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MADRAS RECORD OFFICE.

Government of Madras.

Public Works DEPARTMENT.

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No. 429. Read the following letter from the Government Astronomer, to the Secretary to Government, Public Works Department, dated Madras Observatory, 5th March 1866 :—

I have the honor to reply to the Proceedings of the Madras Government, Public Works Department, and the Order thereon, No. 266, dated 11th January 1866, respecting the best method of measuring the evaporation from the surfaces of large tanks ; and in doing so I beg leave instead of a drawing, to submit for your inspection a small working model of a new form of Evaporator, of which I will now proceed to give a brief description, prefaced by a few remarks upon, and objections to, all former instruments hitherto employed for the purpose of measuring evaporation.

1. The general method hitherto adopted has been to expose, in a shallow copper vessel, a small quantity of water, carefully weighed or measured in the first instance, and offering only a small surface, as a square foot or less, to the atmosphere. The depth of the water exposed rarely exceeded an inch and half, or at most two inches ; it was invariably within four or five feet of dry and heated ground, while the vessel itself, and the water it contained, being freely exposed to the sun's rays, the quantity actually lost, in the course of a sunny day, must have been far in excess of that which would have been evaporated from a similar area of deep tank water. After twelve or twenty-four hours the water exposed was again weighed or measured, and the diminution during the period elapsed was recorded as the evaporation for such time. In this manner observations of evaporation were made at the Madras Observatory between the years 1842 and 1860 inclusive, the water exposed being carefully measured at 6 A. M. and 6 P. M. daily throughout the nineteen years. The Evaporator was well watched by the Lascars to keep away birds, and also to cover it over in case of rain, and to uncover it again immediately the rain ceased. The final means for each separate half month, and for the whole period during which the record was kept, are given in three tables ; showing the total evaporation during the complete twenty-four hours ; that during day, *i. e.*, from 6 A. M. to 6 P. M., and that which occurred in the night only, or between 6 P. M. and 6 A. M. I believe the measurements to have been most carefully made, and the records throughout to be perfectly reliable, but I cannot consider that the results thus obtained represent the actual evaporation from the surface of a large body of water, as from a tank or a river, but on the contrary, that from the widely different conditions of similar areas in the Observatory Evaporator and in the middle of a large body of water, the loss by evaporation from the former must be much greater, during sunshine especially, than from the latter ; and in fact, that the registers hitherto kept, here or elsewhere, are useless for any engineering or irrigation purposes for which such information may be required.

2. I have therefore, after considerable thought upon the subject, contrived an entirely new form of Evaporator, free from all the defects of the kinds hitherto employed ; one which I conceive must furnish results strictly comparable with what is going on from the adjacent portions, if not from the whole area of any tank upon which it may be tried. It requires no measuring or weighing, but simply the reading of an enlarged scale, showing inches, tenths, and hundredths, which may be done once daily, or as often as desired, with the aid of a common telescope from

body of water, as from a tank or a river, but on the contrary, that from the

the banks of the tank, the machine itself being screwed and floating in the middle. The only adjustment ever required is for a cooly to be sent to fill the Evaporator brimful with the tank water, when the index will point to zero or 0.00 inch. If this be done after every reading the scale will indicate the actual evaporation; but if the Evaporator scale is read and registered, without such filling up, the differences of the readings will equally show the loss between each observation, and it may be left untouched for a month together, at the dryest season of the year. Rain cannot sink it, but the quantity measured by an accurate rain gauge must be added to the last reading, to give the evaporation in wet weather. The small model herewith submitted, will, it is hoped, explain the nature of the machine better than any drawing, and will require but little description. The outer cylindrical ring, bearing the light frame work and graduated arc, is intended to be made of copper, four or five feet in interior diameter, but only a few inches in depth, and is merely a large float to keep all steady and to maintain an invariable distance between the zero of the arc and the surface of the tank. The weight of a square foot of the sheet copper employed being known, it will be easy to calculate the dimensions of such a float, so that it shall be sunk to within half or a quarter of an inch of the surface of the tank. Two of the tubes forming the upper frame work may be left open, with their ends turned downwards, or capped, to provide for the expansion of the contained air by sunshine, which would otherwise materially alter the buoyancy of the machine, if it did not actually burst it unless thus taken into consideration. The Evaporator itself, which should not be less than three feet interior diameter, is also to be made double, as in the model; or better still, single, with a sufficient number of attached vertical cylinders, four, eight or more, as may be found necessary to float it nearly level with the outside ring, when brimful of water. The Evaporator must be weighted so as to cause the index attached by a rod to its centre to point to zero, when it is quite full to running over. It is manifest that as the water evaporates from the central vessel it must rise; and as the outer float ring will preserve a fixed position with regard to the surface of the tank, the index will be lowered upon the graduated scale, and will show the amount of evaporation which has taken place by simple inspection. In order to make the model work (which it will be found to do if tried upon a basin or chatty of water) it had to be made out of all proportion to secure sufficient buoyancy to float it upon so small a scale; but the large diameter of the machines as suggested, between three and five feet, would render less depth necessary proportionally, and so the full-sized machine need not draw more than from twelve to twenty inches.

