chellumbrum and Manargoody Talooks, so late as September in that year, "could not but remark that the only difficulty was the superabundance of water," the Veeranum then discharging large quantities by both its calingalas, as well as by the northern outlet into the Vellaur: and it appears from the report of Captain Vardon that this discharge had commenced in July and continued till December. Major Cotton further shows that this great supply of water was wholly independent of local rains, as the tank was dry when the rivers came down, and was filled entirely from the Coleroon.

7th. The levels taken by Major Cotton and Captain Vardon show that the calingalas of the Veeranum are 3 feet 2 inches above the highest calingala of the Wallajah tank, the first on the north bank of the Vellaur into which it is required to throw the Veeranum surplus; and as all the other tanks, of which the most considerable is the Permaul, are much lower, the question of command is at once disposed of; and it only remains to show how it is proposed to carry the Veeranum surplus waters across the Vellaur, maintaining them at a sufficient level. An aqueduct would of course effect the desired object to a certain extent, but with less completeness than an annicut, which would also serve to retain the waters of the Vellaur itself according to the original projects, and is in other respects a work much to be preferred to an aqueduct.

8th. It is proposed, therefore, to construct an annicut, the crown of which will be 9 feet above the bed of the Vellaur, and 4 inches above the high calingala of the Wallajah tank. Its site will be a short distance below the junction of the Veeranum surplus with the Vellaur, and on the opposite or north bank of

that river a new channel will be opened communicating directly with the Wallajah tank. It will be furnished with a head-slucice having six vents, each 2, 9, by 4, 6, and a surplus sluice for discharging water when it can be spared at the lowest level for the purpose of clearing the bed of the channel from accumulations of soil. The Comarum Oodapoor (or breach) affords a convenient channel for carrying the surplus again to the Vellaur, at a point considerably below the annicut.

9th. Where the new channel intersects the present Kinnanoor channel, it is proposed to construct a sluice; and to widen and deepen the Kinnanoor channel for the supply of that of Meraloor; and as this measure will make the former too deep to supply as it does now, the small tanks of Pinnalore and Meraloor, a branch for their benefit on the former level will be taken from it at a point above its junction with the new channel, and carried under the latter by a tunnel. The only other masonry work required is a sluice in the bund of the Wallajah tank, for the supply of the Permaul tank.

10th. The foregoing para. briefly describes the project as it has been submitted to the Board. It has, however, appeared to them necessary, after careful revision of it in this office, to add to it some works designed for the security of the Veeranum tank, which might without such additions be exposed to danger, from the reflux of the Vellaur waters in high freshes of that river. To effect the required purpose, it will be necessary to cut a new channel from the Veeranum surplus, to be carried to the annicut for the supply of the tanks on the north bank of the Vellaur; and at its point of separation from the old channel close to the new Veeranum calingala to build a sluice which will be shut when the freshes of the Vellaur come down. The tank surplus will then fall into the Vellaur by the old channel at a point below the annicut. To complete these improvements, it will be necessary to embank the Vellaur on both sides above the annicut, but principally on the south side.

11th. The following specification will show the extent and character of the work.

12th. The length of the annicut will be 225 yards, which is something more than the natural breadth of the river. The section is perpendicular in rear, and the water falls upon an apron covered with cut-stone, which is partly on a level with the bed of the river, and partly raised one foot above it, and is altogether 16 feet broad; the rear of the apron is to be defended with cubical blocks of brick work, which will accommodate themselves to the natural bed and gradually form an impregnable barrier similar to that of the loose stones used at the Coleroon annicuts, but which could not be obtained for the present work but at a disproportionate expense. The cubes will however answer perfectly well, if the mortar with which they are cemented has sufficient time to harden before they are used.

13th. The front of the annicut it is proposed to make sloping towards the stream, so as to obtain a broader base where the pressure is greatest, with the same quantity of material that would be required for a rectangular section, and at the same time to facilitate the passage of sand over the work. It is proposed to build a set of sluices in the work, for keeping clear the head of the new channel; an object of great importance, and which there is no doubt from the experience derived from the Coleroon annicuts will be fully effected by a judicious use of these works. They are so designed as to be accessible at all times, and it is intended to close them when necessary with horizontal balks of wood, which are the most easily managed. They will be defended in rear by a wider apron than that of the annicut, and will have another apron in front, with wing-walls to prevent the current, which passes through them from first sweeping along the face of the annicut. The foundations of the dam and apron will be laid in the usual manner upon wells, which have answered very well for the Coleroon annicuts, where the soil in which they are sunk is of the same description as that of the Vellaur.

14th. It will not be expedient to build the dam to its full height at first. The safety of the work will be placed beyond risk by proceeding gradually, and the necessary height of water may meanwhile be easily obtained by an earthen dam above the masonry; to which, as an expedient for one or two years, there is no objection.

15th. As the communication across the Vellaur in the direction of the annicut promises to be hereafter of importance, a bridge over the work has been added to the design, but the cost of it is entered separately in the estimate; except that small portion of it which provides for extending the foundations of the pier on each side of the dam; because should the bridge be built at any future period, it could not conveniently be connected with the annicut without such prior arrangement.

16th. The project has received the fullest support from Mr. Hallett, the late Collector, who was present at the consultation of Major Cotton and Captain Var- don, and was perfectly satisfied of the great improvement to the country and the revenue which would result from the introduction of an unfailing supply of water to lands of very considerable extent.

17th. The site of the proposed work was also visited in December, 1842, by the professional member of the Board, Colonel Sim, in company with the Collector of the district, and present Civil Engineer of the district, Captain Lawford, and the practicability and advantages of the project inquired into on the spot. Lieutenant Colonel Sim concurs entirely in the opinion entertained of the expediency of the annicut, and of the extensive benefit which it would confer on the lands lying on the north bank of the Vellaur, which are very scantily supplied at present; while it would at the same time prove advantageous to Manargoody

by relieving it of part of its superabundant water. Thus the opinion of every one who has had an opportunity of examining the proposed work is highly in its favour.

18th. The expected increase of revenue is stated at about 40,000 Rupees. It is evident that where a great part of the land has been long waste, the full extent under command of the new irrigation cannot be cultivated for some years; but at the same time there is no situation, where there is greater promise of early profit from the construction of new works, both on account of their being intended to support others already productive, and of the certain dependence that may be placed on the sufficiency of water.

19th. Detailed statements of the expected increase of revenue accompany this report. They were prepared under the directions of Mr. Hallett, after investigation of the lands and resources of the several villages dependent upon the reservoirs to which the new supplies of water will be conducted, and it is expected that lands still farther to the eastward will in course of time be brought under cultivation.

20th. The project above described is, as will have been observed, of much simplicity in its character. It has no relation to existing works or interests, such as might raise doubts as to the consequences to them of carrying it into execution, and the Board therefore trust that it will appear worthy of being submitted with the strong recommendation of His Lordship in Council to the Honorable the Court of Directors, to whom it is hoped it will appear to present superior advantages for improving the irrigation of South Arcot. The amount of the estimates for which sanction is solicited is

Annicut without Bridge,.....	Rupees 56,877 1 6
Do. with do.....	63,599 6 7
Sixty-three thousand, five hundred and ninety-nine, annas six, and pice seven.	

REVENUE DEPARTMENT.

No. 270.

Extract from the Minutes of Consultation, under date the 1st March, 1845.

“The Most Noble the Governor in Council proceeds to take into consideration the letter in this Department from the Honorable the Court of Directors, dated 24th December, 1844, No. 32.

Para. 1. This Dispatch will be communicated for the information and guidance of the Board of Revenue in the Department of Public Works, with reference to their Acting Secretary's letter, dated 15th February, 1844, No. 89.

2. The Board will make all proper arrangements for the prosecution of the work under efficient superintendence, and report upon its progress periodically to Government. They will also instruct the Collector of South Arcot to give his attention, on the completion of the work, to the state of the cultivation under the tanks, the supply of which is contemplated in the con-

struction of the annicut, and to submit with his reports on the settlement, a statement showing how much of the anticipated increase of revenue has been realized in each year.

Extract from a Letter from the Honorable Court of Directors, dated 24th December, 1844.

“In your letter dated 9th April, 1844, No. 4, in the Department of Public Works, you solicit our sanction to an expenditure of Rupees 63,599 6 7 for the purpose of constructing an annicut and bridge across the Vellaur river, with auxiliary works designed to conduct the surplus water of the Veranum tank across that river, for the supply of waste land under the Wallajah, Permaul, and other large tanks in the district of South Arcot.

Lieut. Col. Sim, Chief Engineer; C. H. Hallett, Esq., late Collector and Magistrate S. D. Arcot.

Major H. C. Cotton, Acting Civil Engineer 5th Division; Captain Lawford, Acting Civil Engineer 5th Division. Lieutenant S. Vardon, Civil Engineer 4th Division.

2. The proposed plan has been investigated on the spot by the officers named in the margin, by all of whom it has been strongly recommended for adoption.

3. The anticipated increase of revenue from the construction of this work is stated at Rupees 34,480 per annum.

4. Under these circumstances, and relying on the accuracy of the statement of the officers to whom we have referred, as to the advantages to be obtained from the work, and to the facility and economy with which it can be accomplished, we shall willingly comply with your strong recommendation in its favour.”

LETTER FROM CAPTAIN E. LAWFORD, CIVIL ENGINEER 5TH DIVISION, ON THE SUBJECT OF THE EFFECT OF THE NEW REGULATING DAM TO THE CAUVERY, AND THE GENERAL BENEFIT DERIVED FROM THE COLEROON ANNICUTS.

The following very valuable paper has been prepared at my request by Captain Lawford, now Civil Engineer 5th Division, and to all those who take an interest in these important works, I feel that I need not offer any apology for inserting it, though at a distance from the other documents on this subject. It gives, what has long been desired, an unprejudiced and fair statement, coming from an unbiased person of the actual bona-fide results, in increase of cultivation, and money returns, which is now experienced from the construction of these works; and it is most gratifying to find that Captain Lawford estimates the latter to be not less than 2½ lacs of Rupees per annum, being at the rate of 35 $\frac{1}{2}$ ths per cent. even upon the outside sum of 700,000 Rupees assumed as the aggregate cost of the whole undertaking.

It may be useful that I should mention, that the regulating dam referred to by Captain Lawford is a work recently built at the head of the Cauvery, where it separates from the Coleroon, and intended to establish its bed there upon a permanent level. It was found after the annicut in the Coleroon came into operation, that the large body of water diverted by it into the Cauvery, had the effect of deepening its bed; and the relative levels being thus disturbed, the whole body of the river was gradually withdrawn from the former and thrown into the latter river, to the great danger of its banks; while the Coleroon was subject to be filled with shoals and sand-banks. It was expected that this evil would be obviated, the relative levels of the two rivers permanently maintained, and the supply of each made more uniform, by a masonry dam defining the proper level of the bed of the Cauvery at the point of separation, and it appears from Captain Lawford's statement that this object has been attained.—ED.

In compliance with your request, I proceed to relate briefly the operations at the head of the Cauvery, and their apparent results subsequent to the last report of Colonel Sim; and I shall then endeavour to show as plainly as possible, the actual advantages which have followed the construction of the Coleroon annicuts, up to the latest period.

During 1844 the enlargement of the head of the Cauvery continued as it had done in the previous year; the direction of the main current was altogether along the south side, and the stream washed away upwards of 30 yards of the land. The north bank, though greatly relieved by the improvement of the Coleroon annicut, yet suffered considerable injury, and demanded incessant labour for its preservation.

Materials for the Cauvery dam were under preparation during the latter part of last year, and the work was commenced on the 9th February following, and

completed on the 20th April without the slightest accident, although the occurrence of most unusual freshes in March threatened to interrupt the undertaking. The head of the Cauvery was kept closed until the middle of May, when the embankment across it was cut, and the stream suffered to flow.

During the whole of May and the early part of June, the river remained extremely low, but on the 25th of the latter month, the freshes suddenly commenced with great violence; and as the stream filled its former deep bed, it attacked the defences of the banks which were as usual immediately repaired and strengthened. As the water subsided, it was evident that a material change had commenced in the Cauvery, and that the current had no longer that irresistible force, so severely felt in former seasons. A deposit of sand was formed along both sides of the river immediately below the dam where the stream had been hitherto extremely deep. This deposit has since gradually

extended itself lower down the river, and effectually secures the banks in these important parts.

In the early part of October the local rains began to fall, and the Cauvery was again filled, but the stream caused no damage to the works near the river head, except to the exposed defences at the outlets, which suffered some injury; and after another subsidence the river has again risen, without causing material injury to any of the defences.

The continuance of the favorable change in the Cauvery is now quite manifest in the uniformity of the section, the regularity of the current, and the absence of masses of sand and deep holes. The stream, spreading over the entire bed, has lost its violence, and the banks, no longer corroded and scarped, have assumed a moderate slope; and although the first burst of the freshes caused a considerable outlay in the repair of defences, yet not one new spot on either bank has been attacked by the current.

This remarkable change in the Cauvery has been accompanied by a corresponding improvement in the Coleroon, the bed of which is clearer and deeper than I have ever before seen it. A strong current sets on the centre of the annicut, and so great has been its effect on the bed below, that I am obliged to close the main sluices to prevent further deepening.

In 1842 the sands of the Coleroon, to the westward of the annicut, were higher than the work itself; but where that accumulation existed, the bed is now six feet lower; nor have other sand banks been formed; but the Coleroon, like the Cauvery, has acquired much greater uniformity than it has had for many years.

It is impossible to account for these changes otherwise than as the effects of recent improvements, and especially of the dam at the head of the Cauvery; as it is evident that after each succeeding fresh, the beds of the rivers become improved, and their regulation more perfect. The body of water which formerly passed in a deep concentrated stream into the Cauvery, is now diffused over the two beds, each receiving its just share; the thread of the stream is more direct, and the banks are less exposed to violent currents, circumstances which establish the correctness of Colonel Sim's anticipations.

In the endeavour to show with precision and distinctness the actual returns in money, which have been realized by the State from the construction of the Coleroon annicuts, I have experienced some difficulty in consequence of the system, which renders the land revenue dependent on the current prices of grain. A succession of favorable seasons, and the improvements effected in other districts, together with the extension of the Arracan grain trade within the last ten years, have had a material effect in depressing the markets, and consequently the revenue of these Provinces; and hence the apparent effect of the annicuts is by no means so great, as that which they have in reality produced.

But the annicuts have in no degree contributed to this effect on prices, as any increase of produce within the provinces is insufficient to cause such result, and therefore the real amount of the profits arising from these works must be calculated by applying the average prices and rate of assessment which prevailed before their construction to the subsequent increase of the extent of land in cultivation. In South Arcot the increase of land yielding two crops has raised the rate of assessment greatly above its former amount.

On the grounds above stated, I come to the conclusion that the following is a correct summary of the returns from the Coleroon annicuts up to the present time.

	Increase of Land.		Increase of Revenue.	
	Acres.	Rs.	A.	
Tanjore,	27,705	1,41,954	0	
Trichinopoly,	1,343	7,984	8	
South Arcot,	7,298	1,00,634	0	
Total for one year,	36,344	2,50,572	8	
Aggregate of nine years,	3,27,096	22,55,152	0	

The aggregate outlay which these works have occasioned directly or indirectly may be roundly stated at 7,00,000 Rupees, so that they have produced in nine years a clear profit of Rupees 15,55,152.

I remain,

Your's sincerely,

EDWARD LAWFORD.

NEGAPATAM, }
5th December, 1845. }

Coleroon Annicuts.

Statement showing the Cultivation and Revenue dependent on River Irrigation in Tanjore, from the year 1830 to 1844.

	Years.	Extent of land. Acres.	Net Revenue. Rupees.	Price of Grain per Cullum.		Average rate of Collections per Acre.			Remarks.
				Dns.	Cash	R.	A.	P.	
Before the Construction of the Annicuts.	1830	542301	2631427	2	30 1/2				
	1831	544251	2732126	2	29 1/2				
	1832	558730	2998184	4	4				
	1833	545772	3117291	4	26 1/2				
	1834	564674	2840689	3	14				
	1835	559881	2669023	2	30 1/2				
	Total.		3315609	16988640	21	24			
Average.		552601 1/2	2831440	3	16 1/2	5	1	11 1/2	
After the Construction of the Annicuts.	1836	532476	2869487	4	23 1/2				
	1837	573170	2875844	3	12 1/2				
	1838	578417	2994744	3	17 1/2				
	1839	583491	2991747	3	12 1/2				
	1840	584932	2798976	2	16 1/2				
	1841	593785	2573458	1	23 1/2				
	1842	592145	2799411	2	13 1/2				
	1843	590440	2941484	3	6 1/2				
1844	595901	3024200	3	11 1/2					
Total.		5222767	25869351	28	9 1/2				
Average.		580306 1/2	2874372	3	4 1/2	4	15	3 1/2	
Deduct.		552601 1/2	2831440						
		27705	42932	0	0	0	0	0	Apparent Increase.
		27705	141954	0	0	5	1	11 1/2	Real Increase.

Statement showing the Cultivation and Revenue dependent on Channels influenced by the Coleroon Annicuts in the Lavalgoody Talook of Trichinopoly District from the year 1825 to 1844.

	Years.	Irrigation of Iyen and Perovully Channels.		Average rate of Collections per Acre.	Remarks.
		Acres.	Net Revenue.		
Before the Construction of the Annicuts.	1825	31733 1/2	190080	4 7/8	
	1826	32154	190872	14 0	
	1827	32078	178045	14 10	
	1828	31871	189428	4 7	
	1829	32004	183600	14 9	
	1830	33401	200659	15 11	
	1831	33248 1/2	194498	10 5	
	1832	33125 1/2	196554	15 9	
	1833	33073	209958	6 8	
	1834	33517	194320	15 8	
	1835	33708	204857	12 8	
Total.		359913 1/2	2139865	1 10	
Average.		32719 1/2	194533	3 1 5 15	1 1/2
After the Construction of the Annicuts.	1836	33886	201145	6 10	
	1837	33575	200263	2 10	
	1838	33643	200601	9 10	
	1839	34230 1/2	200233	10 2	
	1840	33809	200692	0 0	
	1841	34909	205004	14 5	
	1842	35219	197778	14 1	
	1843	33083	190009	13 3	
1844	34206	185974	0 2		
Total.		306561 1/2	1781703	7 7	
Average.		34062 1/2	197967	0 10 5 12	11 1/2
Deduct.		32719 1/2	194533	3 1	
		1343	3433	13 9 0 0	0
		1343	7984	10 8 5 15	1 1/2

Statement showing the Cultivation and Revenue dependent on Channels influenced by the Coleroon Annicuts in Chellumbrum and Manargoody Talooks of the South Arcot District, from the year 1825 to 1844.

	Years.	Nunjah Revenue exclusive of Jaghire.		Kussur or Revenue derived from the irrigation of Poonjah Lands.		Total.	Average rate of Collections per Acre.			Remarks.	
		Acres.	Revenue.	R.	A.		P.				
Before the Construction of the Annicuts.	1825	23,644	1,82,998	3	8	8	2	8	1,83,001	6	4
	1826	22,634	1,71,478	12	8	20	7	1	1,71,498	3	9
	1827	17,567	1,14,182	10	7	3	5	11	1,14,186	0	6
	1828	15,649	1,08,228	9	11	29	6	4	1,80,258	0	3
	1829	16,614	1,19,273	0	0	108	0	11	1,19,381	0	11
	1830	12,846	84,613	15	0	461	15	2	85,075	14	2
	1831	10,283	62,769	11	4	402	13	0	63,172	8	3
	1832	14,560	95,926	14	0	1,632	0	11	97,558	14	11
	1833	16,808	1,14,189	0	8	1,898	3	5	1,16,087	4	1
	1834	22,697	1,10,966	3	5	2,205	6	11	1,73,172	12	4
	1835	25,063	1,82,670	8	7	2,040	1	10	1,84,710	10	5
Total.		1,97,865	14,07,297	9	9	8,906	2	2	14,16,103	11	11
Average.		17,988	1,27,936	2	4	800	9	0	1,28,736	11	4
After the Construction of the Annicuts.	1836	25,150	1,92,706	4	9	4,201	11	2	1,96,707	15	11
	1837	29,411	2,21,450	13	6	4,595	3	8	2,26,046	1	2
	1838	32,164	2,47,576	14	0	9,851	6	0	2,57,428	4	0
	1839	27,678	2,80,922	9	11	0	0	0	2,80,922	9	11
	1840	27,146	2,67,374	0	7	0	0	0	2,67,374	0	7
	1841	21,810	2,03,673	8	8	0	0	0	2,03,673	8	8
	1842	19,318	1,75,526	1	6	0	0	0	1,75,526	1	6
	1843	21,689	2,02,834	12	3	0	0	0	2,02,834	12	3
1844	23,189 1/2	2,16,593	3	4	0	0	0	2,16,593	3	4	
Total.		2,27,555 1/2	20,08,658	4	6	18,648	4	10	20,27,306	9	4
Average.		25,284	2,23,114	0	0	6,216	1	7	2,29,370	1	7
Deduct.		17,988	1,27,936	2	4	800	9	0	1,28,736	11	4
		7,296	95,247	13	8	5,415	8	7	1,00,633	15	3

These amounts include the Kussur or Revenue derived from the irrigation of Poonjah lands.