3. The great advantages of the proposed Evaporating machine may be thus enumerated. The water in the Evaporator itself will always be close upon the temperature of the surrounding water of the tank. It will also be always similarly affected by the humidity of the atmosphere, by the deposition of dew, and by sunshine, so as to be at all times and under all circumstances comparable with the tank water around it. The reading is so extremely simple, that any one accustomed to the roughest kind of measurement can keep the register without risk of mistake. A mis-reading or mis-entry, upon any individual day, would merely falsify the preceding and following days' records, but would leave the mean unaltered; the

erroneous increase of the one entry being exactly counterbalanced by the decrease at the next reading, and *vice versa*. No measuring of any kind required. Adjustment to zero made at any time, when after several dry days the Evaporator began to get too empty, by simply filling it brimful. Not easily injured by wind or exposure; and the effect of rain easily allowed for by having a rain gauge recorded near the evaporating machine. A row of sharp pointed wires round the edge of the Evaporator will effectually prevent the birds from drinking out of it, but this and other details have been omitted in the construction of the model.

4. I am aware that a series of measurements of evaporation, at the Red Hill tanks, was undertaken by (then) Lieutenant Ludlow, of the Madras Engineers, about the year 1844, but none of his papers or results remain amongst the records of the Observatory. Neither does the Observatory Library possess the Professional Papers of the Madras Engineers, so that I am unable to refer to Volume IV., page 151, as mentioned by Lieutenant-Colonel Dyas in his letter, printed with the Proceedings of Government now under consideration. It is much to be desired that all such works should be supplied to the Observatory Library with as little delay as possible, to keep the Astronomer informed of what is most wanted, as well as of what has been done, so as to enable him to shape the publication of the Astronomical, Meteorological and Magnetical results, to meet the demands of practical men more completely than the ordinary forms of purely scientific publications usually succeed in doing.

5. While agreeing with Lieutenant (now Colonel) Ludlow's statement, that "*the amount of evaporation increases while the depth of the tank diminishes*," I must totally dissent from his suggestion, quoted in paragraph 22 of Lieutenant-Colonel Dyas's letter, viz., "*that the amount of evaporation increases not only in proportion to the surface exposed, but inversely as the depth of the water*." This would be to say that the water in a tank ten feet deep evaporated only with one-tenth of the rapidity with which it would be lost if the depth were only one foot; or to extend his law still further, it would amount to saying, that, from a deep lake or from the sea, the evaporation was next to nothing! I believe the rapidity of evaporation to depend solely upon the temperature of the exposed surface water, and beyond a certain definite and moderate limit to be perfectly independent of the depth of the under water, or of the total area exposed. In the small shallow Evaporators formerly employed, the heating of the flat copper dish by the sun's rays, vitiated all the results; but in a larger one, say not under thirty inches diameter, wholly immersed in the tank water, the evaporation of which it is intended to measure, and not less than one foot in depth, all such effect must be eliminated, and the evaporation recorded must be fairly comparable with that actually taking place from the surface water of the tank itself.

6. Should the contrivance herewith submitted meet the approbation of Government, the machines would be best constructed by Mr. F. Doderet of the Public Works Department, under my own immediate supervision; and the first two or three at least should be tested and examined at the Observatory, before being forwarded to their destinations for actual use.

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*Proceedings of the Madras Government, Public Works Department,
21st March 1866.*

Mean Evaporation at the Madras Observatory for nineteen years, during Day only.

	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.		JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.		ANNUAL.	
	1-15	16-31	1-14	15-28	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	Mean.	
1842	0.163	0.223	0.250	0.275	0.309	0.330	0.367	0.390	0.413	0.404	0.386	0.359	0.310	0.341	0.340	0.247	0.275	0.292	0.264	0.207	0.132	0.226	0.219	0.231	0.286	
1843	0.208	0.193	0.268	0.319	0.325	0.331	0.379	0.388	0.412	0.402	0.388	0.388	0.250	0.267	0.272	0.229	0.290	0.214	0.152	0.163	0.175	0.214	0.125	0.197	0.260	
1844	0.176	0.208	0.201	0.268	0.297	0.316	0.327	0.366	0.331	0.313	0.395	0.308	0.293	0.284	0.303	0.252	0.262	0.241	0.179	0.236	0.238	0.254	0.184	0.118	0.266	
1845	0.216	0.251	0.253	0.275	0.280	0.310	0.371	0.369	0.363	0.441	0.391	0.243	0.353	0.306	0.314	0.324	0.303	0.268	0.267	0.287	0.265	0.233	0.184	0.153	0.202	
1846	0.217	0.236	0.282	0.335	0.420	0.422	0.510	0.504	0.499	0.338	0.410	0.304	0.279	0.228	0.225	0.320	0.322	0.376	0.293	0.209	0.264	0.143	0.206	0.162	0.310	
1847	0.249	0.289	0.244	0.324	0.328	0.350	0.391	0.377	0.421	0.421	0.373	0.181	0.303	0.271	0.207	0.284	0.370	0.219	0.262	0.191	0.160	0.149	0.083	0.186	0.278	
1848	0.265	0.351	0.392	0.325	0.327	0.352	0.350	0.367	0.353	0.350	0.450	0.447	0.279	0.338	0.206	0.309	0.352	0.332	0.357	0.221	0.145	0.178	0.168	0.207	0.305	
1849	0.169	0.226	0.246	0.285	0.328	0.364	0.435	0.435	0.384	0.416	0.336	0.330	0.334	0.339	0.303	0.274	0.271	0.333	0.228	0.269	0.214	0.217	0.234	0.216	0.289	
1850	0.244	0.260	0.236	0.275	0.333	0.307	0.326	0.364	0.382	0.326	0.430	0.386	0.419	0.359	0.347	0.293	0.335	0.258	0.237	0.202	0.173	0.209	0.197	0.221	0.292	
1851	0.237	0.253	0.269	0.252	0.297	0.338	0.408	0.389	0.351	0.325	0.331	0.231	0.233	0.237	0.256	0.239	0.335	0.258	0.237	0.223	0.144	0.198	0.213	0.221	0.281	
1852	0.238	0.253	0.269	0.252	0.297	0.338	0.408	0.389	0.351	0.325	0.331	0.231	0.233	0.237	0.256	0.239	0.335	0.258	0.237	0.223	0.144	0.198	0.213	0.221	0.281	
1853	0.206	0.174	0.248	0.267	0.293	0.258	0.275	0.320	0.364	0.404	0.423	0.338	0.290	0.371	0.281	0.302	0.303	0.284	0.304	0.159	0.125	0.144	0.177	0.153	0.263	
1854	0.211	0.233	0.257	0.280	0.302	0.303	0.363	0.386	0.378	0.476	0.481	0.394	0.236	0.349	0.324	0.269	0.219	0.298	0.247	0.132	0.163	0.188	0.167	0.163	0.279	
1855	0.173	0.211	0.241	0.242	0.281	0.324	0.346	0.381	0.401	0.510	0.461	0.375	0.409	0.371	0.402	0.391	0.327	0.291	0.181	0.181	0.233	0.297	0.160	0.204	0.308	
1856	0.218	0.237	0.267	0.313	0.330	0.347	0.366	0.380	0.358	0.319	0.413	0.358	0.299	0.348	0.292	0.163	0.306	0.255	0.248	0.245	0.242	0.195	0.143	0.216	0.286	
1857	0.211	0.235	0.258	0.286	0.322	0.341	0.348	0.397	0.434	0.434	0.270	0.325	0.317	0.237	0.351	0.362	0.322	0.284	0.238	0.130	0.237	0.221	0.219	0.217	0.288	
1858	0.233	0.255	0.307	0.344	0.337	0.348	0.331	0.275	0.401	0.428	0.353	0.244	0.267	0.237	0.317	0.242	0.341	0.192	0.176	0.201	0.107	0.193	0.236	0.277	0.277	
1859	0.197	0.233	0.229	0.275	0.316	0.374	0.397	0.305	0.404	0.371	0.334	0.363	0.409	0.278	0.319	0.268	0.328	0.277	0.258	0.264	0.185	0.097	0.249	0.238	0.290	
1860	0.276	0.323	0.274	0.292	0.311	0.308	0.347	0.391	0.420	0.486	0.452	0.368	0.397	0.324	0.279	0.285	0.233	0.233	0.233	0.216	0.305	0.242	0.239	0.296	0.319	
Mean	0.216	0.245	0.262	0.289	0.317	0.331	0.368	0.380	0.390	0.397	0.337	0.316	0.297	0.301	0.278	0.293	0.272	0.236	0.206	0.198	0.194	0.189	0.204	0.237		

(Signed) N. R. POGSON,
Government Astronomer.

*Proceedings of the Madras Government, Public Works Department,
21st March 1866.*

No. 430. ORDER THEREON, 21st March 1866, No. 904.

ESTABLISHMENT, No. 42.

1. The Government approve of the principles of construction exhibited in the rough model of a machine for registering evaporation, forwarded by the Government Astronomer with this letter.

2. Mr. Doderet will be instructed to make up a working machine on the same principle, but with such modifications or additions as Mr. Pogson may suggest.

3. As soon as it has been constructed it will be forwarded to the Observatory for test and trial.

(True Extract.)

(Signed) CHARLES A. ORR, Colonel, R. E.,

Secretary to Government.

To the General Superintendent of Public Works Stores and Workshops.
Controller of Public Works Accounts.

Government Astronomer.

Exd. S. T. Augustin.

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1. The general method hitherto adopted has been to expose, in a shallow copper vessel, a small quantity of water, carefully weighed or measured in the first instance, and offering only a small surface, as a square foot or less, to the atmosphere. The depth of the water exposed rarely exceeded an inch and half, or at most two inches ; it was invariably within four or five feet of dry and heated ground, while the vessel itself, and the water it contained, being freely exposed to the sun's rays, the quantity actually lost, in the course of a sunny day, must have been far in excess of that which would have been evaporated from a similar area of deep tank water. After twelve or twenty-four hours the water exposed was again weighed or measured, and the diminution during the period elapsed was recorded as the evaporation for such time. In this manner observations of evaporation were made at the Madras Observatory between the years 1842 and 1860 inclusive, the water exposed being carefully measured at 6 A. M. and 6 P. M. daily throughout the nineteen years. The Evaporator was well watched by the Lascars to keep away birds, and also to cover it over in case of rain, and to uncover it again immediately the rain ceased. The final means for each separate half month, and for the whole period during which the record was kept, are given in three tables ; showing the total evaporation during the complete twenty-four hours ; that during day, *i. e.*, from 6 A. M. to 6 P. M., and that which occurred in the night only, or between 6 P. M. and 6 A. M. I believe the measurements to have been most carefully made, and the records throughout to be perfectly reliable, but I cannot consider that the results thus obtained represent the actual evaporation from the surface of a large body of water, as from a tank or a river, but on the contrary, that from the widely different conditions of similar areas in the Observatory Evaporator and in the middle of a large body of water, the loss by evaporation from the former must be much greater, during sunshine especially, than from the latter ; and in fact, that the registers hitherto kept, here or elsewhere, are useless for any engineering or irrigation purposes for which such information may be required.