The increased rate of collection is owing to the greater extent of land yielding two crops.

Net increase.

MEMORANDUM REGARDING A NEW SYSTEM OF ADJUSTING COINS TO THE STANDARD IN WEIGHT, BY CAPTAIN J. T. SMITH, F R S. F R S N A.

1. Some allusion was made in the description of the weighing machines lately brought into use in the Madras Mint, to a new system of adjusting the coins to standard weight, to which those machines are especially adapted, which it is there stated would be afterwards described; a purpose which I now proceed to fulfil, in the hopes that although the peculiar circumstances which rendered such a departure from the ordinary practice necessary here, may be but rarely met with elsewhere, still that a description of the difficulties which it was intended to overcome, and a detailed statement of the results which we have met with in a four years' experience of its application to business on the large scale, may not be altogether uninteresting.

2. When first the new system about to be described was adopted, it suggested itself as the most practicable remedy for the deficiencies in the establishment and imperfections in the Mint machinery, which will presently be described; and after it had been successfully brought into operation, I long thought of it as a contrivance, which although it had certainly afforded us most timely aid at a juncture of great difficulty, and had subsequently recommended itself by its adaptation to our peculiar circumstances and means, was nevertheless not suited to be brought into competition with the more refined methods which are followed in other Mints favoured with the advantages of the highest order of efficiency and completeness in their machinery, and skill in its management.

3. Further acquaintance has, however, greatly improved my opinion of the system, and the slight knowledge which in the course of my connection with the Mint, I have been enabled to obtain of the results of other establishments, induces me to think that it may perhaps not be altogether without its recommendations elsewhere; and that its claims to regard on the score of being an easy and economical means of effecting a difficult operation of the coinage may be worthy of notice at least in some establishments where the machinery may not be on a higher scale than that of Madras. The reader, however, will be best able to form a judgment upon this point himself, by a perusal of all the details which I shall be able to lay before him; in doing which I shall endeavour, as far as lies in my power, to guard against the bias which might be created by my connection with this system, and to represent as fully as possible, both the defects and the advantages which the plan to be described possesses, in contrast with others now in general adoption.

4. When the operations of the Mint first began in August, 1841, the means for effecting accurate lamina-

tion of the silver straps were very imperfect. Instead of the beautiful case hardened rolls turned by steam machinery, which are now common in modern Mints, we had nothing but brass, or rather bell metal, cylinders fitted in machines worked by bullocks. These cylinders were cast on the spot by the Native artificers of the establishment, and there were no other means of making them exact, than such as were afforded by a turning lathe, also of country manufacture, worked by manual labour. The whole of the laminating machinery indeed was of native workmanship, and in addition to the difficulties and imperfection of work arising from the want of stability and accuracy in its adjustments, the softness of the rollers, and the want of power and regularity in the motion, we had to contend against a fourth difficulty arising from our inability to give sufficient condensation to the straps, for want of mechanical force; which, added to the other three, fully accounted for the unfavorable results which had been previously experienced.

5. When we consider, indeed, what extreme precision is rendered necessary by the conditions of the work to be performed, we can no longer wonder that under circumstances such as are alluded to above, very little success should have been met with. In laminating rupee pieces, the thickness of the strap at the time that it is ready for the pieces to be cut from it, is very little more than about the $\frac{1}{16}$ th of an inch. Each of the blanks which is cut from this ought to weigh exactly 180 grains, and the usual limits of allowed error are somewhat less than $\frac{1}{2}$ grain each way.

6. The weight of the Rupee piece being 180 grains, as above stated, a difference of $\frac{1}{16}$ ths of the $\frac{1}{16}$ th part of the total thickness, would of course cause the amount of error above mentioned. In other words, if the strap were thinner than it ought to be, by more than $\frac{1}{16}$ ths of the $\frac{1}{16}$ th of $\frac{1}{16}$ th, or the $\frac{1}{256}$ th of an inch, the pieces would be unfit for use. The allowed error or "remedy" as it is termed, being in fact less than $\frac{1}{2}$ of a grain, the actual deviation from truth in the thickness of the strap, either way, may be assumed to be less than the $\frac{1}{256}$ th of an inch, or about the $\frac{1}{16}$ th part of the thickness of a fine hair; a degree of accuracy so minute, that it is only wonderful that even in Mints possessing the highest advantages of the most perfect machinery, it should be possible to turn out a large proportion of their work in conformity with it. The Calcutta Mint, for instance, in 1836 turned out no less than 87 per cent. of their blanks within a trifle more than the above remedy, and I believe in the Royal Mint the remedy is the same for silver pieces, and none are filed or alter-

ed in any way, though from what will be hereafter stated it will appear that the general results of the work are not materially better there than in Calcutta.

7. Such results were not obtainable in the Madras Mint at the time the new system about to be described was first introduced; for owing to the causes above stated, and the general disrepair and disorganisation of all its machinery, it is doubtful whether it would have been possible to have turned out more than 10 or 12 per cent. within the above remedies. It had been officially stated some time previously, that about 30 per cent. of the pieces were within the limits of $1\frac{1}{2}$ grain each way, and it is probable that proportion of pieces falling within the limits of that larger remedy would correspond to not more than the per centage above stated for the smaller one.

8. When the pieces as originally cut from the laminated straps are inaccurate in weight, the light ones are returned to the melting pot, and the heavier are filed down to correspond with "standard." This involves an excessive amount of toil and expense, and as the loss of labour is greater when the pieces are light, because then they are not only rejected, but have to go through the processes of melting, laminating, and cutting, again to run the risk of a second rejection, it was customary to leave the laminated straps purposely rather heavy, which though it increased the number of pieces to be filed, yet upon the whole caused the least waste of labour, a larger number of serviceable pieces being in the end obtained. These pieces were thus operated upon.

9. Every individual blank which fell from the cutters was singly weighed by hand, and those which were found to be within the allowed remedies were put aside for the further processes of the coinage. The heavy ones being, in the act of weighing, roughly sorted into classes, by guess, were then passed to the filers who gave them two or three strokes of the instrument according to their supposed deviation from standard. They were then passed back to the weighing man, and usually found still heavy, but nearer the mark; they were then again touched with the instrument, and being returned to the scale, again tested; and sometimes it happened that individual pieces had to be operated on four or five times (especially if the working remedies were small) before being fit for use. In other instances the last stroke of the file having been too violent, the piece became too light, and after all the labour expended upon it, was obliged to be rejected.

10. The above describes the system which, to a greater or less extent, is followed in all Mints where the remedies are smaller than can be attained by the mere use of the laminating machinery, and where consequently, the use of the file is indispensable; but the inconveniences of the system, which are great even with the best machinery, are insupportable when it is to any material extent defective; and it was to obviate, on the one hand the great expense, delay, and uncertainty in

the performance of the work, and on the other to get rid of the disfiguring marks left upon the surface of the coins by the file that my attention was very earnestly directed to this subject, previously to the commencement of the new coinage of silver by the Madras Mint in 1841. The result was the adoption of the system of adjustment now about to be described, which has ever since that period been in constant operation.

11. Before proceeding to enter upon a description of the method above alluded to, I must make a few preliminary remarks, showing its connection with the previous practice, and that followed in other Mints, and the steps which led to its adoption. In order to do this, I must observe, that there are two kinds of difficulties to be overcome in lamination. One is to obtain the ribands, or straps of precious metal, afterwards cut into blanks, of precisely *uniform* thickness in every part; and the second is, supposing the first to be attainable, to hit the exact thickness required. Both these difficulties are doubtless experienced in all Mints, a fact which will not appear remarkable when we remember the marvellous degree of hairsbreadth accuracy which is looked for, and a great deal of management is necessary to obviate the consequences of them, which is in practice effected by various mechanical adjustments and accommodations. In the Royal Mint of Great Britain, which is famed for the beauty and accuracy of its machinery, the equality of the strap is finally brought about, within narrow limits of error, by means of the draw bench; but though this instrument enables the workman to secure a tolerable uniformity in every strap passed through it, it does not seem possible to regulate with great minuteness the exact dimension in thickness to which the strap shall be reduced. The consequence is, that a compensation is frequently required, to make up for the general excess or deficiency in the thickness, over the whole surface of the strap, supposing that thickness to be uniform; and the method of effecting this is thus described in a late lecture of Mr. Brande. "Imagine here again the extreme nicety of these cutters, they must be so adjusted as to cut out exactly the proper weight. Supposing that the bar, or fillet, (strap) which is to be cut into sovereigns is exactly 'standard', it goes through a particular cutter which will cut it 'standard'; but suppose that in testing this way, it should be found a shade too light, it then goes to a cutter which will cut them a shade too heavy, or rather compensate for that lightness. There are in fact a number of cutters of this kind, each varying a mere idea, or mere thought, but still producing a very important result."

12. From the above statement, it is impossible to decide what the exact amount of compensation made by the varying sizes of the different cutters above noticed is; but it may be observed, that in regard to gold coins, even after all the pains which are taken in the establishment above referred to, the result is not sufficiently satisfactory to obviate the necessity for further adjustment, and that the aid of a small file to bring the pieces

to "standard" is sometimes necessary. In regard to silver coins, the whole of the pieces are brought within the limits of the remedy of $\frac{3}{4}$ of a grain each way, in half crowns, which is considered sufficiently accurate without further adjustment.

13. The object of the above notice of the method pursued in the Royal Mint of Great Britain, is that of drawing attention chiefly to the use of a variety of different sized cutters, to compensate for trifling differences in the thickness of various straps supposed to be uniform. The same method of compensation is I doubt not used in other Mints, and was the constant practice at Madras, before the present system was introduced, but the results were very indifferent, owing to the very great want of uniformity in the straps, without which it must be evident, that the mere accommodation of the size of the cutter to the accidental thickness of one portion of the strap, could be of no avail whatever.

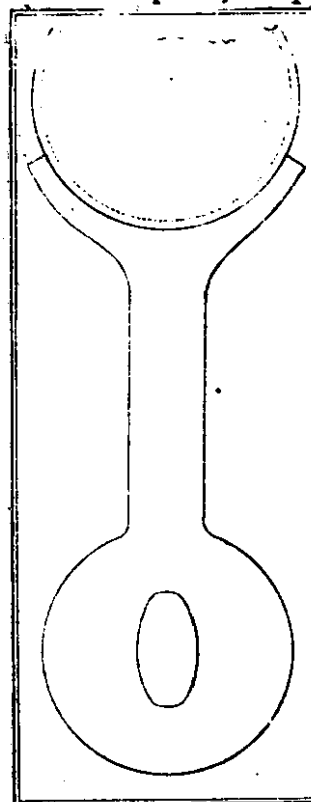
14. On thinking over this subject, the idea which naturally suggested itself in connection with the uselessness of attempting to adjust the cutter to an irregular strap, was that the real desideratum is to apply a different cutter, adjusted to every individual portion of every strap; and it also occurred to me that, as an exact determination of the comparative thickness and density of the different parts, could in no way be so well obtained as by weighing blanks cut by the same cutter, and consequently of equal area, the true object and intent of the above plan of using divers cutters of various sizes would be obtained with certainty if, supposing each strap to be irregular, its different portions could be first cut out and tested by weight, and afterwards brought to the particular cutter exactly suited to them. In other words, if a scheme could be contrived, by which the particular portions of each strap could be first weighed, and then cut in the peculiar cutter suited to them; a condition which it was thought might be fulfilled by first cutting them all out by a cutter somewhat larger than the proper size of the coin; and then, after weighing and separating them into classes, cutting these in a series of different cutters suited respectively, in point of size, to the various thicknesses and densities of the different portions of the strap grouped together.

15. It was a necessary condition of this scheme, that pieces which after being cut with a cutter of one dimension, were equal to one another in weight, should, when afterwards cut a second time with a smaller cutter, yield blanks of equal weight also, and this was easily proved by experimental trial. After this, the arrangement of the practical system was perfectly easy. It must be observed, that when a quantity of laminated metal has been cut up into a great number of extra sized blanks (or as we call them "disks" to distinguish them from the "blanks" which are of the proper size for being fabricated into coins), and these have been carefully separated from one another into parcels of disks of equal weight, we may imagine, that if it were possible to re-combine together all the disks of each parcel, so as to

form them again into new straps, we should then have straps of perfect uniformity, and so exactly true in every part, that all the blanks which fell from the cutter suited to them would be true to standard. Our course of proceeding was therefore very obvious, and the following is a brief outline of the present practice.

16. The laminated straps are rolled down with as much accuracy and uniformity as the machinery is capable of attaining, the object being to bring the average thickness of all parts of each strap, as determined by the weight of disks cut from various parts of it, to true standard. When this is attained in regard to all of the straps, the whole are cut up into disks, that is, into blanks a little larger than the size of the pieces required to form the coins. The next process is that of sorting these disks, whereby the whole mass is separated into different parcels, according to their several deviations above or below the "standard" disk. After this, each parcel is taken to its appropriate cutting press, and one or two of the parcel having been tried, and found to yield "standard" blanks, the whole of the parcel is cut out by that press; and as the disks are all of equal weight with one another, they all necessarily yield blanks equally true to "standard."

17. The difference between the diameter of the disks and that of the blanks is rather less than the $\frac{1}{8}$ of an inch in regard to rupee pieces, and the $\frac{1}{16}$ th of an inch in two anna pieces, and proportionably with regard to



other coins; and I anticipated some difficulty at first in accomplishing in practice the second cutting which this system involves, owing to the nicety which would be required in fitting the disk centrally below the second cutter, so as to admit of the blank being punched out of it exactly in the middle. However, after the trial of a number of contrivances, the very simple one which is shown in the margin, and which consists in the use of a semicircular stop, suited to the size of the disk, and adjusted to the frame so as to lie on the top of the cutter bed, has been found to answer the intended object perfectly; and the little boys who are employed upon this duty are now able to get through the work with perfect accuracy, and with as much

rapidity as in the cutting of straps in the ordinary way. After the piece has been cut, a ring remains, which is separated before another disk is submitted to the ope-

ration. The boy removes the ring with his left hand, while, with his right, he takes another disk from the heap. The diagram is drawn of the full size, and represents a rupee disk, with dotted lines showing the blank to be cut from it, and also the stop which is used to keep the former in its proper position whilst being operated upon.

18. I must now mention, that in speaking of the assortment of the disks into parcels of equal weight, the expression is not to be understood in all the strictness of literal meaning which it is capable of. In fact, when a laminated strap is at all irregular, the number of parcels of disks of truly equal weight into which the disks cut from it would be assorted, must depend upon the nice sensibility of the scale with which they are tested; and if the *utmost* precision be aimed at, it is quite possible that there would be no two disks *precisely* alike. The different parts of an irregular strap vary by imperceptible gradations one from another, and it is therefore only when we are understood to speak within certain reasonable limits, that such a thing as the assortment of a vast number into parcels of disks of equal weight can be considered practicable. Each of the parcels must therefore be understood as comprising all within certain narrow limits each way, and in the existing condition of the machinery of the Madras Mint, we have found it most convenient to form the classes or parcels of rupee disks with differences of half a grain from one another. Of these classes it is necessary to have ten, which thus include all disks within the limits of $2\frac{1}{2}$ grains heavy, and $2\frac{1}{2}$ grains light. In the ordinary course of work a very few fall even beyond these limits, but these are not assorted. They are, however, not at once thrown away, but after being cut in the largest or smallest second cutter, according as they may have transgressed beyond the heaviest or lightest boundary, the resulting blanks are examined, and those which may by chance be within the working remedy are secured.

19. From the circumstance that the several parcels contain disks which are not exactly equal in point of weight, but vary from one another by a trifling quantity, it will have been already inferred that it is impossible that all the blanks resulting from the second cutting can be precisely "standard." Such of course cannot be the case, but, as the second cutter is adapted to produce a piece precisely "standard" from the normal disk, and the whole parcel includes those which vary only as far as $\frac{1}{2}$ grain above and below it, it follows that part of them, namely, those which were nearest to the limit allowed by the class or parcel to which they belonged, would produce, on being cut the second time, blanks $\frac{1}{2}$ grain above or below standard; and all the rest of the disks would within that limit of deviation, produce blanks more or less close to "standard" in proportion to their own proximity or to agreement with the normal disk. Were the system therefore reduced to perfection, and carried into effect without those many blunders and omissions inseparable from Native management, we might reasonably expect, with reference

to the conditions which apply to the Madras Mint, to find all the rupee pieces within quarter of a grain of "standard," and I have no doubt that this is very nearly, if not altogether, possible. Under many disadvantages, the actual results on the large scale, as shown by the result of the Assay Master's examination of the six coins have lately given three-fourths within the above amount of deviation; and if, instead of an infant scheme, every step of which is novelty and experiment, we had been carrying out the details of a thoroughly established system, I think the proportion might have been much increased, and very nearly the whole brought within the remedy of $\frac{1}{4}$ grain.

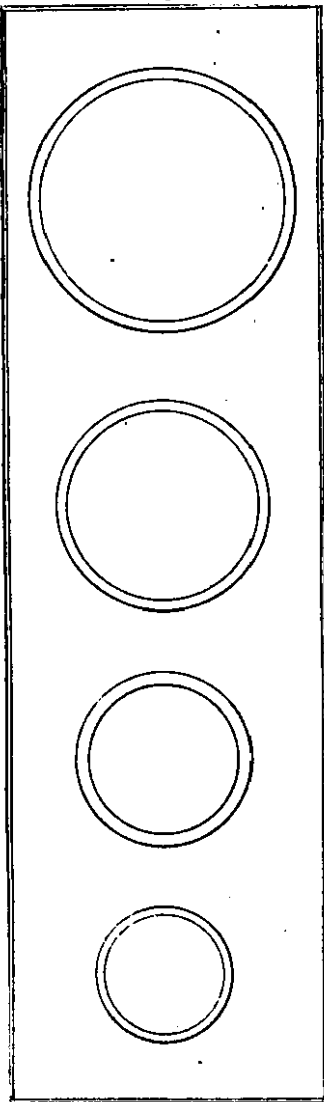
20. But in speaking of the results which have been actually obtained by this method, I only state half the case, if I do not at the same time connect them with the quality of the lamination with which they are associated. I will therefore presently state them more at large, and at the same time give tests of the amount of the errors of lamination, in order that a more definite opinion may be formed regarding the value of the system of adjustment whereby they are compensated. In the mean time, without venturing to enter upon the question as to the advisableness of the adoption of my scheme where the most perfect machinery is at hand, I may observe, that in proportion as the lamination is more perfect, so are the results produced by the second cutting also. For instance, if the lamination effected by the rolling machinery were so true, that very nearly the whole of the disks were produced within $1\frac{1}{2}$ grains each way, it would be possible then to divide them into classes varying from one another by $\frac{1}{2}$ grain only; and after the second cutting the individual blanks would be, only the $\frac{1}{2}$ th grain above and below standard. If the lamination were so perfect as to produce nearly all the disks within the limits of $\frac{1}{8}$ ths of a grain either way, then the individual pieces might be brought to within $\frac{1}{8}$ th of a grain of deviation from "standard."

21. In considering, therefore, the benefits which would ensue from the adoption of this system of adjustment in any other Mint, it is necessary to compare the relative qualities of the lamination produced by the machinery of each, and calculate upon proportionate results accordingly. Now, during the last half yearly settlement of the Madras Mint, the out-turn of the rupee pieces, as produced by double cutting, was as follows. Eighty-two per cent. were within $\frac{1}{2}$ grain of "standard" either way, and of the remaining eighteen, sixteen and a half were within $\frac{1}{2}$ grain, and the rest within $\frac{3}{4}$ grain; which with very rare exceptions is the greatest deviation ever met with, and the following statement, showing the average result of a number of experiments made upon the whole out-turn of the laminating mills, as tested by the accuracy of the disks produced by the *first* cutting, on various days when the mills were judged to be performing their average quality of work, will give as nearly as possible a fair judgment of the accuracy of the lamination with which the above results are connected.