2. I have therefore, after considerable thought upon the subject, contrived an entirely new form of Evaporator, free from all the defects of the kinds hitherto employed ; one which I conceive must furnish results strictly comparable with what is going on from the adjacent portions, if not from the whole area of any tank upon which it may be tried. It requires no measuring or weighing, but simply the reading of an enlarged scale, showing inches, tenths, and hundredths, which may be done once daily, or as often as desired, with the aid of a common telescope from

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3. The great advantages of the proposed Evaporating machine may be thus enumerated. The water in the Evaporator itself will always be close upon the temperature of the surrounding water of the tank. It will also be always similarly affected by the humidity of the atmosphere, by the deposition of dew, and by sunshine, so as to be at all times and under all circumstances comparable with the tank water around it. The reading is so extremely simple, that any one accustomed to the roughest kind of measurement can keep the register without risk of mistake. A mis-reading or mis-entry, upon any individual day, would merely falsify the preceding and following days' records, but would leave the mean unaltered; the

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4. I am aware that a series of measurements of evaporation, at the Red Hill tanks, was undertaken by (then) Lieutenant Ludlow, of the Madras Engineers, about the year 1844, but none of his papers or results remain amongst the records of the Observatory. Neither does the Observatory Library possess the Professional Papers of the Madras Engineers, so that I am unable to refer to Volume IV., page 151, as mentioned by Lieutenant-Colonel Dyas in his letter, printed with the Proceedings of Government now under consideration. It is much to be desired that all such works should be supplied to the Observatory Library with as little delay as possible, to keep the Astronomer informed of what is most wanted, as well as of what has been done, so as to enable him to shape the publication of the Astronomical, Meteorological and Magnetical results, to meet the demands of practical men more completely than the ordinary forms of purely scientific publications usually succeed in doing.

5. While agreeing with Lieutenant (now Colonel) Ludlow's statement, that "*the amount of evaporation increases while the depth of the tank diminishes*," I must totally dissent from his suggestion, quoted in paragraph 22 of Lieutenant-Colonel Dyas's letter, viz., "*that the amount of evaporation increases not only in proportion to the surface exposed, but inversely as the depth of the water*." This would be to say that the water in a tank ten feet deep evaporated only with one-tenth of the rapidity with which it would be lost if the depth were only one foot; or to extend his law still further, it would amount to saying, that, from a deep lake or from the sea, the evaporation was next to nothing! I believe the rapidity of evaporation to depend solely upon the temperature of the exposed surface water, and beyond a certain definite and moderate limit to be perfectly independent of the depth of the under water, or of the total area exposed. In the small shallow Evaporators formerly employed, the heating of the flat copper dish by the sun's rays, vitiated all the results; but in a larger one, say not under thirty inches diameter, wholly immersed in the tank water, the evaporation of which it is intended to measure, and not less than one foot in depth, all such effect must be eliminated, and the evaporation recorded must be fairly comparable with that actually taking place from the surface water of the tank itself.

6. Should the contrivance herewith submitted meet the approbation of Government, the machines would be best constructed by Mr. F. Doderet of the Public Works Department, under my own immediate supervision; and the first two or three at least should be tested and examined at the Observatory, before being forwarded to their destinations for actual use.

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1-15 16-31	1-14 15-28	1-15 16-31	1-15 16-30	1-15 16-31	1-15 16-30	1-15 16-31	1-15 16-31	1-15 16-30	1-15 16-31	1-15 16-30	1-15 16-31	Mean.
1842	0.175	0.229	0.275	0.281	0.326	0.358	0.422	0.454	0.486	0.476	0.435	0.318
1843	0.236	0.209	0.281	0.333	0.359	0.360	0.397	0.417	0.436	0.491	0.381	0.288
1844	0.186	0.232	0.293	0.340	0.312	0.340	0.342	0.391	0.377	0.352	0.345	0.293
1845	0.238	0.262	0.279	0.292	0.302	0.328	0.394	0.396	0.501	0.418	0.345	0.320
1846	0.235	0.251	0.303	0.377	0.449	0.443	0.547	0.534	0.418	0.345	0.317	0.336
1847	0.268	0.302	0.276	0.354	0.341	0.373	0.420	0.467	0.479	0.419	0.340	0.306
1848	0.287	0.360	0.413	0.343	0.350	0.368	0.376	0.393	0.392	0.400	0.346	0.335
1849	0.194	0.243	0.264	0.298	0.343	0.390	0.463	0.304	0.419	0.462	0.393	0.317
1850	0.257	0.274	0.250	0.288	0.317	0.322	0.349	0.395	0.400	0.360	0.287	0.322
1851	0.258	0.276	0.286	0.300	0.311	0.362	0.434	0.415	0.376	0.356	0.263	0.307
1852	0.251	0.275	0.291	0.270	0.319	0.326	0.383	0.376	0.336	0.450	0.345	0.313
1853	0.216	0.159	0.259	0.275	0.302	0.275	0.291	0.337	0.394	0.461	0.370	0.313
1854	0.231	0.249	0.276	0.312	0.323	0.322	0.387	0.416	0.411	0.535	0.438	0.338
1855	0.186	0.226	0.257	0.262	0.303	0.352	0.384	0.402	0.387	0.354	0.318	0.314
1856	0.226	0.249	0.280	0.335	0.347	0.372	0.384	0.402	0.403	0.415	0.365	0.317
1857	0.231	0.253	0.268	0.294	0.341	0.342	0.363	0.372	0.354	0.275	0.214	0.302
1858	0.247	0.261	0.297	0.324	0.363	0.354	0.368	0.346	0.291	0.454	0.286	0.309
1859	0.216	0.253	0.234	0.288	0.328	0.385	0.420	0.329	0.341	0.396	0.314	0.347
1860	0.291	0.338	0.284	0.310	0.322	0.320	0.365	0.407	0.451	0.396	0.300	0.315
Mean	0.233	0.260	0.279	0.306	0.336	0.352	0.391	0.394	0.412	0.439	0.344	0.315