22. On the occasions specified, the disks, taken as they fell from the (first) cutters, gave the following results: 20 per cent were within $\frac{1}{2}$ grain each way, 54 per cent were within $\frac{3}{4}$ grain, and 77 $\frac{1}{2}$ per cent fell within 1 $\frac{1}{2}$ grain on either side; three per cent being beyond the limits included in the sorting for adjustment, which as above stated takes in all within 2 $\frac{1}{2}$ grains over and under the "standard" disk. These results it must be remembered apply to *disks*, which are heavier than rupees by 20 grains, but making allowance for this, they show the state of the laminating machinery very well; and with such lamination, the whole of the pieces which by the first cutting were delivered within the limits of 2 $\frac{1}{2}$ grains, were by the second, brought within the working remedy of $\frac{3}{4}$ grain, the greater part being within one-third of that amount of deviation from "standard." Thus the number of serviceable blanks amounted to 96 or 97 per cent.

23. The same process is followed with the smaller coins, and the results are equally satisfactory, but the blanks are not brought within a degree of proximity of standard proportionate to their weight, in consequence of the difficulty of separating the disks with any thing like rapidity, when the difference between the classes is less than $\frac{1}{2}$ grain. The following are the weights of the disks and blanks for all the coins, of which full sized drawings are given in the margin.

Rupees.	Disk.	Blank.	Ring.
200	200 grs.	180	20
$\frac{1}{2}$ R.	100 do.	90	10
$\frac{1}{4}$ R.	50 do.	45	5
$\frac{1}{8}$ R.	27 do.	22 $\frac{1}{2}$	4 $\frac{1}{2}$



It will be observed here, that the last or smallest coin has a larger proportional ring than the rest, and this is owing to the great difficulty of correctly cutting out so small a coin, if the margin to be separated from it, were so very narrow. We have found that it could in practice be reduced below 4 $\frac{1}{2}$ grains, but the reduction has been thought of too little consequence, to make it worth while to diminish the facility of work, to effect it.

24. Perhaps it will tend most to the thorough comprehension of all the details of this system, if I enter at once upon a comparison of its merits and defects with those which are already fully established; and as this will give me an opportunity of stating facts, which require to be known to judge of it fairly, and anticipating

objections which might be made against it, I will at once enter upon a fair investigation of all the chief points of comparison.

25. On first beginning business upon this plan, I was chiefly apprehensive that the differences in diameter which essentially belong to the different blanks after adjustment, would be the occasion of some trouble or imperfection in the pieces in the after processes; but this is now proved not to be in the least degree the case. My fear was, that the stamped pieces would differ from one another, but this has since been proved to be impossible, owing, partly to the exceeding minuteness of the differences in question, and partly to the compensating effect of the processes subsequent to the second cutting. Although there are ten different classes of rupee disks, and the difference in weight between the heaviest and lightest is not less than 5 grains, yet, the difference in diameter between the largest and smallest blank produced after the second operation of cutting has been proved by accurate measurement to be only the $\frac{1}{16}$ th part of an inch.

26. The blanks, after milling, are all brought to the precisely same diameter, and it might be supposed, that as the difference in diameter vanishes after that operation, the defect of metal in the smaller blank ought to be shown in a want of elevation in the raised edge, produced by the operation. Even this, however, is almost imperceptible, as I have ascertained by careful measurement that the difference in thickness of the rim between the largest and smallest Rupee blanks milled to the same gauge is only the $\frac{1}{16}$ th part of an inch. And I may add, that in taking up a parcel of the mixed blanks after milling, it is not at all perceptible.

27. It is evident, that as the pieces after milling do not sensibly differ from one another, there can be no difference, from the supposed cause, in the pieces after stamping. Indeed even if such a thing were to happen, as that any of the pieces differed in a trifling degree in their diameter, or the thickness of rim, the expansion of the metal, and its moulding to the form of the die must necessarily efface the defect. It is therefore unnecessary for me to say more, than that we have never had the slightest inconvenience on this head, even although we have been obliged to include within the limits of adjustment so wide a range as 5 grains of deviation; were our means of lamination more perfect, so that the differences in weight to be compensated were less, and consequently the differences between the greatest and least diameters of the blanks less also, the possibility of such an inconvenience being felt would be still further removed.

28. But although we have had no practical difficulty whatever on the score of the differences of size, and it would not have occurred to myself that any such could arise from it, a difficulty has been suggested to me, to which we, in Madras, are not liable. All our pieces are milled by two or three operations, which method has been in use for many years, having arisen probably from the circumstance that the force necessary to raise

the edge by one process is too great to be done with facility and despatch by manual labour. The rupee pieces are milled three times in general, but the smaller sized blanks merely pass through the first time unaffected, by the machine. When different sized blanks are attempted to be milled by one stroke, as is usual in Mints worked by steam, I am informed that some difficulty is experienced, from their very various behaviour under the operation. This evil would certainly require correction, and it would probably be most easily done by keeping distinct in three classes the medium, large, and small blanks, and milling them separately; but if no other plan could be found, it is certain that the utmost extent of the inconvenience resulting from it must be this, that to carry on the new system with steam machinery, a threefold number of milling machines would be required. They are of so little cost, that this would be a matter of no moment; and the whole extent of the evil would be comprehended by the first cost of purchasing, and the wear and tear in working, the larger number of these machines; for it is not probable that the same operation of milling, if performed in three stages, would consume more power than when done by one.

29. Another objection was suggested to me as the consequence of the new method of adjustment, and this was founded upon the consideration, that in contrasting its results with those of other well known methods of proceeding, it would be necessary to add the weight of the *rings* left after cutting out the blanks from the larger disks, to that of the rejected blanks, in estimating the loss per cent. I think this objection is valid, and that it would not be fair to contrast merely the proportion per cent of good blanks gained, out of the number of pieces cut, without such addition; but the most perfect method of obtaining a fair test of the system in this respect, is that of taking the actual practical results on a large scale, in respect to the proportion of good coins out of the whole weight of bullion laminated, and contrasting it with similar results obtained by other means; on doing which it will be seen that there is no need for apprehension on this score.

30. In the Calcutta Mint, where the plan adopted is that of repeated lamination in a separate series of the most exquisitely finished rollers, and where the results are considered to be as perfect as in any Mint in the world, the out-turn of correct blanks within the working remedy of $\frac{2}{3}$ grain each way, has been above stated to be 87 per cent, as ascertained by careful trial made for the purpose. The heavy blanks which exceed that remedy are filed down, and the lighter ones rejected; and taking the average of ten years' work, viz. from 1833-34 to 1843-44 both inclusive, and comparing the bullion laminated with the coins issued from the Mint, the proportion of the latter to the former is very nearly 53 per cent. By comparing together the melters' accounts of the quantities of solid bullion and scissel melted during the same period, the proportion obtained

rather exceeds 54 per cent, as the ratio of coins to bullion laminated, which is somewhat in excess of the above. During this period the rupee pieces formed about 94½ per cent of the whole out-turn, the half rupees about 3½ per cent, and the quarter rupee pieces, 2 per cent. The importance of noting this, will be seen hereafter.

31. In the Bombay Mint, which I believe is also supplied with English machinery, kept in the highest state of efficiency, I have no means of stating the result from the experience of a series of years, but from an official statement given by Captain McGillivray, in a letter dated 11th November, 1835, it appears by comparing the "ingots received from the melter, gross weight" with the "good coin to Mint Master, during one year's work, that the proportion per cent of good coins to bullion laminated, was nearly 54 per cent. I have lately received private accounts of the performance of the same Mint, in which the result of a few months' work has reached as high a ratio as 62 per cent, in rupee pieces singly; but in other coins it was very much below this, and therefore taking all together it is probable that, though the result last mentioned is highly favorable, still that the general average of a long course of years applicable to all coins may not be materially in excess of the per centage shown by Captain McGillivray's statement above referred to.

32. In the Royal Mint of Great Britain, where it must be supposed that the highest possible advantages of mechanical efficiency are to be found, it appears from Mr. Bingley's evidence before the House of Commons, No. 2589, by comparing the solid bullion and scissel melted during the course of 15 years, that the proportion of coins to bullion laminated is 53½ per cent.

33. Taking, therefore, the whole of the above facts in connection with one another, it seems to be pretty clearly indicated, that in the ordinary course of business on the large scale, in the best Mints, the proportion of the good coins issued to the bullion passed through the laminating mills, may be safely assumed at about 54 per cent, as applicable to all descriptions.

34. In contrasting with this the actual results on the large scale by the new process, I must preface the statement by an explanation, why it is impossible with fairness to appeal to the experience of a larger period than one half-yearly settlement. The truth is, that the new system of adjustment was begun at a time when the Mint was in the greatest disorder in every respect, and until a late period, there were many serious unremedied defects, which materially affected the result now under inquiry, but which were in no way connected with the *system* to be tested by them. Thus, for some time the department not being furnished with dies for any other than the coinage of rupees, all the straps which became too light for that coinage were unserviceable, and were necessarily added to the scissel, instead of being, as usual, rolled down for smaller coin. Again, till very lately, for want of proper implements, all the

ingots were of one uniform breadth, no matter what were the coins which were to be cut from them. To this I need only add, that the use of the *stop* in the cutting presses has been only very recently adopted, to show, that if the experience of the Mint were to be taken during the existence of all these drawbacks, a very fallacious comparison would be made of it, when placed side by side with that of other Mints in all respects fully provided with implements and means, and in perfect working order.

35. I take the results, therefore, of the latest settlement, because it is the only one in which some one or more of the above most serious drawbacks has not been experienced; and it is on this account the only one from which even an approximately fair comparison can be drawn, but even this I consider to be far from just to the system, owing to the injurious effect upon the result under inquiry which an usually large proportion of small coins has, as will be seen hereafter; and in this settlement the proportion of small to large coins very greatly exceeded that usual in most Mints, and probably that of the Mints above mentioned, certainly that of Calcutta.

36. The actual result on the large scale now spoken of, as having been experienced during our last (8th) settlement was, comparing the bullion laminated with the good coins issued from the Mint, 59.4 for the rupees taken alone, and 56.87 for all the coins taken together; the whole weight of ingots worked during the settlement having been 31,47,784 tolas, and the weight of the finished coins actually remitted to the Government Treasury being 17,90,150 tolas. During this time the proportion of whole rupee pieces was only 73.4 per cent, half rupees 15½, quarter rupees 7, and one-eighth rupee, or two anna pieces, 4 per cent.

37. The importance of taking into consideration the relative proportions of the larger and smaller coins will be at once seen from the following statement. The out-turn of finished good coins actually remitted to the Government Treasury, as compared with the bullion laminated was, as above stated, in regard to rupees 59.4 per cent. In half rupees it was only 53 per cent, in quarter rupees only 52.65 per cent, in one-eighth rupees, or two anna pieces, only 44 per cent. Combining all these ratios in the respective proportions in which they formed part of the remittances of the settlement, as above stated, they will be found to come to within a fraction of the same per centage as has been given as the actual result of the whole, viz. about 57 per cent; but it is evident that, had the proportion of the smaller coins been less, the per centage would have been nearer to 59.4 per cent, which is that properly belonging to the rupee pieces. In contrasting, therefore, the experience of this system with that of others, an injustice is done when, as in the present case, the comparison is made between unequal ratios of large and small coins.

38. The results above given are sufficient to show that the new system of adjustment is not liable to any

objection on account of its occasioning a greater production of scissel than is usual by other methods; and I do not wish at present to say more. I must observe, however, in regard to the rupee pieces, in reference to a contrast of the per centage of out-turn of those coins with the superior produce of the Bombay Mint, that a strict comparison of the two systems would only be just were the conditions of acceptance and rejection of the pieces the same in both. In Madras, not a single piece was filed or altered in weight in any way, and every piece in the smallest degree beyond the working remedy of ¾ grain, heavy and light, was rejected and added to the scissel. In the Bombay Mint, the remedy is, I believe, 1½ grain each way; and I am of opinion, that had the same allowance been made in Madras, a large part, if not all of the difference would have been done away with.

39. It is perfectly true, however, that there is an increase in the scissel in the smallest coins, if the results of the new system, working with very limited remedies, be compared with the old methods and more easy ones. The remedies within which the whole of the above coins were confined, were as follows:—Rupees, ¾ grain, each way; ½ rupees, ¾ths grain; ¼ rupees, ¼th grain; ¼th rupees, ¼ths grain. If these remedies were rigidly insisted upon, I am doubtful whether, even in regard to the smallest coins, the common methods of adjustment would be able to effect more than is above stated, as the actual result of the new one; and it has been seen that on a general average of all work, even when the small coins were in an unusually large ratio, the latter has the preference.

40. I now come to a third objection, which is of a practical nature more easily to be understood, and this is the necessity for a large number of cutting machines. This is true, as an indispensable condition of the system, for it is necessary to have, not only the usual number required by the old methods of coinage, but I am of opinion that it would be desirable in every Mint adopting the new principle of adjustment, and having a large amount of varied business, to have a separate set of 10 cutters for each of two, or perhaps even three of the coins most usually in demand, to avoid the necessity of dismounting and changing the punches frequently. We have hitherto managed with only a single series of 10 cutters besides the original set of first, or "disk" cutters, not having had leisure and opportunity to provide ourselves with others, but this has subjected us now and then to the inconvenience of delay in dismounting one series and mounting that belonging to a different species of coin, which is usually a day's work for a couple of men. The defect will soon be remedied, and it may be here noticed, that it is not necessary that these instruments should involve all the cumbrous and elaborate complication to be found in Boulton's or Hague's Mints, much more simple apparatus, even for steam power, having been found perfectly efficient. In regard to the very small coins, the series of ten second cutters, when mounted in a single machine, may be easily worked by a couple of men, the whole forming a compact and efficient work-

ing instrument, of a size not exceeding that of a common four-foot lathe. We have lately constructed a machine of this kind, which is not yet sufficiently advanced to have been put to regular work, though enough has been done to test its efficiency; and the results have been very satisfactory.

41. It is fortunate that in the second cutting, which requires such a number of instruments, there is the greatest facility in bringing them into work, and indeed of making them automatic, so that the whole labour may be transferred to the steam engine; for as the metal to be cut is no longer in straps, but in circular disks of uniform shape and size, nothing is easier than to supply the cutter with a continual succession of them, in a manner somewhat similar to that in which the Boulton stamping press is fed, and the power being transmitted merely in the ordinary way, by a horizontal shaft working a pair of eccentrics, with another pair to work the feeders; the only thing which is further required is the attendance of a boy on a set of 10 cutters, to keep the hoppers holding the disks full, all the rest being done by the machine.

42. In taking into consideration the amount of disadvantage entailed by the increased number of cutters, it must be noticed, that although for the sake of comfort, and the most luxurious facility in the execution of business, it would be desirable to have many sets of second cutters, say even 3 or 4 sets of 10 in addition to the number at present allowed; still, that with the exception of the money required for first providing these instruments, and the interest upon the outlay, the expense is not proportioned to their number, the real additional number absolutely required for all kinds of coins being only one series of ten, with which provision only, in fact, the whole of the business of the Madras Mint, with a very varied coinage, has been carried on for the last four years. The multiplication of instruments is merely a facile way of providing for the ready application of the second process to various species of coins; but however numerous they might be, it must be remembered that the whole amount of *cutting* is only once more, in addition to the once common to all systems of coinage. Of the expense of this addition I shall have to speak presently, but in the mean time I may observe, that the cost of a machine such as that we are just completing, containing a set of 10 cutters, would be I should judge, if executed in the best manner in London, about £150; and that taking all sizes of coins together, a Mint might be perfectly furnished with three or four such machines for £1,000.

43. In the same way, four weighing machines, upon the principle of that described in a former paper in this volume, (page 169), and which I should conjecture would cost an equal sum, would render a Mint completely independent in that part of the process, and thus the whole first cost of construction of the necessary machinery would be represented by £2,000; or if three or four hundred pounds be added on account of extra milling machines, say £2,500, a sum which I should imagine was not much in excess of the cost of the

draw benches, or finishing mills now employed in other establishments.

44. I am aware of no other peculiarities which come under the head of disadvantages, and I may therefore proceed to consider the question of the current expenses of the new, as compared with the old system; but here I labour under a difficulty which I am altogether unable to surmount. It is impossible to make a fair estimate of the comparative expense by this and other methods, except by first deciding for which part of the former processes the new are to be substituted, and it is in this that the difficulty lies. My belief is, that the process above described must be considered not merely as a substitute for the *adjustment* which pieces require after the straps have undergone the elaborate rolling in the exquisite machinery of a set of finishing mills, or have been rendered accurate and uniform by the toilsome and difficult operation of the draw bench; but that it is to be taken as a new means of effecting the same object as is attained by these operations, in addition to adjustment with a file when that is used; because I think it probable that the condition of the strap previous to the cutting of the "disks" which are by the new system brought within the limits of accuracy above stated, is not superior to what it is in other Mints previous to the use of the finishing mills and draw bench. However this I must leave to be judged of by the average statement of the tests of the lamination, which I have before given; and it is evident that if my supposition be correct, and if the condition of the straps usually operated on by us is not superior to that of the straps in other Mints, previous to the use of finishing mills or draw bench, then the whole of those operations are saved by our method of adjustment.

45. From the description given by Mr. Brande of the vast pains taken in rolling previous to the use of the draw bench, I have no doubt that the whole of the latter expense is saved by our method, in which case the difference of expense must be very great indeed. In other Mints where adjustment by the file is used, the saving is also very considerable, putting out of consideration the expense of "finishing" the straps. The cost of adjusting the cut pieces by the file has been officially stated to be about 28 Rupees per lac, and this includes all the cost from the time the blanks fall from the cutters to the time that the whole lot is delivered, the pieces being singly weighed and adjusted to within the prescribed remedy. By the new system, the operations which the blanks (disks) would have to undergo, would be, weighing or assorting, and second cutting. Speaking of rupee pieces, which are the most expensive by our plan, the cost of the weighing, supposing it done by a machine of only 50 beams, worked by hand, would be as explained in art. 56, page 179, only 14 annas 1 pie, per lac of pieces. The second cutting, if done by coolies and the pieces supplied by feeding boys, as has been practised by us, would be 3 rupees 10 annas 8 pie; a man and a boy, whose joint pay is 11 Rupees, finishing 12,000 daily, or 3 lacs per month of 25 working

days. The whole cost of adjustment is thus shown to be 4 rupees 8 annas 9 pie per lac of pieces; but the estimate might be reduced to less than half that sum, in regard to a Mint worked by steam instead of manual labour. A trifling addition may perhaps be made to this estimate to account for the wear and tear of a three-fold number of milling machines, but it is doubtful whether the wear would be much increased, since the force exerted by each would be only one-third of those with which the comparison would be made.

46. If the comparative expense be as $4\frac{1}{2}$ to 28 in regard to rupee pieces, it is much less in regard to the smaller coins. The expense of assorting small coins in a machine of 100 beams, would be less than 8 annas per lac; and it appears certain, by the experience we have thus far had with the cutting machine before alluded to, that the cost of that process may be reduced to about 12 annas per lac, making the total expense $1\frac{1}{2}$ rupee. Indeed as regards very small coins of the precious metals, I can hardly help feeling that if they should be required to be brought within limited remedies, such as those which are required by us, viz. $\frac{1}{8}$ th grain for the two anna pieces; it would be quite impossible to get through a coinage of them in a large Mint, by any other means than those I have above described; for the infinite labour and time requisite for the individual examination and adjustment of the innumerable quantities comprised in an extensive coinage, would demand such a multitude of men as to create the greatest inconvenience to find accommodation for them, and a still greater trouble to keep them in order.

47. It has been before stated, that the weight of the rings is comparatively more in the small coins, so that the yield of the straps is less; and I question whether the out-turn of two anna coins can by the new process be made to exceed 50 per cent of the bullion laminated. Nevertheless, I cannot help thinking that the system of double cutting is peculiarly suited to the fabrication of small coins, when these are required to be brought near to standard, on account of the great ease and expedition with which the whole of the business of lamination, cutting, and adjustment is effected; indeed I am convinced that the regularity and certainty with which the desired effects are arrived at, could not fail to be a great relief to any department charged with the fabrication of these coins, when contrasted with the confusion, uncertainty, and disorder, not to mention also risk, involved in the employment of such a number of men as would be required to adjust them by the ordinary means.