(Signed) N. R. FOGSON,
Government Astronomer.

Proceedings of the Madras Government, Public Works Department,
21st March 1866.

Mean Evaporation at the Madras Observatory for nineteen years, during Night only.

JANUARY.	FEBRUARY.	MARCH.	APRIL.	MAY.	JUNE.	JULY.	AUGUST.	SEPTEMBER.	OCTOBER.	NOVEMBER.	DECEMBER.	ANNUAL.
1-15 16-31	1-14 15-28	1-15 16-31	1-15 16-30	1-15 16-31	1-15 16-30	1-15 16-31	1-15 16-31	1-15 16-30	1-15 16-31	1-15 16-30	1-15 16-31	Mean.
1842	0.012	0.006	0.023	0.006	0.017	0.028	0.015	0.032	0.041	0.032	0.044	0.032
1843	0.028	0.016	0.013	0.014	0.034	0.029	0.018	0.029	0.024	0.029	0.048	0.028
1844	0.010	0.024	0.022	0.012	0.015	0.024	0.015	0.025	0.046	0.041	0.037	0.027
1845	0.022	0.011	0.026	0.017	0.022	0.018	0.021	0.025	0.039	0.034	0.041	0.028
1846	0.018	0.015	0.021	0.038	0.029	0.021	0.037	0.030	0.028	0.019	0.032	0.028
1847	0.019	0.013	0.032	0.030	0.013	0.023	0.029	0.035	0.046	0.021	0.018	0.030
1848	0.022	0.009	0.021	0.018	0.023	0.016	0.026	0.039	0.050	0.060	0.071	0.028
1849	0.025	0.017	0.018	0.014	0.013	0.014	0.026	0.031	0.036	0.042	0.041	0.026
1850	0.013	0.014	0.016	0.013	0.021	0.024	0.026	0.033	0.040	0.041	0.041	0.023
1851	0.021	0.023	0.022	0.018	0.022	0.024	0.028	0.033	0.043	0.050	0.037	0.028
1852	0.023	0.015	0.011	0.008	0.009	0.017	0.016	0.022	0.030	0.031	0.031	0.030
1853	0.010	0.015	0.011	0.019	0.032	0.021	0.019	0.022	0.036	0.038	0.027	0.028
1854	0.020	0.016	0.016	0.019	0.022	0.028	0.029	0.035	0.043	0.043	0.043	0.029
1855	0.013	0.015	0.015	0.016	0.022	0.025	0.025	0.035	0.045	0.045	0.045	0.024
1856	0.008	0.012	0.013	0.012	0.017	0.022	0.024	0.032	0.041	0.041	0.041	0.019
1857	0.020	0.018	0.010	0.009	0.012	0.017	0.020	0.023	0.033	0.033	0.033	0.027
1858	0.014	0.009	0.012	0.017	0.021	0.023	0.024	0.024	0.024	0.024	0.024	0.025
1859	0.019	0.020	0.005	0.013	0.012	0.011	0.023	0.024	0.024	0.024	0.024	0.027
1860	0.015	0.015	0.016	0.016	0.018	0.011	0.018	0.018	0.018	0.018	0.018	0.028
Mean	0.017	0.015	0.017	0.017	0.019	0.021	0.023	0.026	0.032	0.049	0.048	0.028

(Signed) N. R. FOGSON,
Government Astronomer.

body of water, as from a tank or a river, but in the contrary, that from the

Mean Evaporation at the Madras Observatory for nineteen years, during Day only.