48. Nothing can be simpler, indeed, than the routine followed in the adjustment of coins to the most limited remedies by the processes above described, and it seems to me that this is a strong argument in favour of the system. During the four years that it has been followed at Madras, the desired results have been attained with the greatest uniformity and ease; the number of pieces which have been rejected in consequence of exceeding the remedies being, according to a late average, less than $\frac{1}{4}$ per cent. This is the practical de-

duction from the experience of a system still in its infancy, and very imperfectly supplied with means; but the $\frac{1}{4}$ per cent refers only to the pieces actually lost in adjusting, and does not include the loss of pieces which owing to bad lamination fell beyond the limits capable of adjustment, which were about $2\frac{1}{2}$ per cent more. During this time the management of the processes of adjustment as well as the lamination of the straps was done entirely by Natives under the direction of an East Indian Superintendent, and though, I doubt not, that they were conducted with utmost care and attention of which they were able, yet there was nothing at all, even in the most remote degree corresponding with the difficulties spoken of in the following paragraph of Mr. Brande's lecture; which indeed it will be evident from the state of the straps after lamination, as shown by the tests before given, were not attempted nor required to be removed.

49. The following is Mr. Brande's statement regarding the rolling given to the straps in the Royal Mint previous to the use of the draw-bench. "The rolling of the Mint is perfectly distinct from the rolling of iron, copper, or other metals commonly carried on. The utmost nicety is required to proportion the edges and parts of the ribbon (strap) to the particular thickness, which is determined by very nice gauges; above all, to take care that there shall be no inequality in the pressure, so that one side of the bar should become thinner than the other. It is necessary, further, to take care that the ribbon is perfectly true, not curved or curled in any way, and that the edges especially are correctly squeezed out. All these are matters of extreme difficulty in practice, but most highly essential, in order to avoid a great deal of trouble which must result if points of this kind are not attended to in the earlier process of manufacture." The points here specified are, I think, all of them attended to, but most probably not with that minuteness and precision which are necessary when any irregularity in the strap once created is so difficult to rectify. According to our system, all these irregularities being subsequently compensated for, are of little consequence, provided the whole out-turn of "disks" can be brought within the broad limits of remedy established by us; and the only question as to the propriety of bestowing any more care upon this part of the operation is, whether with such machinery as we have, the additional trouble necessary to bring the $2\frac{1}{2}$ per cent of "disks" lost by bad lamination within the reach of our adjustment, would be well bestowed; a question which the Natives have practically answered in the negative.

50. I think I have now touched upon all the peculiarities of the new system, and fully stated all its defects as well as advantages. Amongst the former, in treating of the expected difficulties, I have stated that the minute differences in size of the various blanks are quite imperceptible in practice, and that they are not felt by us in the only way in which they could manifest themselves, viz. in milling, in consequence of our

independently being in the habit of performing that process by three operations. That the evil of adopting this course, where it is not already followed, amounts to the cost of purchasing a three-fold number of milling machines, to be worked at the same expense as before, but that this cost is so trifling as to be of no moment. I have shown also, that on contrasting the new system with the old, as to the produce of the straps, counting the rings and rejected pieces, and every thing except the good blanks within the working remedies, as scissel, the new system gives results upon the large scale quite as favorable as any other at present in use. In other respects, that as regards accuracy, uniformity, the certainty with which the results are obtained, and the ease of obtaining them, it is to the best of my judgment superior to any other system that I am acquainted with; and lastly, that in point of expense the cost is less than $\frac{1}{10}$ th in regard to the large coins, and probably less than $\frac{1}{20}$ th in the small ones; and that too, as determined by experience under circumstances wherein steam power was not available, which would materially add to the economy of the processes.

51. I might add to these recommendations, the fact that owing to the absence of filings, and the perfect cleanliness of the whole business, there is no possibility of the occurrence of waste, which as it might occur to a trifling extent by the old process, is apt to be made an excuse for a regular allowance for loss. I shall however only say in conclusion, that although, owing to the incessant demands of a constantly increasing coinage, and the very defective state of the machinery of the Mint in general on our first commencing work in 1841, we have never yet had leisure to provide the department with a complete set of instruments to carry out the system, yet still, with the most inadequate means we have found the advantages so great as to have been constrained to follow it exclusively ever since it was first adopted; and every day's experience has confirmed and added strength to the opinion, which induces me to recommend it for trial in other establishments placed in similar circumstances with ourselves.

December, 1845.

J. T. S.

POSTSCRIPT TO THE MEMORANDUM ON WASTE IN THE VARIOUS PROCESSES OF COINAGE, BY CAPTAIN J. T. SMITH, F.R.S. F.R.S.N.A.

Since the paper on this subject passed through the Press, I have been favored with the criticism of a friend, whose opinion I value most highly, based as it is upon a thorough knowledge and long practical experience of the subject. The remarks which he has kindly made, were not written with any intention that they should be thus noticed, but as the subject is an important one, and as they state difficulties which might naturally present themselves to others as well as the writer, I have taken the liberty of entering into the explanations to which they give rise, to guard against the misconception which might otherwise exist in the minds of others. My correspondent writes thus: "I admit to the full most that you assert, but with reference to the loss in melting, I cannot make up my mind that the quantity of silver remaining in the dross is so small a fraction as you suppose it to be; it could only be ascertained by some most careful experiments; for instance, if in your assays of bullion any allowances are made for cupel loss, for refining in muster melting, &c. &c., and that estimated quantity is greater than it really is, so much more silver has to be accounted for from the dross. It is true that most of the silver in the dross is recoverable, but when the quantity is very minute, it is practically out of the question, as the expense of the process becomes greater than the value of the bullion recovered." Upon this I must explain, that my arguments as to the absence of any essential waste in coinage are based upon the supposition that the bullion is truly and fairly debited to the department, according to the "trade assay;" in which case, as I have stated, instead of a waste by the processes, there ought necessarily to be an actual and considerable gain. If owing to an inaccuracy in the cupel allowance, or the allowance for refinement in muster melting, more or less than what is proper should be left in the dross, then, in that case this gain would be greater or less according to the amount of error, but it appears to me to be unadvisable to embarrass the question by the supposition of errors in the assay, which may tell either way, because the conditions under which the argument is stated exclude that supposition, and they are not affected by it.

The quantity of silver which has been stated by me to remain in the dross at each settlement, is not a matter of inference or deduction, but is ascertained by actual experiment by the Assay Master; every separate dross belonging to each department of the Mint, being ground to impalpable powder, and after being thoroughly mixed, a sample recovered with the utmost possible care, as a specimen of the whole. It has, however, been stated, in the Memorandum, (para. 62) that while the drosses usually contained these amounts of bullion, the accounts of the department during seven

settlements had been made up, and showed a considerable excess. If it were possible that the drosses contained more than was supposed, the same having escaped the scrutiny of the Assay Master, we should be forced to conclude from that circumstance that had the recoveries been made more perfectly, a larger excess of the deliveries beyond the accounts would have been the consequence.

My friend proceeds: "Again there is a slight irrecoverable loss in all the Minting processes; minute particles of silver are separated from the ingots under the rolls. In annealing, very thin laminae are melted, and lost in the furnace: in filing, as in the rolling mill, some of the minute particles stick to the workmen's clothes and felt; and I believe that in pickling, with the alloy, a small quantity of silver also is separated. Even in the coining presses, when a collar begins to wear, I have found particles of silver about the floor, so light as to be easily blown about with the breeze, and so small as to be scarcely worth collecting. It is true the quantity of all these losses, except that of melting, is so minute as to be almost inappreciable; yet it is not correct to say there is not any." Upon the whole of these items, except the filing, in which I have admitted in the Memorandum, that a very trifling amount of loss may be unavoidable (except by adopting a new process of adjustment.) I must observe, that in my Memorandum I addressed myself more to the essential characteristics of the different operations, than to the *accidental* contingencies which might accompany them; and that in showing, generally, that so far from a considerable waste being the necessary consequence of coinage, the opposite ought to be the true result, I did not think myself called upon to enter into those minutiae of explanation which are required to meet these difficulties. I must however now explain, that the principles already given include all these minor exceptions. In regard to every one of the minute losses above referred to, except filing, a complete recovery may be made. In the Madras Mint, the sweepings of every room, rolling mills, &c. are carefully collected together, and recovery made of the silver as far as it is profitable to do so: what remains in the dross is estimated, and is included in the statement of the quantity of bullion contained in the dross before given, and *credit for it is taken in the accounts*. In regard to losses in the furnace, the sweepings of it are fully searched, and there is no possibility of metal escaping, for it cannot be volatilised. In regard to the minute quantity of silver which is dissolved together with the alloy in the pickling liquor, that also is recovered, by the simple method of inserting copper sheets.

It may be objected, however, that spite of all the sweeping and gathering of drosses, particles will re-

main which will defy the most elaborate search and investigation. This objection which I look upon as the very last stronghold of resistance, I feel it to be hardly necessary to meet in support of an argument professedly directed only to the main principles of the question; but I believe that the doctrine I advocate will stand to be pushed even thus far, and that even then its truth, as applicable to the ordinary operations of a Mint, will be vindicated. But in order to perceive this, it will be necessary to enter into some little explanation, and I trust that the following illustration will show my meaning.

If a Chemist makes an analysis of a mineral so accurately, that not a single particle of it is either dissipated by heat, blown away in powder, or left behind in the solutions or mixtures which may have been made of it, we may conclude that he is able to collect every particle of it again, with the exception of such minute quantities as may adhere to the different vessels he has used in the process. I assume that he has not dissipated any part of it, or allowed it to escape unnoticed, mingled with any fluid or solid matters which may have been used in his processes. These solid and liquid "drosses" contain nothing whatever, and none has been dissipated; the only deficiency therefore is that which adheres to the vessels. Let us suppose the mineral weighed 100 grains, and that the deficiency is $\frac{1}{2}$ grain.

Another precisely similar mineral is treated exactly as before in the same vessels, and its particles are removed with precisely the same care. Can it be supposed that the deficiency will again be $\frac{1}{2}$ grain? Let us suppose 10 minerals successively treated, and by the use of the same vessels and instruments, can it be supposed that still the half grain of imperceptible adherent matter will in each remain unaccounted for. At the end of 20 operations, there would need to be accumulated in the vessels 10 grains of matter undiscoverable; not thrown away in the drosses, not dissipated, but inseparably adherent to, or absorbed by the instruments employed. Of course this is impossible. After the first or second trial, this source of deficiency must cease; for as it is almost certain that the vessels would be made equally clear of matter on each occasion, so it would follow as a consequence that the amount of imperceptible adherence and absorption would constantly be the same, and that after the first few trials, there would cease to be any further loss from that cause.

And the same is the case with regard to the sweeping up of successive coinages of silver or gold. The whole Mint may be looked upon as a vast laboratory, and each successive room as a large vessel for performing certain processes upon bullion passing through it. On the first occasion of a coinage of any metal, we might expect the sweeping of any and all the rooms to be partially defective, and to leave behind a certain trifling amount of undetected particles; but after two or three such sweepings, it may be concluded that the room will be *saturated*, if I may use the term, and have no further capacity for holding them out of the reach of the sweeper. After this, which must

happen on the first establishment of a Mint, not even the trifling loss from the minute particles which have eluded search would be experienced. All the remaining coinages would be free from any loss, for although it is very possible that some of the particles of each might escape discovery, yet if, as is probable, the total amount of latent bullion always remains the same, it is evident that the losses in each succeeding coinage would be replaced by recoveries from some of the former ones.

The practical advantage of this principle may however be lost when coinages of the precious and base metals are made to alternate frequently with one another, and the drosses are not carefully separated. In this case, the trifling remnant of unrecovered particles of gold and silver might be confounded with that of the base metal; but this is not the state of things contemplated by me as the ordinary routine of a well conducted Mint; and even this, though certain to occasion trouble and inconvenience, ought not to be the necessary occasion of any loss.

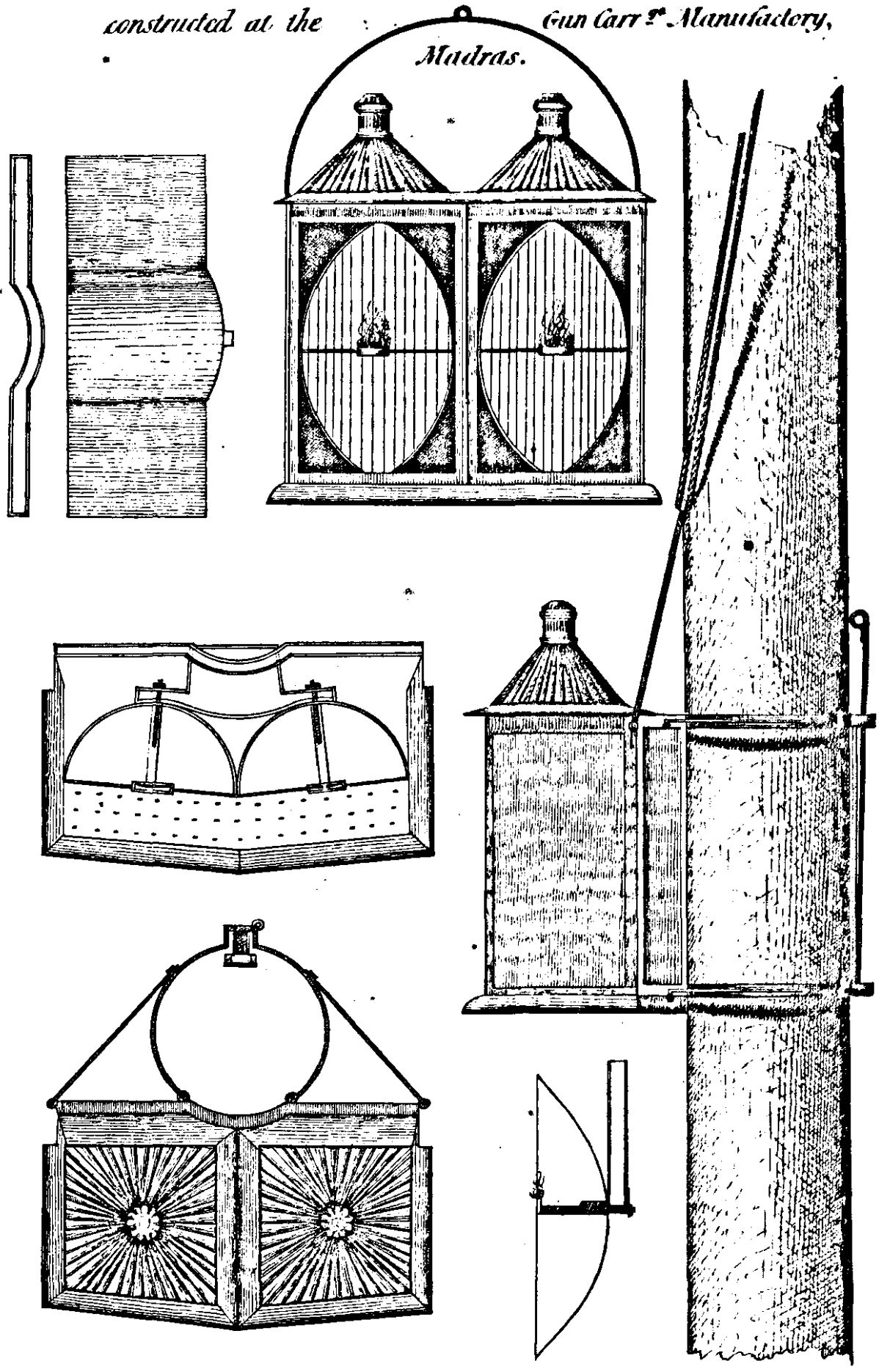
Moreover, if the possibility of the occurrence of waste be pushed to such an extreme, it would be necessary to do the same in regard to the various causes of a surplus. I have shown, I trust satisfactorily, that on general principles, in the large way, a considerable excess ought to be met with in the operations of every Mint; arising from the fractional difference in value between the "trade assay" and the true fineness of bullion. As a set-off against any minute possible exceptions against the general principle, such as those above noticed, I might appeal to the benefit by the trifling gain in *weight* arising from a similar cause to the above, and additional to it, viz. owing to the purchaser being given the benefit of the "turn of the scale" in weighing as well as assay. In Madras, merchant's bullion is weighed in bars of about 1,500 tolas, and the weight is calculated to the $\frac{1}{4}$ th tola, the benefit of the turn of the scale being given to Government. The gain arising from this source, if the practice were followed universally, would be in a year's coinage, suppose of 50 lacs of Rupees, more than 200 Rupees, a sum which would, I imagine, cover more than ten times all the minute chances of loss last referred to.

I may take this opportunity of observing, in regard to the statement given in the Memorandum, (para. 31) as to the loss of weight in blanching coins, that subsequent experiments have shown that the process adopted for the separation of the grease, also carries with it a considerable quantity of oxide of copper. This circumstance explains the reason of the apparent difference stated in the Memorandum between the experience of the Madras and other Mints as to the result of the action of the acid; for the total loss of weight in regard to blanks cut from straps laminated without the use of oil, we have found during the last settlement to amount, including this oxide, to $11\frac{1}{2}$ annas per mille or 1 anna 1.8 pie per cent, a proportion which does not differ in any remarkable degree from that experienced elsewhere.

December, 1845.

J. T. S.

COAST LANTERN,
with two Reflectors,
constructed at the Gun Carr^y Manufactory,
Madras.



NOTES REGARDING THE EXPERIENCE OF THE NEW SYSTEM OF FIXED LIGHTS.

When the first volume of our transactions was published, the experimental trial of the new system of fixed lights had only recently been made, and it was therefore not possible to appeal to the actual results derived from more than one or two of them.

Since that time, the use of the lanterns, and of larger lights constructed upon the same principle has been much extended, and already more than a dozen lights are in actual operation. Of these the forms and dimensions are different according to the localities to which they are suited, and the number of their reflectors; the smallest being of the pattern of that which was established at Cochin, of which a figure was formerly given; (vol. 1, pl. vii.) and that most commonly used, being a lantern with two reflectors, of which a general idea may be formed from the drawings contained in the annexed plates.

The following notes will serve to make known the chief particulars respecting each of the beacons at present established, and give some idea of the mode in which the system is applied in various situations. The details regarding cost have been kindly furnished to me by Captain Maitland, Superintendent of the Gun Carriage Manufactory, by whose department many of the lanterns have been made; the other particulars, I regret my inability to render more complete, having no other source to apply to for them than my own memory and a partial reference to the correspondence. The first in order as to the date of exhibition is,

Madras Temporary Light—This light has been already noticed in Volume I., it was a substitute for the 12 lamps and reflectors formerly in use in the Madras Light-house. It consisted of 4 lamps and reflectors upon the new plan, and was found to answer the purpose perfectly, the power of the light being increased four-fold. The whole cost of the apparatus was about 200 Rupees. The average consumption of oil previous to the substitution was 370 maunds at the cost of Rupees 3 ,, 2 ,, 10 per maund, or Rupees 1,194 ,, 12 ,, 8 annually. After the change, the cost was less than 8 maunds, at the cost of 24 ,, 14 ,, 3 per month, or 298 ,, 11 per annum. The light continued in use from the date when it was first lighted, 19th June, 1839, till it was superseded by the New Madras Light on the 1st January, 1844.

Coringa Light—This was built for an insular situation, and intended to show a light all round the whole circle of the horizon; it was therefore composed of a set of nine large sized 3 feet reflectors disposed circularly, facing outwards, secured to a strong frame, &c. The cost of this apparatus, including all the charges of freight from Madras to the spot, and the erection and fitting

was 1,144½ Rupees, and it was reported by the Collector of the District on completion, to be admitted by all who had seen it to be "very far superior" to the old light, for which it had been substituted. The monthly cost of the latter in wicks and oil had been 142 ,, 3 ,, 2, afterwards the whole cost for these articles was 37 ,, 6 ,, 3, but this latter sum appears to be somewhat greater than the amount of expenditure of former years, though probably the light was then very much inferior. The lantern stands on a masonry tower 60 feet high.

Masulipatam Light—This is a flag-staff lantern of two reflectors, of which drawings have been given in the accompanying plates. The cost is stated to be 270 ,, 8 ,, 10, and the report on its completion stated that it "perfectly answered the end of a light-house, being reported to be visible, bright and clear 16 miles off." The light was first shown on the 30th November, 1840, and has been exhibited ever since. The consumption of oil is 8lbs. per night, at a cost of about 27 Rupees per month. It has been found necessary to keep a duplicate lantern and apparatus in store, because in the course of years, repairs become necessary, at which time, the lantern in use is removed, and the spare one substituted for it, without this precaution it might happen that the illumination could not be continuously kept up.