	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.		JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.		ANNUAL			
	1-15	16-31	1-14	15-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	Mean.	
1842	0.163	0.223	0.250	0.275	0.309	0.330	0.367	0.390	0.413	0.404	0.386	0.359	0.310	0.341	0.340	0.247	0.275	0.202	0.264	0.207	0.132	0.226	0.219	0.231	0.286			
1843	0.208	0.193	0.268	0.319	0.325	0.331	0.379	0.388	0.412	0.462	0.308	0.288	0.250	0.267	0.272	0.229	0.290	0.214	0.152	0.165	0.175	0.214	0.125	0.197	0.260			
1844	0.176	0.208	0.201	0.268	0.297	0.316	0.327	0.366	0.331	0.318	0.395	0.308	0.293	0.284	0.303	0.252	0.262	0.244	0.179	0.256	0.238	0.254	0.184	0.118	0.266			
1845	0.216	0.251	0.253	0.275	0.280	0.310	0.371	0.369	0.363	0.441	0.391	0.243	0.353	0.306	0.314	0.324	0.303	0.268	0.267	0.287	0.265	0.233	0.184	0.153	0.292			
1846	0.217	0.236	0.282	0.339	0.420	0.422	0.510	0.504	0.499	0.338	0.410	0.304	0.279	0.228	0.225	0.320	0.322	0.376	0.223	0.209	0.264	0.143	0.206	0.162	0.310			
1847	0.219	0.289	0.344	0.324	0.328	0.350	0.391	0.377	0.421	0.421	0.373	0.181	0.303	0.271	0.207	0.284	0.370	0.219	0.262	0.191	0.160	0.149	0.083	0.186	0.278			
1848	0.265	0.351	0.392	0.325	0.327	0.352	0.350	0.367	0.353	0.350	0.450	0.447	0.379	0.338	0.296	0.309	0.352	0.232	0.257	0.321	0.145	0.178	0.168	0.207	0.305			
1849	0.169	0.226	0.246	0.285	0.326	0.364	0.435	0.382	0.381	0.416	0.336	0.330	0.334	0.237	0.303	0.274	0.271	0.333	0.228	0.269	0.214	0.172	0.234	0.216	0.289			
1850	0.244	0.260	0.236	0.275	0.333	0.307	0.326	0.364	0.354	0.326	0.444	0.354	0.231	0.253	0.256	0.229	0.335	0.258	0.237	0.223	0.144	0.198	0.213	0.221	0.292			
1851	0.237	0.253	0.270	0.287	0.290	0.338	0.408	0.389	0.354	0.325	0.444	0.354	0.231	0.253	0.256	0.229	0.335	0.258	0.237	0.223	0.144	0.198	0.213	0.221	0.291			
1852	0.228	0.253	0.269	0.232	0.297	0.298	0.350	0.347	0.306	0.408	0.361	0.275	0.323	0.214	0.310	0.214	0.233	0.306	0.234	0.183	0.159	0.125	0.144	0.177	0.153	0.263		
1853	0.206	0.174	0.248	0.267	0.293	0.258	0.275	0.320	0.364	0.404	0.423	0.388	0.290	0.371	0.281	0.302	0.303	0.284	0.304	0.159	0.125	0.144	0.222	0.232	0.279			
1854	0.211	0.233	0.257	0.230	0.302	0.303	0.365	0.386	0.378	0.476	0.481	0.394	0.236	0.349	0.324	0.269	0.219	0.298	0.247	0.132	0.165	0.138	0.167	0.163	0.282			
1855	0.173	0.211	0.241	0.242	0.281	0.324	0.346	0.381	0.401	0.510	0.461	0.375	0.403	0.371	0.402	0.391	0.327	0.291	0.181	0.181	0.233	0.297	0.160	0.204	0.308			
1856	0.218	0.237	0.267	0.313	0.330	0.347	0.366	0.380	0.358	0.319	0.413	0.358	0.299	0.348	0.292	0.163	0.306	0.255	0.248	0.245	0.195	0.145	0.216	0.286				
1857	0.211	0.235	0.258	0.286	0.322	0.326	0.341	0.348	0.397	0.434	0.270	0.325	0.317	0.237	0.351	0.362	0.322	0.286	0.238	0.130	0.227	0.221	0.219	0.217	0.288			
1858	0.233	0.255	0.285	0.307	0.344	0.337	0.348	0.331	0.275	0.403	0.423	0.353	0.244	0.267	0.317	0.317	0.242	0.341	0.192	0.176	0.201	0.107	0.193	0.236	0.277			
1859	0.197	0.233	0.229	0.275	0.316	0.374	0.397	0.305	0.404	0.371	0.334	0.363	0.409	0.278	0.319	0.298	0.328	0.277	0.258	0.264	0.185	0.097	0.249	0.238	0.290			
1860	0.276	0.323	0.274	0.292	0.311	0.308	0.347	0.391	0.420	0.486	0.452	0.368	0.397	0.324	0.319	0.279	0.285	0.234	0.253	0.216	0.305	0.242	0.239	0.296	0.319			
Mean	0.216	0.215	0.262	0.289	0.317	0.331	0.368	0.368	0.330	0.390	0.397	0.337	0.316	0.297	0.301	0.278	0.293	0.276	0.236	0.204	0.198	0.194	0.189	0.204	0.287			

(Signed) N. R. POGSON,
Government Astronomer.

Proceedings of the Madras Government, Public Works Department.
21st March 1866.

No. 430.

ORDER THEREON, 21st March 1866, No. 904.

ESTABLISHMENT, No. 42.

1. The Government approve of the principles of construction exhibited in the rough model of a machine for registering evaporation, forwarded by the Government Astronomer with this letter.

2. Mr. Doderet will be instructed to make up a working machine on the same principle, but with such modifications or additions as Mr. Pogson may suggest.