Tellicherry Light—Is similar to that at Masulipatam, but in order to distinguish it from other beacons in the neighbourhood, there is in addition to the double light above mentioned, a second lantern containing a single lamp and reflector placed on the same mast 40 feet lower down; by this means as a ship draws in towards the land, she perceives an exhibition of two lights one above the other. The cost of the double lantern was the same as that of Masulipatam 270 ,, 8 ,, 10, of the single one 106 ,, 10 ,, 11. It was first shown on the night of the 15th December, 1845.

Cannanore—Trincomallie—Point de Galle—Negapatam—Are all supplied with lights on the same principle as the Masulipatam flag-staff light, and at the same cost, but the supply of a duplicate lantern to each, which is in progress if not already carried into effect, will raise the cost of each work to Rupees 541, Annas 1, Pie 8.

Cochin—This station was one of the first supplied with a signal lantern of the smallest size, agreeably to the pattern of which drawings were given in Volume I. The cost of a lantern of that description including all the apparatus is stated to be Rupees 106 ,, 10 ,, 11. Including the duplicate the whole cost is Rupees 213 ,, 5 ,, 10.

Calicut—Singapore, and the second light for *Telli-*

cherry above mentioned have been supplied of similar pattern to that of Cochin.

Mangalore—Has been supplied with an apparatus of a large size and considerable power, consisting of three large reflectors of 3 feet in height, placed side by side, pointing in the same direction, and fitted in a substantial well constructed lantern, which is placed upon a wooden frame-work or stage erected on a hill 200 feet above the level of the sea, it being unnecessary in this case to raise it further. The cost of this apparatus is stated to be 1,150½ Rupees, the light was first shown on the night of the 29th October, 1842.

Tuticoreen—Has been supplied with an apparatus of equal power with the above, viz. three large sized reflectors at a cost of 1,283½ Rupees. It was first exhibited on the night of 1st August, 1845.

Paumbum.—This is the largest lantern which has yet been made up expressly to suit periscopic reflectors, the circumstances of the case requiring a light to be exhibited all round the horizon. For this purpose four reflectors are used pointing in directions at right angles with one another, by which arrangement the full effect of two reflectors is visible in every aspect, and the light is therefore on a par in respect to power with those on the pattern of the Masulipatam light; which, with half the number of lamps and reflectors illuminate only half the circle of the horizon. The cost of this lantern which is fitted on the top of a masonry tower about 40 feet in height is reported to have been 2,269 Rupees, exclusive, I believe, of the lamps and reflectors.

The best judgment which can be formed of the general utility of the system upon which these lights have been established, will be formed by a perusal of the following letter from the Secretary to the Marine Board at Madras, to the Secretary to the Superintendent of Marine in Bengal, in answer to inquiries regarding them; to which it need merely be added that it has been thought unnecessary to give the correspondence from the Military Board referred to in it, as it only conveys information which has been given in detail above.

From J. R. BOYSON, Esquire,
Acting Secretary to the Marine Board.

To
J. SUTHERLAND, Esquire,
Secretary to the Superintendent of Marine.
SIR,

With reference to your letter of the 21st December last, No. 2369, I have the honor, by desire of the Marine Board, to forward herewith for submission to the Acting Superintendent of Marine, a copy of a communication received by this department from the Military Board at this Presidency, which affords all the information sought for by the Commissioner of Arracan. A counterpart of the lantern constructed for Masulipatam was forwarded to Calcutta in December, 1841, per Ship *Lord William Bentinck*, consigned to Captain

Boileau. The drawing furnished to this department by the Military Board is transmitted to you by this day's tappal. The light at Masulipatam is under the charge of the Master Attendant. 1 Head man at 10 Rupees per month, and 2 Lascars at 7 Rupees per month each, are employed to attend to it. It consumes about 8lbs. of cocoanut oil nightly, and the only other expense is that for wick and cloth for cleansing it, which the Board thinks may fairly be estimated at about 8 Annas per mensem. The Board desire me to add that the same description of light has been applied to many other stations, and that to the best of their belief, the results have in every case been *most satisfactory*. In all cases the practical management of the light has been entrusted to Natives.

I have the honor to be, &c.

(Signed) J. R. BOYSON.

The only additional information on the subject of these lights which it is in my power to afford, relates to the detailed instructions which it is necessary to give to the parties entrusted with their erection and first exhibition, and perhaps the best mode of conveying a clear idea of the various minor particulars necessary to be attended to, will be that of inserting copies of the instructions which actually accompanied one of the larger and one of the smaller kinds of apparatus. I subjoin therefore copies of the instructions sent with the Coringa and Masulipatam lights; the former an apparatus on a large scale fitted into a full sized lantern already built on the old plan, the latter a flag-staff lantern of two reflectors as above described.

Directions to accompany the Coringa Lighting Apparatus.

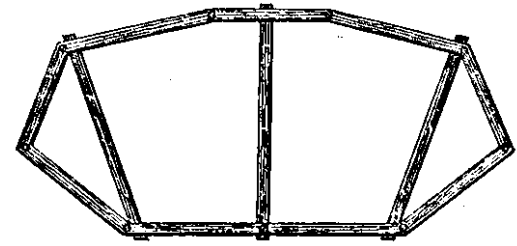
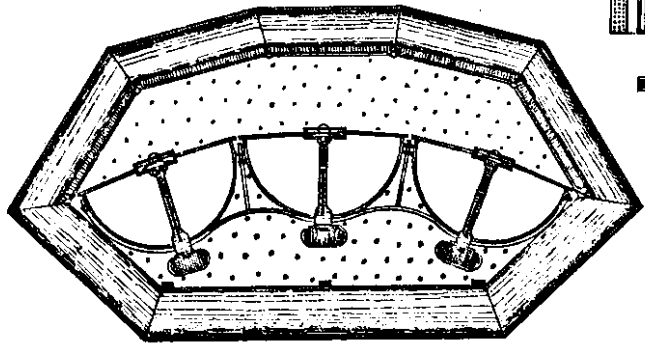
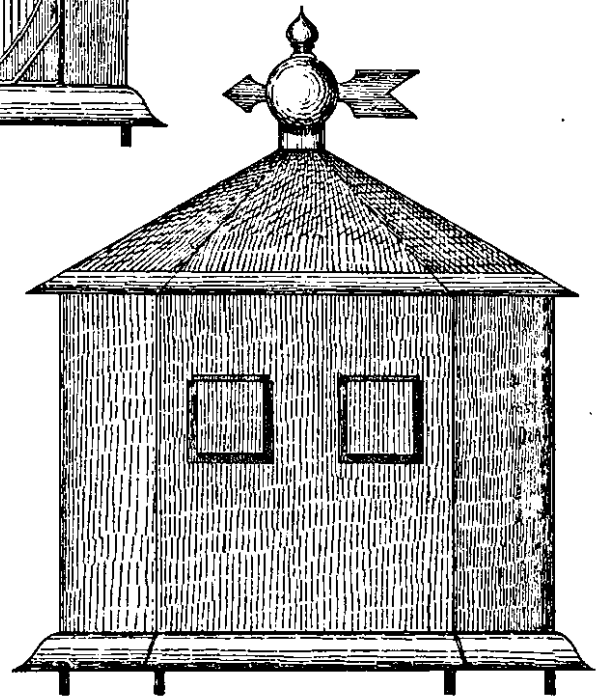
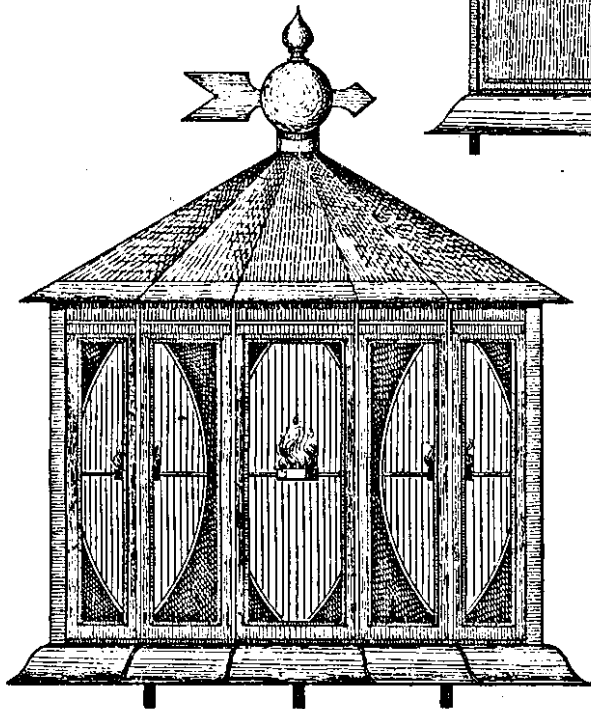
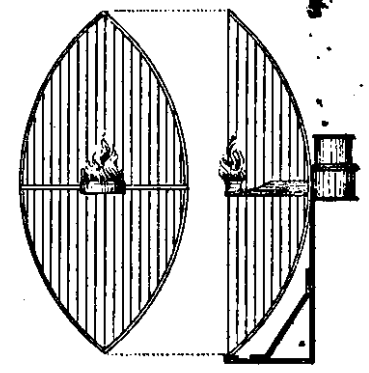
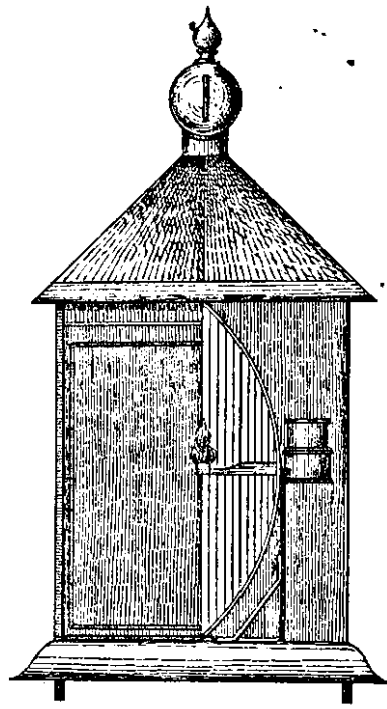
"In fixing these lamps and reflectors two points are necessary to be attended to.

"*First*,—That when the tin reservoirs of oil are filled and dropped into their places, every lamp must be filled to such a height, that the oil shall stand touching the front edge of the burner, or the least thing below it. *Second*,—The reflectors ought to stand perpendicularly, as shown by a plummet hung from the upper point of each.

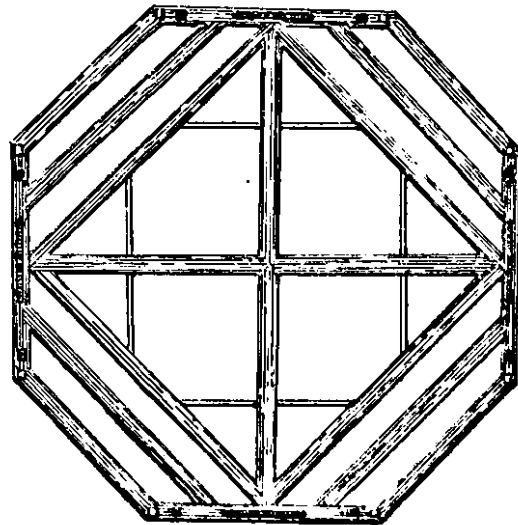
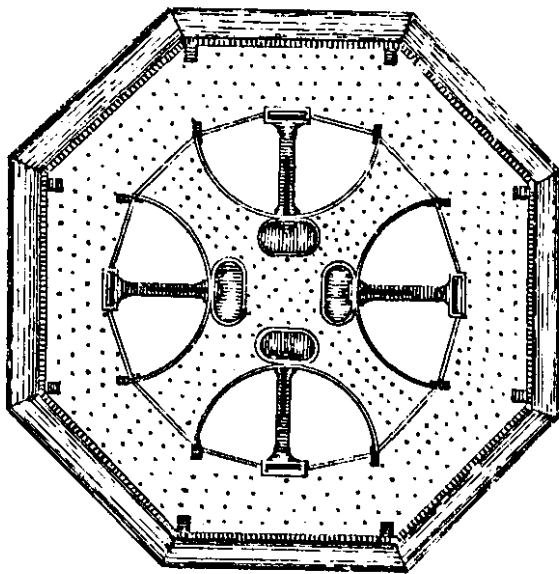
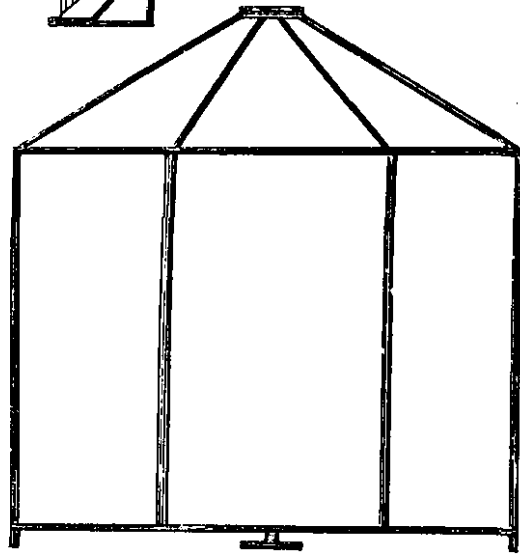
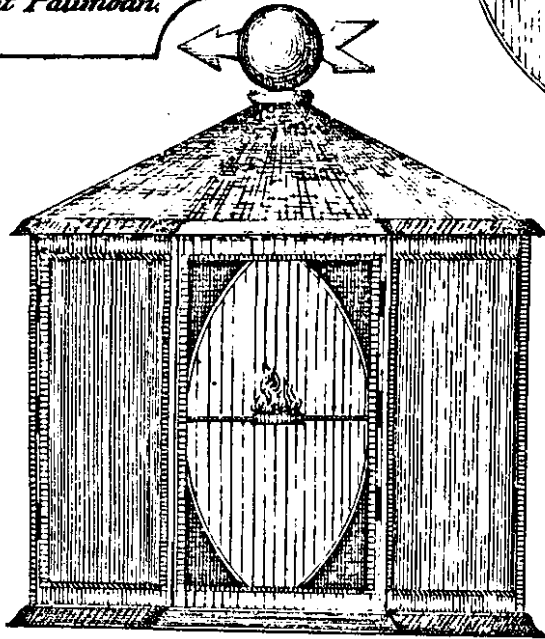
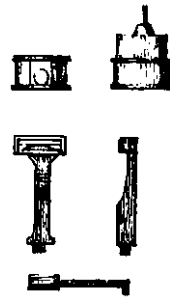
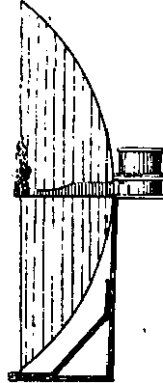
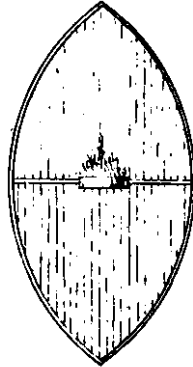
"If these points be not shown to have been correctly attained on the erection of the apparatus, they must be altered until the whole of the lamps and reflectors are exactly right. The lamps ought to be trimmed once in three hours, and particular directions must be given, and care taken, to prevent their being suffered to smoke, which is apt to be caused by the ignorance of Natives who do not understand these matters, by their raising the wicks too high. If this is carefully attended to, and the wicks correctly elevated, the lamps will burn with a clear steady light for a longer period than that named above.

"If there be no openings made already in the floor of the lantern for the purpose of ventilation, two or three dozens ought to be made for the purpose through the boards, of about 1½ inches diameter, with a bent tin tube

A COAST LANTERN
 with
 Three Reflectors
 constructed at the
 Gun Carr. Man.
 Madras,
 for the
 Port of Mangalore.



*Coast
Lantern
with
Four Reflectors
constructed
at the
Gun Carr. Man:
Madras
for the Island
at Pambour.*



ACCOUNT OF EXPERIMENTS ON REVETMENTS MADE AT SINGAPORE IN NOVEMBER,
1843, BY CAPTAIN BEST, AND LIEUTENANT ELLIOT.

At the foot of a sandy bank, a space 15 feet long by $1\frac{1}{2}$ foot broad was made level, and 3 courses of bricks, 3 bricks thick, were built on it as a pavement with clay.

The bricks used in the experiments were of the ordinary kind in Singapore, averaging $8\frac{1}{2}$ inches long, 4 broad, and $1\frac{1}{2}$ to $1\frac{3}{4}$ thick—9 of them weighed 25 lbs., and their specific gravity is hence about 1807—9 bricks which in air weighed $25\frac{1}{2}$ lbs. weighed in water $10\frac{1}{2}$ lbs. When soaked in water they weighed $29\frac{1}{2}$ lbs. in air, and 13 lbs. in water. When dry they begin to slide on one another with a slope of $6\frac{1}{2}$ base to 5 vertical, or at an angle of 36 degrees with the horizon.

The sand when quite dry and loose weighed 113.4 lbs. per cubic foot, and stood with a base of 3 to 2 vertical, or at an angle of 34 degrees. $27\frac{1}{2}$ lbs. of dry sand imbibed $5\frac{1}{2}$ lbs. of water. When well shaken down, the dry sand is reduced in bulk about one-tenth, and weighs $124\frac{1}{2}$ lbs. per cubic foot. When wet and shaken down 162.8 lbs. per cubic foot.

EXPERIMENT 1.

Upon the pavement above mentioned, a wall of whole bricks, half a brick, or 4 inches thick was built, 15 courses or $25\frac{1}{2}$ inches high, sand being used instead of mortar. Sand from the bank was then brought down, and levelled behind the wall. When the sand reached the top of the 12th course, or to a height of $20\frac{1}{2}$ inches, the wall fell over forwards, leaving 5 lower courses standing.

EXPERIMENT 2.

A similar wall was built 13 courses or $22\frac{1}{2}$ inches high. It fell over when the sand was levelled up to the back of the 11th course, and left 3 courses standing at bottom.

EXPERIMENT 3.

A wall was built with headers and stretchers alternately to a height of 20 courses, or 33 inches. It fell over when the sand rose to the 19th course, or to a height of $31\frac{1}{2}$ inches, and left 7 courses standing.

EXPERIMENT 4.

A wall was built 1 brick or $8\frac{1}{2}$ inches thick, and was raised 27 courses = $44\frac{1}{2}$ inches. The sand upset it when it reached the top.

EXPERIMENT 5.

This wall was $8\frac{1}{2}$ inches thick with counterforts $4\frac{1}{2}$ inches deep, and $8\frac{1}{2}$ inches long at every $8\frac{1}{2}$ inches. The height was 38 courses, or $57\frac{1}{2}$ inches, and the wall

fell when sand reached the top. 4 courses remained standing.

EXPERIMENT 6.

A wall half a brick or 4 inches thick was built with mortar composed of sand $1\frac{1}{2}$ and lime 1, and plastered on both sides. Its height was 25 courses at 7 courses to a foot. It was built very carefully and allowed 20 days to dry and harden, but it rained 2 days out of 3, so that when the wall had been upset, the mortar was found to have but very little consistency. The sand was raised to the 20th course, or $34\frac{1}{2}$ inches, when the wall fell over.

The theory of Colonel Pasley, according to which the part of the earth which tends to overthrow the revetment is bounded by a plane having the slope of the soil, and passing through the outer edge of the base of the wall appears to be confirmed by these experiments; in each of which, some courses of the wall at the foot remained standing. The different ratios of the thickness of these rectangular (in section) walls to the height of soil sustained by them were as follows:— a being the thickness of the wall, and x the height of the earth.

EXPERIMENT 1.	$a = 4. x = 20\frac{1}{2}. \frac{x}{a} = 5\frac{1}{4} = 5\frac{1}{4}$	} average 5.
EXPERIMENT 2.	$a = 4. x = 19\frac{1}{2}. \frac{x}{a} = 4\frac{7}{8} = 4\frac{7}{8}$	
EXPERIMENT 3.	a averages $1\frac{1}{2}. x = 31\frac{1}{2}. \frac{x}{a} = 21 = 5\frac{1}{4}$	
EXPERIMENT 4.	$a = 8\frac{1}{2}. x = 44\frac{1}{2}. \frac{x}{a} = 5\frac{1}{4} = 5\frac{1}{4}$	
EXPERIMENT 5.	a averages $10\frac{1}{2}. x = 57\frac{1}{2}. \frac{x}{a} = 5\frac{1}{4} = 5\frac{1}{4}$	

The experiments are not sufficiently numerous, perhaps, for a safe conclusion to be drawn from them. The conclusion to which they point, however, seems to be, that for a counterscarp wall with a rectangular section, a thickness of one-fifth the height is sufficient, the material of the wall not being of less specific gravity than 1807, and that of the soil not more than 113 lbs. per cubic foot, standing with a base of 3 to a vertical of 2.