3. As soon as it has been constructed it will be forwarded to the Observatory for test and trial.

True Extract.)

(Signed) CHARLES A. ORR, Colonel R. E.,
Secretary to Government.

No. 904 A.

Copy of the above forwarded to the Secretary to the Government of the North-Western Provinces in the Public Works Department, with reference to Lieutenant-Colonel Dyas' endorsement No. 380I, dated 4th December 1865, and with an intimation that the result of the trial which has been ordered to be made of Mr. Pogson's Evaporator will be communicated in due course.

(Signed) CHARLES A. ORR, Colonel, R. E.,
Secretary to Government.

Erd. S. T. Augustin.

body of water, as from a tank or a river, but in the contrary, that from the

Madras Observatory - March 5th. 1866.

The Government Astronomer

To Colonel C. A. C. R. E.

Secretary to Government - P. W. D. -

Sir,

I have the honor to reply to the Proceedings of the Madras Government, Public Works Department, and the Order thereon, No 266, dated 18th January, 1866, respecting the best method of measuring the Evaporation from the surfaces of large tanks, and in doing so, I beg to send, instead of a drawing, to submit for your inspection a small working model of a new form of Evaporimeter, of which I will now proceed to give a brief description, prefaced by a few remarks upon and objections to all former instruments hitherto employed for the purpose of measuring Evaporation.

1. - The general method hitherto adopted has been to expose, in a shallow copper vessel, a small quantity of water, carefully weighed or measured, in the first instance, and offering only a small surface, as a square foot or less, to the atmosphere. The depth of the water exposed rarely exceeded an inch and half or at most two inches; it was invariably within four or five feet of dry and heated ground, while the vessel itself and the water it contained, being freely exposed to the sun's rays, the quantity actually lost in the course of a sunny day must have been far in excess of that which would have been evaporated from a similar area of deep tank water. - After twelve or twenty-four hours the water exposed was again weighed or measured, and the diminution during the period elapsed was recorded as the evaporation for each time. - In this manner observations of evaporation were made at the Madras Observatory between the years 1842 and 1860 inclusive, the water exposed being carefully measured at 6 A.M. and 6 P.M. daily throughout these nineteen years. - Due allowance was always made. The evaporimeter was well watched, by the barriers, to keep away birds, and also to cover it over in case of rain, and to uncover it again immediately the rain ceased. - The final means for each separate half-month, and for the whole period during which the record was kept, are given in three tables, showing the total evaporation during the complete twenty-four hours, and that during day i.e. from 6 A.M. to 6 P.M., and that which occurred in the night only or between 6 P.M. and 6 A.M. I believe the measurements to have been most carefully made and the records throughout to be perfectly reliable, but I cannot consider that the results thus obtained represent the actual evaporation from the surface of a large body of water, as from a tank or a river, but on the contrary, that from the

widely different conditions of similar areas in the Observatory Evaporator and in the middle of a large body of water, the loss by evaporation from the former must be much greater, during sunshine especially, than from the latter, and in fact, that the registers hitherto kept, here or elsewhere, are useless for any engineering or irrigation purposes for which such information may be required.

2. - I have therefore, after considerable thought upon the subject, conceived an entirely new form of Evaporator, free from all the defects of the kinds hitherto employed; one which I conceive must furnish results strictly comparable with what is going on from the adjacent portions, if not from the whole area of any tank upon which it may be tried. - It requires no measuring or weighing, but simply the reading of an enlarged scale, showing inches, tenths and hundredths, which may be done once daily, or as often as desired, with the aid of a common telescope from the banks of the tank, the machine itself being raised & floating in the middle. - The only adjustment ever required is for a scale, to be sent to float the Evaporator himself with the tank water, when the index will point to zero or 0.00 inch. - If this be done after every reading, the scale will indicate the actual evaporation, but if the Evaporator scale is read and registered, without such filling up, the difference of the readings will equally show the loss between each observation, and it may be left untouched for a month together, at the driest season of the year. - Rain cannot sink it, but the quantity measured by an accurate rain gauge must be added to the last reading, to give the evaporation in wet weather. - The small model herewith submitted, will, it is hoped, explain the nature of the machine better than any drawing, and will require but little description. - The outer cylindrical ring, bearing the light framework and graduated one, is intended to be made of copper, four or five feet in interior diameter, but only a few inches in depth, and is merely a large float, to keep all steady, and to maintain an invariable distance between the top of the air and the surface of the tank. -

The weight of a square foot of the sheet copper employed being known, it will be easy to calculate the dimensions of such a float, so that it shall be sunk to within half or a quarter of an inch of the surface of the tank. - Some of the tubes forming the upper framework may be left open, with their ends turned downwards, or capped, to provide for the expansion of the contained air by sunshine, which would otherwise materially alter the buoyancy of the machine, if it did not actually burst it unless thus taken into consideration. - The Evaporator itself, which should not be less than three feet interior diameter, is also to be made double, as in the model, or better still, single, with a sufficient number of attached vertical cylinders, four, eight or more, as

may be found necessary to float it nearly level with the outside ring, when full of water. - The Evaporator must be weighted so as to cause the index attached by a rod to its center to point to zero, when it is quite full to running over. - It is manifest that as the water evaporates from the central vessel it must rise; and as the outer float ring will preserve a fixed position with regard to the surface of the tank, the index will be lowered upon the graduated scale, and will show the amount of evaporation which has taken place by simple inspection. - In order to make the model work (which it will be found to do if tried upon a basin or shoal of water) it had to be made out of all proportions to secure sufficient buoyancy to float it upon so small a scale; but the large diameter of the machines as suggested, between three and five feet, would render less depth necessary proportionally, and so the full sized machine need not draw more than from twelve to twenty inches. -