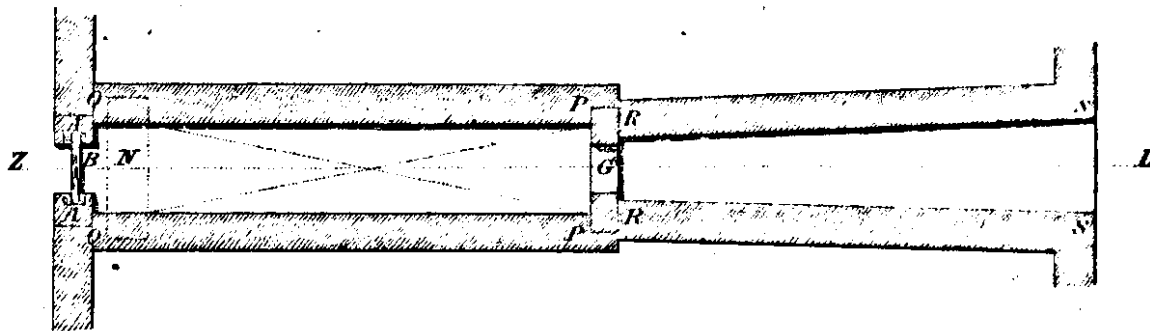
But if the wall be built with good mortar, and attached firmly to a massive foundation, the pressure of the earth must either uproot the foundation, or break the cement, and the power required to do either the one or the other is to be added to the strength of the wall supposed to be built without mortar. In the 6th experiment, the wall had no foundation, and the mortar was but very slightly cohesive. It nevertheless seems to have added considerably to the strength of the wall.

EXPERIMENT 6.	$a = 4. x = 34\frac{1}{2}. \frac{x}{a} = 8\frac{1}{4} = 8\frac{1}{4}$
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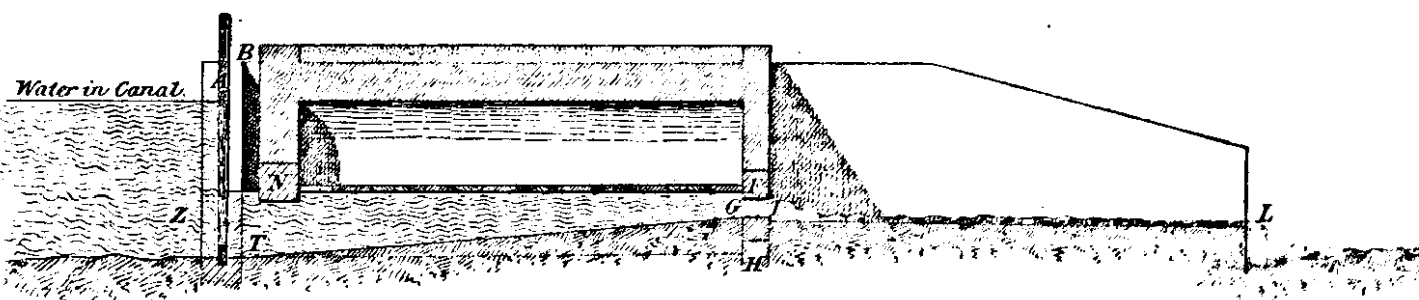
THE MODULO MAGISTRALE

used in Italy for measuring
WATER FOR IRRIGATION.

Plan on the level ZL.



Section through ZL.



DESCRIPTION OF THE SLUICE OF IRRIGATION, CALLED THE MODULO MAGISTRALE,
 PREFACED BY REMARKS ON THE TAXATION OF IRRIGATED LANDS,
 BY CAPTAIN BEST.

However difficult it may be for me to discover or admit the merits of a permanent settlement of land revenue in *this* country, where the characteristic improvidence of the people seems to preclude the hope of their saving in seasons of abundance, a provision against those of famine,* even in their own behalf; (and it is still more improbable that they should do so for the purpose of paying their taxes,) where the home trade is but an aggregate of village monopolies, where, the revenue being barely sufficient to meet ordinary expenses, if *one* order raises a new regiment in the North-West, *another* puts a stop to improvements in the far South, where great resources are neglected for want of capital which none but the State will ever furnish, and in which the State has a claim to the first share, a professional Memoir would not be the fittest place to bring forward my opinions, even though they could be supposed worthy of attention when at variance with the standard authority of those whose business it has been to investigate and deliberate upon a subject which I have only casually and cursorily noticed. But I do not see any reason against my making a few remarks upon a part of the land revenue management in which objections are likely to be more obvious to an Engineer accustomed to study the best means of irrigating the country, than to the Collector who looks chiefly to the most effectual manner of getting revenue from it..

Lands, under the old Governments were classed as *dry* and *wet*.† To these has been added *garden*. Land entered as *dry* may be converted to *wet*: *dry* or *wet* to *garden*, but *wet* can never revert to *dry*: while, in defiance of theories of rotation, land once capable of yielding tobacco, or other exhausting crop, is held *officially* to retain its powers for ever.

The land and the water (from tanks, &c.) are part of the public capital. Since any given amount of labour bestowed on good land will yield a greater profit than if given to soil less naturally productive, it is fair that the best lands should be highest assessed. If the State lends the land and the water, it has also a

* Under a permanent money settlement, the Collector comes down upon the ryot, whose crop has failed *this* year, and takes the *kist* in virtue of the profits of *last* year, long since expended; or of *next* year, to anticipate which the ryot must buy the Soucar's aid at a high discount. But, if the land tax varied in *just* proportion to the crops and the prices of the year, instead of being fixed by averages made up of questionable data and incorrect arithmetic, the agreeable and easy task of the Collector would be to look to the advantage of the ryot as the *primary* object, and to trust to the increase or facility of collections being the never failing result of his welfare.

One very easy test of the correctness of an assessment may be deduced from this consideration. In ordinary circumstances, if lands have been correctly classed, and the tax fairly rated, land of each superior class will *all* be cultivated, before that in the lower classes will be taken up.

† Dry or Poonjay.
 Wet or Nunjay.
 Garden or Bagayat.

fair claim to expect a proportionate return, greater when it grants land and water too, than when it grants the former only.

But, in consequence of the permanence of the classification above mentioned, it often occurs that the same tax is leviable when water is *not* given, as when it *is* given; for, land which was irrigated when it happened to be assessed, has been saddled with the water tax ever after, upon the erroneous assumption that the water of a tank which once sufficed to irrigate a thousand acres will always continue to do so.

The supplies of water from the large rivers which flow right across the Peninsula, and fill with both monsoons, especially with the more copious western rains, are tolerably regular. Tanjore, now that its works of irrigation are good, and provision is made to keep them so, is never likely to suffer from drought, and its superiority to the other districts in regard to its supplies of water makes scarcity elsewhere beneficial to it. It is, perhaps, the only district east of the Ghauts in which a settlement can possibly be permanent.

Rivers filled by the drainage of the eastern country alone are very uncertain in their freshes, and that nothing can be more precarious than the filling of *mānāmāree* tanks by the rains which fall in their immediate neighbourhood may be understood, when it is remembered that the annual fall of rain varies from 18 to 88 inches.* In some cases, the repairs of one tank have lessened the supply of another: generally, tank banks are mended in an inefficient and slovenly manner, but it may be said that almost universally, tanks do from natural causes wear out with old age, and the land to which they once supplied water, in process of time, is wholly or partly deprived of it. This land, rich in alluvial deposit, is the very best in the country, but our Collectors' records will show, that of the *Ayacut Nunjay*, † not three-fourths are on the average cultivated, and that the remaining fourth which would yield better dry crops than any ordinary dry fields, is left almost always and entirely waste, in consequence of the restrictions imposed on the culture of *Nunjay Mēl poonjay*. ‡

To say that if *Nunjay* land were under any circumstances to pay only *poonjay* tax, a door to abuses would be opened which could not be shut, is a very poor excuse for permitting the far greater actual abuses arising from the present system.

Most tanks receive with water, large quantities of sand, silt, and mud; and, as from the usual form of the wasteweirs (*calingulas*) the *clear*, surface water only escapes, when there is a surplus, and very little silt

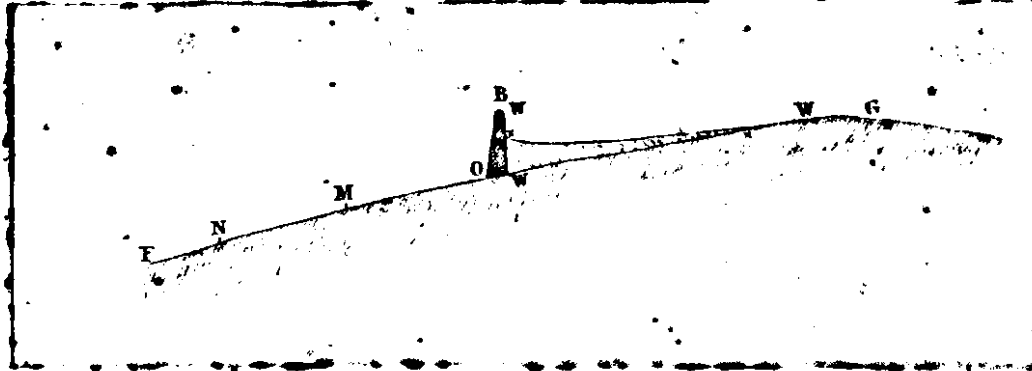
* 18.45 inches in 1832, } at Madras.
 88.66 inches in 1827, }

† Entire wet land.

‡ Dry crops on wet lands.

makes way through the sluices which feed the fields, the bed of a tank has a continual tendency to fill up. There are many tanks in, which the operation of this process is very manifest to any one standing on the

bank when the tank is empty. It is then perceived that the exterior or rear of the bank is very much higher above the fields, than the interior is above the bed, the section being somewhat as follows :



This section represents a tank bank *B* thrown across a valley, of which the fall is in the direction *G F*. When the tank is new, the water of this valley is withheld by the bank and fills the whole space (*W W W* in section) the quantity being then sufficient to irrigate the *nunjay* ground below the tank, say 1000 acres, (represented by *N O*;) but, in the course of time, by accumulation of silt, part of the hollow which ought to hold water only is filled up. To remedy this, the bank *B* is raised, but the accumulation still goes on; and it is clear that after a certain height has been obtained (that of the source *G* whence the water flows) no advantage can be obtained by raising the bank further. The silt at last gains the victory, and the tank which was once capable of holding water enough for 1000 acres (*O N*) now holds water enough for 500 (*O M*) and no more. Part (*M N*) of the ground entered as *nunjay* in the accounts, and which is too highly taxed to yield a profit if cultivated as *poonjay*, becomes waste.

This would be bad enough; but the actual result is still worse. The land *N M* belongs to ryots who have as good a claim to share the water of the tank as those who cultivate *O M*. They, therefore, insist on having part of the water, so long as there is any. If the season is unusually favourable, the water that is drawn off is replaced; but, in an unfavourable year, if the water which, properly economized would have been sufficient for a fair harvest from *part* of the ground, be distributed over the *whole*, no part receives enough for the perfection of the produce, and the whole crop perishes.

Then come the clamour for remission, the bribe giving of the richer ryot, the ruin of the poor one, the gain of the dishonest *Tasildar*.

In every important tank there should be standards by which observation of the quantity of water in it should be made at *some fixed date*, when rain can no longer be reasonably expected. In all large tanks, there are long stones, built upright in the bed at the head of the sluices, and it would be easy, at such *fixed dates*, to mark on these stones the height of the surface of the water, and *at the same time* to note the quantity of land under cultivation, and the number of months for which it *requires* water.

In the following table, given as an example, the first three columns show what quantity of water was supposed necessary to complete the irrigation of the crops on the ground. The next nine show how the water was actually distributed, and the actual supply of water in a tank afterwards ascertained from the record of that distribution.

State of the cultivation under—Tank taken on the 21st of January, 184—, water at 5 feet 6 inches on the—sluice.

1	2	3	4	5	6	7	8	9	10	11	12
Acres.	Number of days water required for the crop.	Product of the two preceding columns.	Acres which yielded full crop.	Number of days that water was supplied.	Product of the two preceding columns.	Acres which yielded half.	Number of days that water was supplied.	Product of the two preceding columns.	Acres which yielded no crop.	Number of days that water was supplied.	Product of the two preceding columns.
120	15	1800	100	15	1500	80	10	800	0	0	0
60	30	1800	30	30	900	30	20	600	0	0	0
45	40	1800	33	40	1400	10	30	300	0	0	0
80	60	4800	0	0	0	80	80	1000	80	25	2100
300		10900	163		3900	80		2100	80		2100
			40		+ 2100						
			203		+ 2100						
					8000						
											Total supply of water.

The evaporation in the hot season is about half an inch a day, or from an acre (4,840 square yards) about 67. cubic yards of water. The quantity of water required for the whole 300 Acres would thus have been $67 \times 10,200$ or 6,83,400 cubic yards, but the tank yielded only $67 \times 8,000$ or 536,000 cubic yards. Omitting to take into consideration the less total evaporation had the water been used on the crops soonest gathered, it appears that [had the statement existed beforehand] the distribution of the water might have been as follows :

Acres.	Days.	
120	15	1800
60	30	1800
40	45	1800
43	60	2600
37—No water.		
300		8000

Knowing that the water in—tank at the end of the rains would suffice for only 263 Acres out of 300, the remaining 37 should have received no further supply, the full crop of 263 Acres might have been gathered in lieu of what is equivalent

to that from only 205 Acres, while the labour would have been bestowed to the fullest advantage on 263 Acres instead of being in great measure thrown away upon 140 out of 300.

In the year 1835 in a Memorandum which was afterwards reported on by the Board of Revenue, I endeavoured to draw attention to the subject of the preceding observations; but as I did not enter into this or similar detail in explanation of my proposition, I doubt if it was understood. Some objection was made, on the score of the Natives being well acquainted with the necessity, and well versed in the practice of obtaining from the water in their tanks and channels the greatest possible benefit, and some, on account of the alleged difficulty of adopting standards or *Nilometers*. The proposition fell to the ground.

As for the second objection, the detail above entered into is sufficient to show that there is no insuperable nor great difficulty in making such standards; for, if it were known that water up to 5 feet 6 on the stone of—sluice in—tank signified a supply represented by 8000, as is shown by the resulting cultivation, in any other season when it was at the same height on the same date, a remission of revenue on 37 cawnies might at once be given, and the remainder of the crop secured: and, with similar record made through a series of years, the standards might by gradual additions and corrections be made nearly perfect.

Surely, it is not to be supposed that the recollections and opinions of Native agriculturists, let their wits have been ever so much sharpened by their necessities, are to be compared with such records as these.

We are too much in the habit of supposing the Natives of India to be beyond improvement in the art of farming, merely, because they know more than ourselves of growing *rice* and other crops of warm climates; and we have allowed this opinion too great influence in judging prematurely of the *cotton* experiments. Though an Italian or Carolina rice-planter might *not at once* succeed in farming the swamps of Bengal or the fields of Tanjore, either, no doubt, could give useful hints to the brightest Vellalun that ever followed a yoke of buffaloes; and it were absurd to suppose for an instant, that more advantage could not be taken of the seasons, by men who should form their judgment from data such as real science affords, than by those who are guided by the occultations, conjunctions, and quadratures of Jupiter, Venus, and the Dragon that swallows the moon.

Yet, though I believe that standards measuring the water, by simple inspection showing to how much land it can be prudently given, and from how much it is wise to withhold it, serving to regulate remissions by better rules than the ryots' supposed ability to pay (the revenue to the Government or the bribe to the *Tasildar*, as

the case may be) can at once be adopted, and with very considerable immediate advantage, no measure would, in my opinion, so fully, so fairly and so beneficially remove what I have represented to be objectionable in our land revenue system as the entire separation of the *land* tax and the *water* tax.

Instead of classing land as *dry* and *wet*, the *land* should be assessed as good land or bad land, and the *water* should be sold to those who cultivate the adjacent fields and might wish to irrigate them, whether for paddy, sugarcane, or any other crop.

This is the system which prevails in Lombardy, where, instead of interfering with the agriculturist, taxing him so much for growing rice, and so much for tobacco, &c., and driving him from all attempt at improvement, by the apparition of a Harpy which his fancy, guided by his experience, represents to him in the act of watching for the first fruits of his superior intelligence and industry, the Milanese farmer is left free to cultivate whatever he may expect the greatest profit from.

It would occupy too many pages, and might now be useless, were I to suggest how such a change of system could be introduced here. Suffice it to say, I am convinced it can be *easily* introduced, and that I shall be glad to learn what difficulties have to be overcome ere the change is brought about. For the present, I will content myself with a short description of the

MODULO of SOLDATI,

the sluice of irrigation used throughout the Milanese for measuring the water sold to the farmers there, an account of which cannot fail to be interesting to my brother Officers employed in the Civil Engineer Department.

Great part of the province of Lombardy is cultivated with rice, and the produce, as in warmer climates, depends upon a sufficient supply of water. Besides the rice fields, there are meadows called *Marciti* which require much water during the winter months. The frost is prevented from being injurious to these by a gentle current of water flowing constantly over the grass; and, the herbage continuing to grow abundantly during the whole year, serves as food to numerous cows, from whose milk is made an enormous quantity of Parmesan* cheese.

The canal of Pavia, called Naviglio Grande, and the Martesana, led from the Ticino and Adda, serve to connect the towns on the banks of those rivers and of the lakes Maggiore and of Como, with the city of Milan. These canals yield a considerable revenue to the state, derived from not only the tolls of the merchandize which is borne on them, but from the *sale* of the *water* used for *irrigation*. The Oglio, the Muzza, and other great artificial drains are chiefly valuable on account of the fertilizing effects of their waters.

* Parma being a principal market for it, it is named from that city, but the reputation of this famous production rather belongs to the province of Lodi.

However surprising such ignorance may now seem, it is the generally received opinion that, until a period considerably later than the construction of the first of the Milanese channels, Engineers did not know how much the pressure or *head of water* above an orifice augmented the velocity with which the fluid issued from it, and it was not till a comparatively recent period that the method of estimating this was discovered. Yet it could not have been long ere practice must have shown the Lombards, that the quantity of water that their fields received did not depend only on the dimensions of the orifice through which they received it.

Their measurements continued to be inaccurate for many years, and much contention was occasioned by the erroneous decisions of the tribunals, in cases of water privilege. It was about A. D. 1575, that a Milanese Engineer, Giacomo Soldati, invented the sluice called the *Modulo* or *Modello Magistrale*, so simple yet so admirably suited to its object, that it has been almost ever since, and is now used throughout Lombardy; while in other forms, on the same principle and differing only in details, it has been introduced in other Italian states, and authorized by law to be used in the measurement of water.

The principle of the sluice of Soldati is this. The water passes from the canal or reservoir under a shutter into a chamber, from which it issues through a measured orifice. Were it allowed to pass *directly out* of the canal, it is evident that, as the depth varied in droughts or with the melting of the Alpine snows, the velocity and quantity flowing through an opening of a fixed size would vary too; but by the intervention of the shutter which is lowered as the water in the canal rises, and of the chamber, in which the water is thus kept always at one level above the holes from which it issues, the velocity is easily regulated, and is in fact, kept perfectly constant.

The shutter is made to slide up and down in two upright grooved stones *A A*, which are placed in the line of the bank of the channel with an opening between them, the width of which is regulated by the number of ounces* for which the sluice is made. The walls of the chamber join to these vertical stones, while a sole of stone is placed below them, on or a little above the level of the bed of the canal. The chamber consists of two walls, *O P*, parallel to each other, 20 feet long and 20 inches wider apart than the grooved stones, *A A*. At 2 feet height above the floor of the chamber, a stone, *N*, is placed across from wall to wall, and the chamber being covered by an arch which springs from the walls *O P*, a gable end is built upon the stone *N*, which, with the arch and another similar gable, built upon another stone, *F*, at the other end, completely cover and close it. An interval, *B*, of 4 inches is left between the shutter stone and the cross

* The quantity of water that will flow through an oblong orifice 6 inches wide and 8 inches high under a pressure of 4 inches is called an ounce or ounce, and this quantity is the unit of measure of water in Lombardy. According to Professor Tadini, it equals 2.1168 cubic metres per minute, or in 24 hours 107,653 cubic feet English.

stone *N*, which allows the depth of water at the entrance of the chamber to be ascertained by sounding. Four inches above the bottoms of the stones *N* and *F*, a horizontal ceiling or soffit, of planks or of masonry, is fixed: and immediately below *F*, is the *modello* or orifice *G*, through which the water issues. This is always 8 inches high, and its width at the rate of 6 inches for each ounce of water. Its floor is formed by a wall, *G H*, 16 inches high, which is usually of stone. The sides of the orifice are also of stone, and it is generally surrounded with iron to prevent the dimensions from being fraudulently altered. The floor of the chamber is of brick-work, and either horizontal as *T H*, or sloping upwards as *T G*.

Beyond the chamber, is an open channel which has a masonry floor and side walls. The former at *I*, is two inches lower than the sill of the modello *G I*, and it slopes two inches more as far as *L*. The side walls, *R S*, are vertical, 18 feet long, and at *R*, four inches on each side from the outer edge of the modello, and they diverge each six inches more, so as to be three feet eight inches apart at *S*.

The water being admitted, by raising the shutter until the depth above the floor *T* is exactly 28 inches, which is ascertained by sounding in the interval *B*, while the height of the top of the modello is $16 + 8 = 24$ inches above the same floor, the pressure or head is always equal to the difference = 4 inches; and all disturbance of the water is most effectually prevented by the contrivance of the ceiling in the covered chamber.

When the water has passed the point *L*, it is at the disposal of the buyer or renter of it, and care is taken to let it fall freely into a hollow, or down a slope from *L*, lest regurgitation *there* should be communicated to the water inside the modello and diminish the supply.

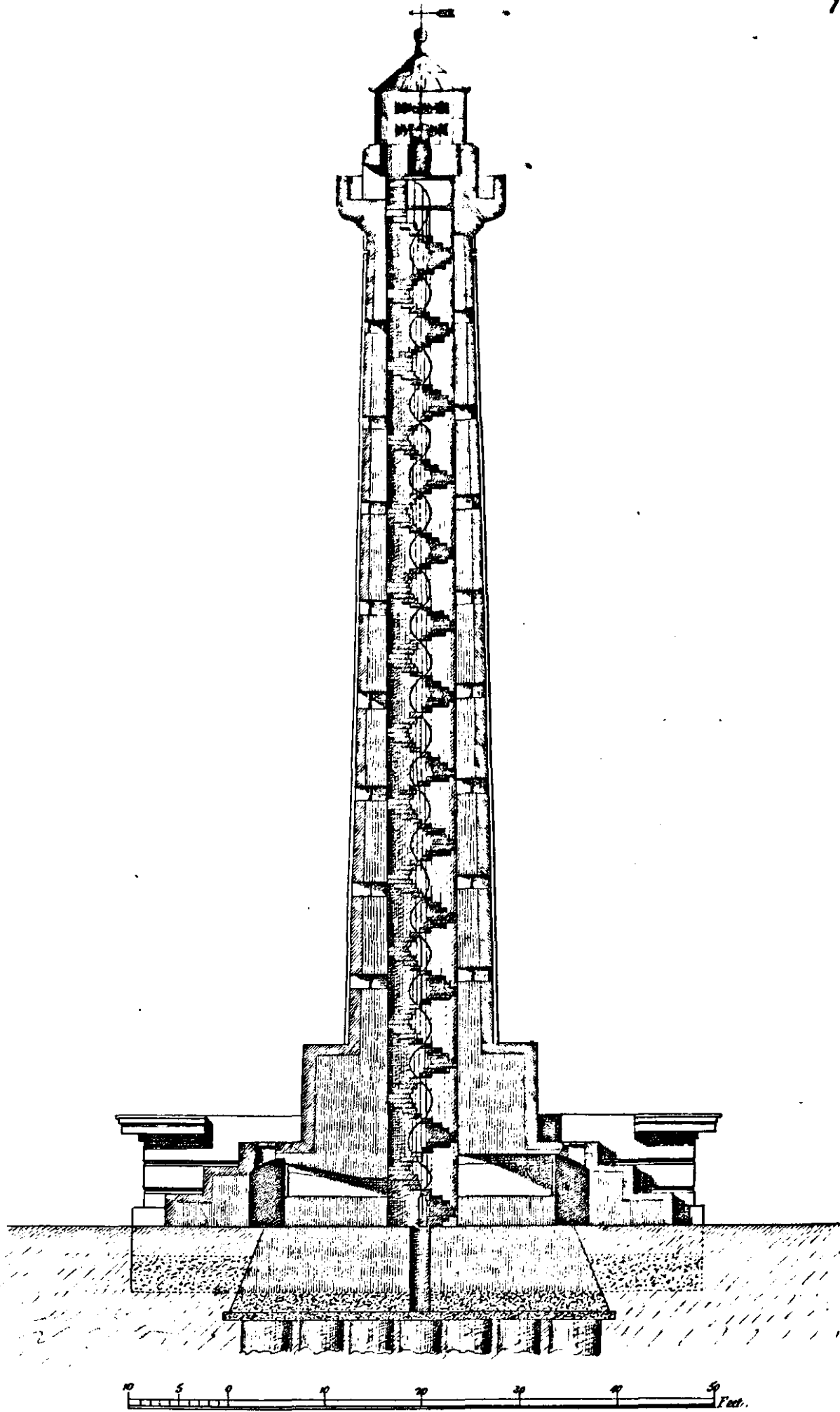
Most of the sluices are put up to auction and sold for the season or for the year. In some cases they are let on leases for season or year. In others sold in perpetuity. The buyer or renter of a sluice then disposes of the water to the owners of the land adjacent at so much for one or more hours per day, per week,* &c.

The water being purchased, its value is well known, and of course, it is not wasted by its purchasers. The Government derives the advantage that is its due, from the works made at its expense for public benefit, while the farmer pays exactly in proportion to the advantage he derives, and buys the water or not at his own option.

* The following is a Memorandum of the average prices of water let and sold from the canals in Lodi, Pavia, and Milan, from 1809 to 1814.

	Lire.	£.	s.
No. 1. Sold absolutely for the whole year, -	33628.	656.	3.
2. Do. for the summer (1st April to 7th Sept.)	31289.	610.	9.
3. Do. for the winter (1st Oct. to 15th March.)	2342.	45.	14.
4. Rented (livello perpetuo) at per annum, -	1710.	33.	7.
5. Do. for the summer season, -	1611.	31.	8.
6. Do. for the winter season, -	125.	2.	9.
7. Do. (fitto or temporary lease) at per annum, -	2164.	42.	2.
8. Do. for the summer, -	2032.	39.	6.
9. Do. for the winter, -	131.	2.	11.

N. B.—The prices are per oncia Milanese. The Milanese lira is equal to English £ sterling '017.



NOTES REGARDING THE CONSTRUCTION OF THE NEW MADRAS LIGHT HOUSE, BY
CAPTAIN J. T. SMITH, F. R. S. F. R. S. N. A.

1. I cannot close this volume without a few brief remarks upon the construction of the new Madras Light House, of which drawings have been prepared for insertion. It will be out of my power to give more than the chief particulars, but I trust that they will be sufficient, with the assistance of the drawings, to give a general idea of the nature of the work, and the principal points of interest connected with it.

2. The excavation of the foundations was commenced on the 17th July, 1838, and carried down to a depth of 10 feet below the surface. Beneath this, wells 8 feet deep were sunk, the insides of which were filled in the usual way with brick jelly and sand, and laterite jelly and sand in every other well alternately. The intervals between the different wells were filled up with the same materials, and the whole level surface thus formed, well soaked with water and hardened by beating with heavy rammers. After every part of the area had become sufficiently compact, a platform of laterite of 40 feet square was laid, upon which the brick work of the foundation rested. This was a solid block of masonry 38 feet square at the bottom, tapering to the dimension of a side of 30 feet at the level of the ground, and about $8\frac{1}{2}$ feet high. A well of 3 feet diameter was left in the middle for the purpose of increasing the fall to be given to the weight by which the machinery is kept in motion, with this exception, the whole was one solid mass, and great attention was paid in laying the bricks, that they should be firmly bedded upon one another.

3. The *first stone* of the building was laid in the presence of Lord Elphinstone and a number of other Gentlemen, on the 17th September, and the foundation was completed as far as the level of the ground, by the 15th of October following. It became then necessary to close the work for the season on account of the monsoon, and before the operations were resumed, it had been determined to apply to the Honorable Court of Directors for permission to add to the expense of the work, by facing it with granite, instead of common plastering, pending which reference, the work was slowly proceeded within the early part of 1839, in the hopes that the decision of the Court would arrive before it would be necessary to take measures in the construction of the building, which were contingent upon the nature of the reply. A block of masonry of 28 feet square stands above the brick foundation, and above this stands the block which is seen as the pedestal of the column. The last is visible from outside, and therefore, as it was necessary that, if a granite facing should be sanctioned, it should be built together with the masonry; we were soon at a stand for want of instructions, and thus although the work had only been resumed in May, 1839,

we were not able to continue long at it, for the utmost height to which it could be carried, without the use of the granite facing, was reached on the 20th July, and the operations were then temporarily put a stop to.

4. In May, 1840, the instructions of the Honorable Court, sanctioning the use of granite, having been received, the work was again proceeded with, and from that time it advanced uninterruptedly till its conclusion, but the use of stone greatly added to the difficulties and delay of the work, owing to the limited number of stone-cutters procurable for employment at the building, and the constant disappointments in the supply of the materials, owing to the quarries being at a distance; and the contractors a poor and miserable race, incapable of entering upon any business with energy and spirit, and very troublesome to deal with, owing to their poverty rendering the advance of cash an indispensable preliminary to their undertaking any work, and their dishonesty making it exceedingly difficult to avoid loss by such an arrangement.

5. It will be observed by the figures, that the four flanking buttresses are buildings quite independent of the shaft, and its pedestal and foundations, and although the foundations of these were laid at this time, it was thought most advisable in order to expedite the completion of the column, and thus the exhibition of the light, that the whole of the workmen procurable should be employed upon the column only, and on this account nothing was done either to the four buttresses, or the steps which connect them, till after the whole of the business of the shaft had been completed, and it had been crowned by its capital, surmounted by the lantern and its machinery.

6. The four buttresses just referred to form four convenient rooms for depositing the oil, stores, tackling, and apparatus belonging to the work, &c., and as it would have quite ruined the appearance of the edifice, in an architectural point of view, to have had any windows in them, visible from outside, the object of lighting and ventilating them was attained by sinking their roofs below the level of the cornice, and constructing a sky light in the middle of each, which although sufficiently high to give abundance of light to the apartment, is still low enough to be quite undiscoverable from the outside. The communication between the different rooms is made by passages which connect every two of them, and thus encircle the whole of the block of masonry. They are formed under the highest step or that which adjoins the block, and are sufficiently spacious to be very convenient. Light is admitted to them by bull's eye lenses inserted in the granite stones which form the roof, and besides this, at those points opposite to the middle of each face where there are passages

leading into the interior of the block; larger openings, of about 18 inches square, are made for the purpose of admitting a larger supply of light to aid in removing the darkness of the staircase at that part.

7. The entrance to the building from outside was made, by leaving open a small part of the lowest and middle step next adjoining one of the buttresses, in the least observable point, where a door is made which admits a person into one of the corner rooms; from thence he is led into the passage above described, from the middle of which an arched communication leads direct to the centre of the block, whence he may ascend by a flight of 200 stone steps to the summit of the column. The lower part of this staircase is lighted by the rays admitted partly by the opening from above, for the geometrical stair does not wind round a solid newel, but leaves a well in its centre, as a passage for the machine weight; partly by windows pierced through the block into the outer passage, when light is admitted to them through the openings above-described, and partly by light admitted by openings cut from the centre of the building horizontally outwards towards the face of the die or pedestal, and then continued upwards vertically, so as to open into the air on the upper surface of the die, the right angle formed between the vertical and horizontal portions of the cut being replaced by an inclined plane at an angle of 45 degrees, by the means of which some light is reflected into the interior.

8. By these contrivances the difficulty of supplying light for the interior of the lower 20 feet of the column, which is totally shut out from any direct communication with the external air, is overcome, and the staircase is sufficiently well lighted to occasion no inconvenience. Above that point there are narrow windows in each of the four faces of the column, which give admission to more than a sufficient supply of both light and air.

9. It required our utmost efforts in the first season to complete the pedestal upon which the column stands, owing to the great delay in procuring, finishing, and fitting the granite stones facing it; the first of which did not make their appearance, even in their rough state, till near the end of June. Great difficulties were also experienced with the contractors for the supply of other articles, with whom a constant warfare was obliged to be maintained, in order to ensure any thing like a tolerable fulfilment of their engagements. In regard to the bricks I found it at last the best plan, while constructing the large solid masses of masonry, of which the foundations, pedestal, &c. were composed, to contract with the supplier to furnish the *very best* materials, and to leave it to me to take such as suited me, and leave what I pleased, paying, not in proportion to the number said to be delivered, but by the cubic foot of masonry actually finished, and in this way a large part of the work was built of very excellent material at the rate of 10 cubic feet for 17 annas, for bricks only. The season closed with the completion of the pedestal, preparations being made and continued during the monsoon for the commencement of the column after the rains.

10. The shaft of the column consists of 48 courses of cut stone, each of which contains 16 pieces, each 3 feet by 2 feet by 1 foot. The shaping, cutting the flutes, dressing and accurately fitting these, was a work of great labour and delay, but by keeping up a constant succession of labour, by a large number of workmen, some increase of expedition was brought about. The average time of fitting each course was upon the whole nearly a fortnight, but under the most favourable circumstances, three and almost four courses were completed in a single month. In the first few or lowest courses, iron cramps were introduced for the purpose of securing all the different stones of the course more firmly together, but these were soon afterwards abandoned on account of its being observed, that in spite of all the pains which could be taken, the Natives inserted and fixed them so inefficiently, that they could in fact be of but little real benefit, and it was hoped that the system of bonding would be sufficiently secure without them.

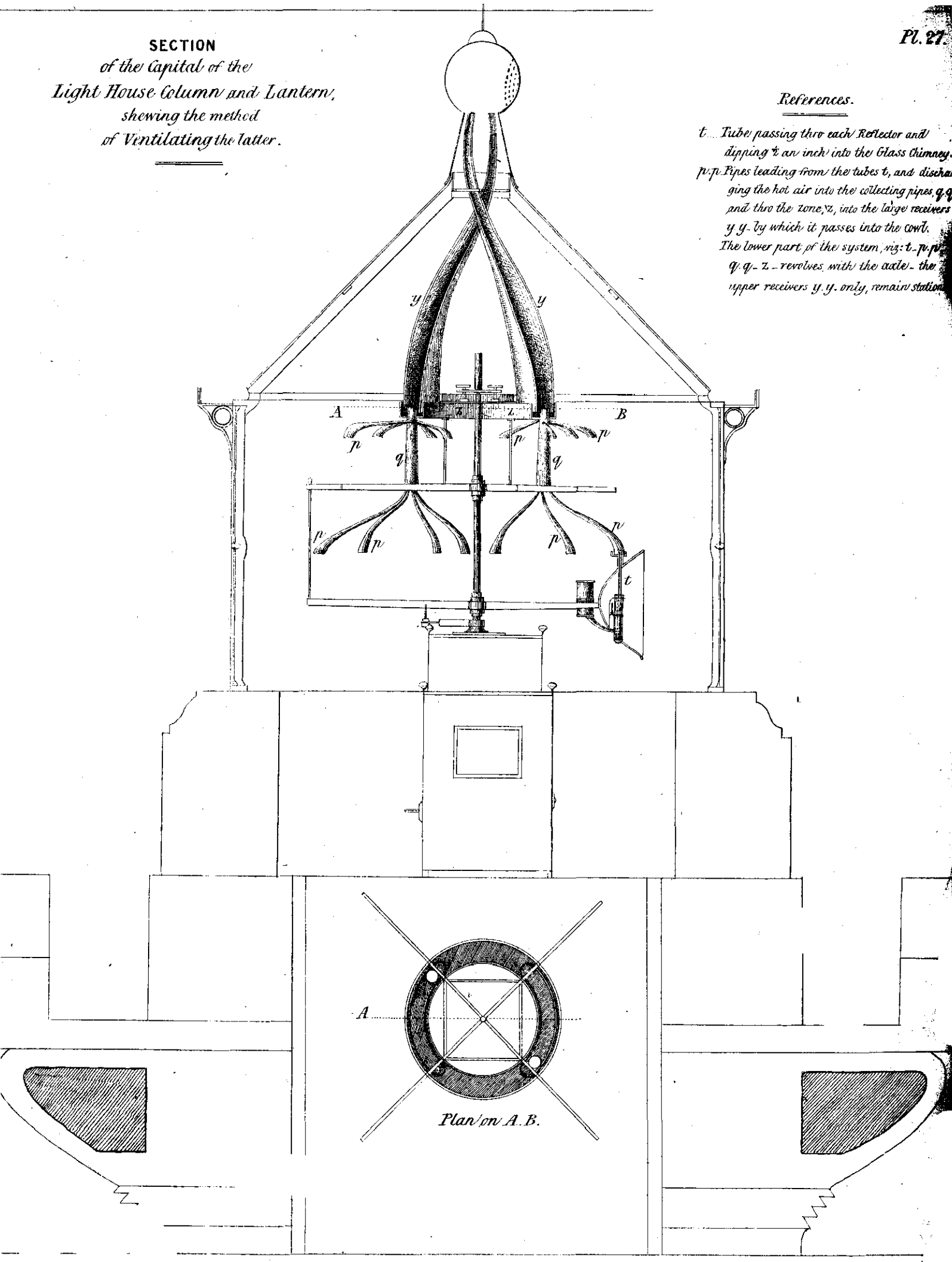
11. The bond introduced was that of making every fourth stone in each course of half the height of the rest, but of such a thickness as to reach inwards towards the centre of the building three or four feet, the deficiency in height was made up by a false half block placed above or below it, so that the two combined, presented the same appearance (excepting the horizontal joint) as the rest of the single stones of the course. In every succeeding course, the precaution was taken of choosing for the bond stone a block which did not lie vertically above any other bond stone in either of the three preceding courses; to effect this, the bond stone in each successive course in height was next in advance laterally or rather circularly, of that beneath it, and taking all the bond stones throughout the building, they would be found disposed in the form of spirals regularly winding round the shaft of the column. By this arrangement it will be seen that the weight of every third course is supported by a complete set of thorough stones, as certainly, though not so evidently, as if the three courses had been constructed without a bond, and their support derived from a complete course of bond stones inserted beneath them.

12. Towards the neck of the capital, the brick-work is reduced to nothing, and the few last courses are entirely of stone. Here iron cramps were again resorted to, and the stones which form the capital are secured together by a solid iron ring, let into a channel cut in the middle of the upper surface of each course, after it had been laid and fitted together. The capital was composed of four courses; the fillets and the ovolo of two courses, and the abacus of two more. It was arranged that the whole of the stones forming the capital should be of such a length in the direction of the centre that on their being placed in position previous to fitting the inner end of them much preponderated, there is therefore no tendency in any of them to fall over or downwards, even were they not fitted to one another, or cramped as they afterwards were, and secured by the insertion of the circular iron ring.

SECTION
of the Capital of the
Light House Column and Lantern,
shewing the method
of Ventilating the latter.

References.

t... Tube passing thro each Reflector and dipping 2 or 3 inch into the Glass Chimney.
p.p. Pipes leading from the tubes t, and discharging the hot air into the collecting pipes, q.q. and thro the zone, z, into the large receivers y.y. by which it passes into the cowl.
The lower part of the system, viz: t. p.p. q. q. z. revolves with the axle - the upper receivers y.y. only, remain station



Plan on A. B.