3. The great advantages of the proposed Evaporating machine may be thus summarized. The water in the evaporator itself will always be close upon the temperature of the surrounding water of the tank. - It will also be always similarly affected by the humidity of the atmosphere, by the deposition of dew, and by evaporation, so as to be at all times and under all circumstances comparable with the tank water around it. - The reading is so extremely simple, that any one accustomed to the roughest kind of measurement can keep the register without risk of mistake. - A misreading or misentry upon any individual day would merely falsify the preceding and following days' records, but would leave the mean unaltered, the erroneous increase of the one entry being exactly counterbalanced by the decrease at the next reading, and vice versa. - No measuring of any kind required. - Adjustment to zero made at any time, when after several dry days the evaporator began to get too empty, by simply filling it brimful. - Not easily injured by wind or exposure; and the effect of rain easily allowed for by having a rain gauge recorded near the evaporating machine. - A row of sharp pointed wires round the edge of the evaporator will effectually prevent the birds from drinking out of it, but this and other details have been omitted in the construction of the model. -

4. - I am aware that a series of measurements of evaporation, at the Red Hill tanks, was undertaken by (then) Lieutenant Sadow, of the Madras Engineers, about the year 1844, but none of his papers or results remain amongst the records of the Observatory. - Neither does the Observatory Library

possess the Professional Papers of the Madras Engineers, so that I am unable to refer to Volume IV, page 131, as mentioned by Lieut Col Dyas in his letter, printed with the Proceedings of Government now under consideration. — It is much to be desired that all such works should be supplied to the Observatory Library with as little delay as possible, to keep the Astronomer informed of what is most wanted, as well as of what has been done, so as to enable him to shape the publication of the Astronomical, Meteorological and Magnetic Reports, to meet the demands of practical men more completely than the ordinary forms of purely scientific publications usually succeed in doing. —

5. — While agreeing with Lieut (now Colonel) Guthrie's statement, that "the amount of evaporation increases while the depth of the tank diminishes," I must totally dissent from his suggestion, quoted in para. 22 of Lieut Col Dyas's letter, viz. "that the amount of evaporation increases not only in proportion to the surface exposed but inversely as the depth of the water." — This would be to say that ^{the water in} a tank ten feet deep evaporated only with one tenth of the rapidity with which it would be lost if the depth were only one foot; or to extend his law still further, it would amount to saying, that from a deep lake or from the sea, the evaporation was next to nothing! — I believe the rapidity of evaporation to depend solely upon the temperature of the exposed surface water, and beyond a certain definite and moderate limit to be perfectly independent of the depth of the under water, or of the total area exposed. In the small shallow evaporators formerly employed, the heating of the flat copper dishes by the sun's rays, vitiated all the results; but in a larger one, say not under thirty inches diameter, wholly immersed in the tank water, the evaporation of which it is intended to measure, and not less than one foot in depth, all such effect must be eliminated, and the evaporation recorded must be fairly comparable with that actually taking place from the surface water of the tank itself. —

6. — Should the contrivance herewith submitted meet the approbation of Government, the machines would be best constructed by Mr. F. Dodderet, of the Public Works Department, under my own immediate supervision, and the first two or three at least should be tested and examined at the Observatory, before being forwarded to their destinations for actual use. —

I have the honor to be

Sir,
Your most obedient servant

M R Pogson

Government Astronomer.

125 March 1866. D. 165

1866

125 March 1866. D. 165

Submittal, with
renewals, a small
working model of a
new form of bar-
ometer -

82 (P)

Recd 5 } March 1866.

The Govt Astronomer

27 10 1866 D. 165
Govt Astronomer for Madras
1866

Public Works Department.
No. 904 77 100 100 100 100
Proceedings of the Madras Government
Under date the 21st March 1866
Read the following

From the Government Astronomer / Recd 5th March 1866.

The Government ap-
prove of the principles of
construction exhibited in the
rough model of a machine
for registering evaporation
forwarded by the Govern-
ment Astronomer with this
letter.

2. Mr. Dodder will
be instructed to make up
a working machine on the
same

Handwritten initials and signatures.

same principles but with
such modifications or
additions as Mr. Pogo
may suggest.

3 As soon as it
has been constructed it
will be forwarded to the
Observatory for test and

that instrument
of measuring the
distance of the
sun from the
earth.

Copy of the above
forwarded to the Secy to
the Government of the
North

To the Secy of P. W. Stores
" Controller
" - Government Astronomer
Decr. 23rd March
16

Fort St George
21st March/66

Decr. 23rd March

North Western Provinces
in the Public Works De-
partment, with reference
to Lieutenant Colonel
Dyer's endorsement No. 3801
dated 4th December 1865,
and with an intimation
that the result of the trial
which has been ordered
to be made of ^{Mr Pogo's} ~~the~~ evapo-
ration ~~machine~~ will be
communicated in due
course.