13. Above the capital stands a blocking course of larger sized stones, each of which weighed upwards of $1\frac{1}{2}$ tons, these were fitted and cramped together in the form represented by the drawings. The lower curb of the lantern serves the purpose of the bond for the upper course of these stones, as it was let into a groove cut into it for the purpose. The stanchions of the lantern had been originally intended to be fitted to a wooden frame, and were provided with long bolts fitted into the foot of each, and tapped to receive a nut, which was intended to be screwed home underneath the wooden frame so as to bring the foot of the stanchion into firm contact with its upper surface. The same arrangement was made to answer very well with the granite blocks also by boring a hole in the proper position for receiving the bolt, and cutting out a horizontal cavity in the side of the stone corresponding with it, and carried inwards until the lower part of the bolt was cleared, and there was room all round it to receive the nut to be screwed upon it, as well as a circular washer interposed between the nut and the granite. This plan was adopted in preference to running the stanchions into their places with lead, on account of the great facility which it afforded in adjusting the different parts and the lantern together on first putting it up, and also the ease with which it might at any future period be dismantled, in part or altogether, for repairs or any other purpose.

14. The rest of the lantern was put together with great facility, ample precautions having been taken by the makers in England, to obviate any mistake; previous to fixing the last two or three stanchions, the larger parts of the machinery were hoisted from below into the lantern and fitted into their places, though the final adjustment of the apparatus was of course postponed till after the lantern had been closed in and glazed. The hoisting of the machinery as well as of all the stones used throughout the work was done by the means of a crane of a peculiar kind, of which a description has already been given at page 106, and was effected without the smallest accident to any part. The whole was completed and ready for illumination in the month of December, 1843, and the light was first exhibited on the 1st January, 1844, since which time it has been in uninterrupted use.

15. The box containing the machinery of the light rests upon two cast iron beams placed across the building, bars of wrought iron connect them firmly together, and form a support for the wooden flooring of the lantern room. This floor is provided with ventilators, which can be opened or closed at pleasure.

16. It was found necessary to contrive means for carrying off the heated air from the interior of the lantern, and some difficulty was experienced in doing this in consequence of the apparatus having to be applied to a machine already constructed, and to its being a revolving one. In England this would be easily effected by making the central spindle of the revolving apparatus hollow, and leading all the conducting tubes of hot air into it, but as such a spindle could not be construct-

ed in Madras, it was necessary to devise some other means, and that was done as follows. Taking the hint from the ingenious method invented by Mr. Faraday for the British Light Houses, the hot air of each lamp was carried off by a small tube dipping into the inside of the glass chimney and passing through the reflector, and a number of these being led to one point, the currents of hot air carried by them were united in a tube of larger capacity, the upper edge of which projected about three or four inches above the highest part of the revolving apparatus, which carried the lamps and reflectors, and to which the whole was secured. Here it dipped, or rather rose into, a circular trough which formed the lower mouth of a funnel shaped receiver, the bottom of which corresponded with the circular track of the hot air pipe above-mentioned, and the upper part tapering away to the dimensions of a similar but larger pipe reached up into the ball of the lantern. As the motion of the reciprocating machine only extends through a quarter of a circle, the mouth of the funnel was shaped as a quadrant, and there were two of these on opposite sides of the lantern, because it was found most convenient to collect the hot air from the various lamps in two streams on opposite sides. The two hot air pipes were connected together by a flat circular copper-plate, shaped like a zone, with a lip round its outer and inner edges, and through which on opposite diameters the hot air pipes passed, while the zone itself being in every position of the movement in close contact and correspondence with the mouth of the two funnels, kept them close, and prevented the entrance of any other air than that conveyed by the hot air pipes, and also precluded the exit of any hot air into the body of the lantern. This apparatus gave every satisfaction on trial.

17. A memorandum will be found in the appendix on the subject of the conductor which was fitted to the building to secure it against the effects of atmospheric electricity, detailing the principal points necessary to be attended to in applying such an apparatus, and a description of the particulars of that which was made use of on this occasion. It was kindly drawn up at my request by Captain Ludlow, whose familiar acquaintance with these subjects led him to take a peculiar interest in this part of the work, and to study the principles connected with the best methods of precaution, and by whose design the arrangement was carried into effect. There will also be found attached a number of useful suggestions and memorandums of dimensions and prices respecting the stone work, which Captain Ludlow has recorded, and which are likely to be highly valuable in any future undertaking of this kind. I have already mentioned that I was indebted to Captain Ludlow for his valuable assistance during the construction of most part of the edifice, the chief superintendence having devolved upon him almost immediately after the commencement of the shaft of the column, and the building having been completed by him; and it is to his close attention and unwearied pains that we must attribute the great accuracy and solidity with which the work was put together.

**SOME REMARKS RELATING TO THE MATERIALS AND CONSTRUCTION OF THE NEW
LIGHT HOUSE, BY CAPTAIN LUDLOW.**

The granite used in the building was procured near the four villages of Tahmurrum, Palaveram, Trichellum, and Treeneermullay, all situated in the neighbourhood of the Palaveram cantonment. The stone found at Tahmurrum is of a lighter colour and more easy to work than that procured elsewhere, and on account of the latter quality is more in demand. There is also a species of stone of a much darker colour and harder grain found at Assanapooram, in the same neighbourhood, but its extreme hardness renders it quite unfit for building purposes, and it is only used for making stone hammers, mortars for rice beating, &c.

There are not more than 40 or 50 men in these villages, who gain their living by quarrying stone, it is in consequence very difficult to procure a large quantity of it for any work unless a long previous notice is given. They are always in the habit of demanding advances upon receiving an order, and being a very drunken, dissipated, and dishonest set of fellows, will, unless proper precautions are taken, make away with the money without fulfilling their engagements.

The following is their method of quarrying. Having selected a part of the rock where there appears to be a sufficient depth of good stone for their purpose, the upper crust which generally consists of stone of an inferior quality is removed by blasting to the requisite depth, about 1 or 2 feet, and the solid mass below thus laid bare. Holes of about 4 inches square and from 3 to 4 inches deep (according to the thickness of the stone required) are then cut at distances of from 4 to 6 inches in the line of the intended fracture. Iron wedges are inserted, and being repeatedly struck with a large hammer formed of the hard stone I before mentioned, slung in a pliable wooden frame, a large mass is thus detached. This mass, (except in cases where very large stones are required) is again broken up into smaller ones by inserting wedges along the intended lines of fracture as before, with this difference that the wedges are much smaller and placed much closer together. The stone then receives two dressings with heavy chisels, by which the greater inequalities are reduced and is then ready for transport to the work.

As the fracture is frequently very irregular, in order to avoid all risk of the stone being *short* of the requisite dimensions, they are constantly in the habit of making it much too large, whereby the labour of reducing it to the proper form is materially increased. By driving the smaller wedges rather deeper and with more care, a more regular fracture would be produced and indeed it would be well worth while to run the risk of spoiling many stones rather than make those which are sent

to the work so much in excess of the requisite size. But as affairs are managed now, this is no business of the stone quarry-men who only engage to supply stones not smaller than the required size. It would be advisable hereafter to have the stones finished (with the exception perhaps of the final dressing) on the spot, by contract, and if possible by the same parties who furnish the rough stones.

As the price paid for the rough stone supplied for the Light House included the cost of carriage to the beach, I am not able to state how much this latter item amounted to. The mean distance from these quarries to the beach is $14\frac{1}{2}$ miles, the smaller stones were brought on bandies drawn by 1 pair and in some cases 2 pairs of bullocks, but the largest stones were placed on heavy carts, and dragged in by coolies.

The 12 large stones at the top of the column to which the stanchions of the lantern are fixed, were conveyed in the latter manner. They measured almost exactly one cubic yard, each weighing about 2 tons. For each of these 25 coolies were employed. The contractors paying them 4 annas per man for the job, that is, loading, conveying, and taking back the empty carts, thus making the cost of carriage in this instance, 6 Rupees 4 Annas per cubic yard, or about 22 per cent of the price paid for the stones. The average cost of carriage however was doubtless much below this.

The price of the rough stone (in which were included the two dressings it receives at the quarry, and the cost of transit to the beach), was considerably diminished during the course of the work. At first it amounted upon an average to as much as 1 Rupee 11 Annas 6 Pice per cubic foot. The following is a statement of the average price of the different kinds of stone from 1842 to 1844, after the reduction was made.

Slabs 9 inches thick,			
	Ft.	Ft.	
Varying from	$5\frac{1}{2}$	to 6	in length.
" "	$3\frac{1}{2}$	to $2\frac{1}{2}$	in breadth.
" "	15	to 12	square feet Supl. measurement.
Containing from	12	to $9\frac{1}{2}$	cubic feet.
			R. A. P.
Price per square foot,	-	-	0 12 6
" " cubic foot,	-	-	1 0 6
<hr/>			
Slabs 6 inches thick,			
	Ft.	Ft.	
Varying from	5	to 4	in length.
" "	$2\frac{1}{2}$	to $1\frac{1}{2}$	in breadth.
" "	14	to 6	square feet.
Containing from	7	to $3\frac{1}{2}$	cubic feet.

	R. A. P.
Price per square foot, - - -	0 8 4
" " cubic foot, - - -	1 0 8

Blocks No. 1.

	Ft.	In.
Average Length, - - -	4	10
" Breadth, - - -	2	9
" Thickness, - - -	1	8
" Cubic contents, - - -	18 cubic feet.	

Varying from	6	to	3	in length.
" "	3½	to	2½	in breadth.
" "	2½	to	1½	in thickness.
" "	35	to	15	cubic feet.

Average price 15 Annas and 2 Pice per cubic foot.

Blocks No. 2.

	Ft.	In.
Average Length, - - -	4	3
" Breadth, - - -	2	4
" Thickness, - - -	1	3
" Cubic contents, - - -	8.87 cubic feet.	

Varying from	6	to	2½	in length.
" "	3	to	1½	in breadth.
" "	2½	to	1	in thickness.
" "	8	to	14	cubic feet.

Average price 12 Annas and 10 Pice per cubic foot.

Blocks No. 3.

	Ft.	In.
Average Length, - - -	2	11
" Breadth, - - -	1	10
" Thickness, - - -	1	1
" Cubic contents, - - -	5.67	

Varying from	3½	to	2	in length.
" "	2	to	1½	in breadth.
" "	1½	to	1	in thickness.
" "	3	to	7	cubic feet.

Average price 8 Annas and 3 Pice per cubic foot.

It would appear from the above statement that slabs from 6 to 9 inches in thickness are the most expensive kind of stone (reckoning by cubical contents) which can be used. This arises from the difficulty of splitting off pieces of so little thickness, without breaking the stones. This difficulty is greatly increased as the length and breadth of the stone become greater. In a granite building therefore the use of such thin stones, even on account of the expense should be avoided as much as possible, but moreover as they are very apt to be broken in moving there is still stronger reason for not employing them.

The price per cubic foot of blocks of granite, increases of course with their size, but not in so rapid a ratio as might be supposed. The difference between No. 1 and No. 2 for instance being only 2 Annas 4 Pice per cubic foot, although that between No. 2 and No. 3 is 4 Annas 7 Pice.

The objections to the use of large stones are their higher price and the difficulty of handling them. The former it appears is not a very formidable item; with regard to the latter it would be impossible to say what it exactly amounts to; experience however has shown that

even with the defective apparatus procurable in this country, the difficulty of managing moderately large stones is not very great. The principal objections to the use of small stones are the greater number of joints required, the additional surface requiring to be dressed and the loss of material in dressing.

If the surface of a stone of the form of a parallelepiped, be reduced by dressing a quantity in depth represented by $\frac{1}{x}$ of a foot, the quantity cut off in cubical feet will be represented by the formula.

$$\frac{ab+ad+db}{x} - \frac{a+b+d}{x^2} + \frac{1}{x^3}$$

ab and d being the length, breadth, and depth of the original stone in feet.

Now if we take a single stone measuring 6 feet \times 2½ \times 2 and dress it to a depth of 2 inches. (The quantity cut off the rough stone supplied for the Light House exceeded this, and I believe it was nearer 3 than 2 inches,) all ways; the loss in dressing calculated by the above rule will be 9½ cubic feet out of 30, and 20½ cubic feet of finished stone will be left.

If on the other hand we take 3 stones measuring originally 2 \times 2½ \times 2, or in all 30 cubic feet, the loss on dressing the 3 will be 12 cubic feet, and we shall only have 18 cubic feet, of finished stone left.

The price in the rough of the large block was 15 Annas 2 Pice per cubic foot, or 2 Annas 4 Pice per foot more than the small blocks.

The price per foot of the large block when finished is 1 Rupee 6 Annas 1 Pie, that of the small block 1 Rupee 5 Annas and 5 Pice. In this case therefore by using one large instead of 3 small blocks, while the price of the material is only increased 8 Pice per cubic foot, we save 2 joints and 20 square feet of surface dressing, matters of no small importance, besides adding both to the strength and appearance of the building.

When the size of the stones increases beyond a certain point, a limit is doubtless imposed upon us by the difficulty of handling such large masses, but I think that no stones of less than 10 or 12 cubic feet should be used in a granite building when it can be avoided.

An instance of great waste both of material and workmanship, owing to want of attention to these considerations, may be seen in the piers of the groined arches of the gateways under the ramparts of the Fort, where the stones are of a very small size, and where not only must the expense of the work have been much increased but its strength is also materially diminished.

The pillars of the railing which encloses the road round the Light House were mostly procured at a quarry near the Seven Pagodas. They were supplied in a finished state at 14 Rupees each—they are 6½ feet long of which the lower 1½ feet are undressed. They contained in the rough state about 10 cubic feet, and their dressed surface is about 24 square feet. The price paid for them included carriage for a distance of about 35 miles. The price paid for the carriage of each was nearly as I could ascertain was 4 Rupees.

Some pillars were lately supplied from the same quarries for some Native building in Triplicane. They were 18 feet in length of an octagonal shape and two feet in diameter. They had received an extra dressing before leaving the quarry, and were therefore more than half finished. They contained 54 cubic feet, and cost 59 Rupees 8 Annas each including carriage. They were conveyed a distance of 33 miles, and the carriage of each cost 31 Rupees 8 Annas. Each stone required two bandies and eight pairs of bullocks.

Stone may be procured at the Seven Pagodas of a much larger size than at Palaveram, it is of a lighter colour and much more easily dressed. I am credibly informed that pillars of 50 feet in length and proportionate thickness have been procured at these quarries, whereas at Palaveram they cannot procure stones of half the length, if that, and at a much greater expense. If communication by water were established between the

Seven Pagodas and Madras, (a project of no very difficult execution seeing that a backwater already exists for a considerable part of the way,) I have no doubt but that stone of a quality and size better adapted for building might be procured and at a more reasonable rate than that brought from Palaveram.

I may here mention a circumstance which is but little known, viz. that quarries of sand stone admirably adapted, both in point of beauty of appearance and economy of workmanship for building purposes, exist within a distance of about 20 miles from Madras, at a place called Coopoor. As the line of the proposed Madras and Arcot railroad runs within a few miles of these quarries, it may perhaps be found advisable to introduce this stone in building which has never yet been done, the cost of the carriage at present being the chief objection.

MEMORANDUM ON THE LIGHTNING CONDUCTOR ATTACHED TO THE MADRAS LIGHT HOUSE, BY CAPTAIN LUDLOW, MADRAS ENGINEERS.

The necessity of providing a lofty isolated building, such as the Light House, with a conductor, in a climate like that of Madras, so frequently visited by Thunder Storms, of a serious nature, will be apparent when it is stated that two out of three of the Church spires here (those of St. George's and the Scotch Kirk) have, within the last 6 years, been more or less damaged by lightning; the 3d, that of St. Mary's in the Fort, having only probably escaped owing to its being provided with such a safeguard.

In event of a discharge of the electric fluid taking place on a building of this kind, it would in all probability fall on the lantern, that being the most elevated point and possessing a large conducting surface of copper. To secure the machinery and building therefore it is necessary to provide a sufficiently capacious and direct channel for the conduction of the fluid from the lantern to the moist soil below, where the discharge would be innocuously dispersed.

The conductor is formed of a bundle of 22 copper wires varying from $\frac{1}{4}$ to $\frac{1}{8}$ of an inch in diameter, strongly bound together, and running in a straight line, through holes pierced in the steps, from the top to the bottom of the building along the inner surface of the wall. At the top it is connected with the frame of the lantern, the machinery of the light and all the principal masses of iron by broad bands of copper; at the bottom it is joined to a rod, 2 inches in diameter, sheeted with copper, which is driven through the well in the foundation of the building, into the wet soil below. It is connected moreover both above and below with the iron rail of the stairs.

This form of conductor fulfils all the conditions con-

sidered requisite by those who are supposed to be the best authorities on this subject, such conditions being,

1st. That the metal employed should be copper, it being the best conductor.

2d. The quantity of metal should not be less than that represented by the section of a solid cylinder half an inch in diameter. The united sections of the 22 copper wires exceed this.

3d. The metal should be placed under as great an extent of surface as is consistent with strength, and should be perfectly continuous. A maximum of surface is obtained by using a number of cylinders, and the strength of wires of the size used is amply sufficient especially when bound together, as these are; each wire runs unbroken from top to bottom of the building; all these conditions are therefore fulfilled.

4th. The conductor should involve in its course the principal detached masses of metal in the building. This is the case also.

5th. It should be placed as close as possible to the walls which are to be defended and not at a distance from them, and be carried at once directly into the ground; both these points are fully attended to.

6th. It should be attached to the most prominent parts of the building. This is done if being attached to the frame work of the lantern.

7th. If the length is considerable, its dimensions should be increased. It does exceed in some measure the required dimensions, and moreover the iron rail with which it is connected above and below form a supplementary conductor greatly increasing the conducting channel.

GLOSSARY OF INDIAN TERMS MADE USE OF IN THIS VOLUME.*

<i>Aumauny</i>	Under the immediate management of Government; or applied to a settlement under which the Government receives its share of the produce of the land from each cultivator, in kind, instead of stipulating for a pecuniary commutation, (in contradistinction to <i>Ezarah</i> ?)
<i>Anna</i>	The sixteenth part of a Rupee, or of a yard.
<i>Annicut</i>	A masonry or earthen dam across a river.
<i>Apron</i>	That part of an annicut on which the water falls after passing over the top of the work.
<i>Ayacut</i>	Total cultivable land; also signifies the whole of the lands of a village.
<i>Bamboo</i>	A large species of reed or cane, used for making baskets, frame work of boats, mats, &c. &c.
<i>Bandy</i>	A cart, usually drawn by two bullocks or buffaloes.
<i>Bazaar</i>	A market.
<i>Boetul</i>	A species of the pepper vine, the leaves of which are commonly chewed by the Natives of India.
<i>Beriz</i>	Rent, revenue.
<i>Bund</i>	The artificial bank of a tank, lake, pond or other reservoir for water.
<i>Cadarumbum</i>	Dry or waste lands.
<i>Culingula</i>	A masonry work in the margin of a tank, or in the bank of a channel, to allow surplus water to flow freely off.
<i>Candy</i>	500 lbs. avoirdupoise.
<i>Catamaran</i>	A rude raft, made usually of three logs tied together, on which fishermen sit and paddle about in the water.
<i>Casney</i>	A land measure equal to 6,400 square yards.
<i>Chatty</i>	An earthen pot.
<i>Chumba</i>	The name of one of the rice crops in Southern India, the Chumba harvest begins about the middle of July, and ends about the end of January.
<i>Chunam</i>	Lime, or Mortar.
<i>Circar</i>	The state; or Government; head of affairs.
<i>Codamoorty</i>	The name of a branch of the Cauvery river; also a small river in the Trichinopoly district.
<i>Corumboo</i>	A temporary dam of mud or sand and grass, stretching obliquely across a river, to turn a portion or the whole of its waters into a side channel.
<i>Cuddoopoo</i>	The name of one of the rice crops in Southern India.
<i>Cuddoopoo-car</i>	A species of coarse rice—the harvest for which begins about the middle of August, and ends about the beginning of December.
<i>Cullum</i>	A dry measure, equal to about 19 gallons and 1 quart, or 12 marcalls.
<i>Calwah</i>	A channel.
<i>Cutcherry</i>	A building in which public business in the Revenue or Judicial Department is carried on—also a Court.
<i>Dasewandum Tanks</i> .	Tanks which are kept in repair by the cultivators, and for which they agree to give up 1-10th of the revenue.
<i>Dasevinedum</i>	An allowance of land or rent, given as a compensation for the construction of a tank, or assignment for making a tank.
<i>Dhoney</i>	A country coasting vessel of from 10 to 100 tons burthen, used by the Natives.
<i>Dittum</i>	Settlement—literally fixed, applied to the engagement which a ryot makes at the commencement of the year.

* The Orthography of these terms is not to be strictly insisted upon; various modes of spelling being in use, and mistakes having unavoidably occurred in printing them.