MANUAL

OF

PHYSICAL RESEARCH

FOR INDIA.

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ADAPTED

FOR INDIA.

COMPILED BY

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ADVERTISEMENT.

THE present Work was projected by the Bombay Geographical Society in 1849: its preparation was entrusted to the Secretary in concert with the Committee on Physical Research, consisting of Lieut.-Colonel Holland, Quartermaster General Bombay Army; Captain Hawkins, Deputy Superintendent of the Indian Navy; Captain Barr, Paymaster General Bombay Army; Mr. John Ritchie, Manager to the *Oriental Steam Navigation Company*; and Professor Patton; gentlemen of great ability and accomplishments, and who were always ready to afford council, or render whatever assistance was desired of them; and after many and unlooked for delays and retardations, it had nearly reached its present form when it was in August, 1851, deemed expedient to apply to the Society to have it withdrawn from under their patronage: the application was complied with, and it now, therefore, appears on the sole responsibility of the compiler.

To avoid a continuance of those inexplicable and interminable delays occasionally experienced at press in Bombay, when anything bearing the name of illustration is desired, it has been considered expedient to issue the first portion of the Manual in an imperfect form: the Chapter on Geology, and a General Index of Indian Authors and Subjects, as well as a considerable amount of Appendix, being still in the Printer's hands. As it stands it will be found tolerably complete so far as it goes, and it will be optional for purchasers to provide themselves with the Second Part or not as they think fit: the present Part of itself, consisting of 268 pages, mostly of small type, contains about the same quantity of print as the Admiralty Manual altogether, and it will be increased by a third by that still in process of preparation.

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INTRODUCTION.

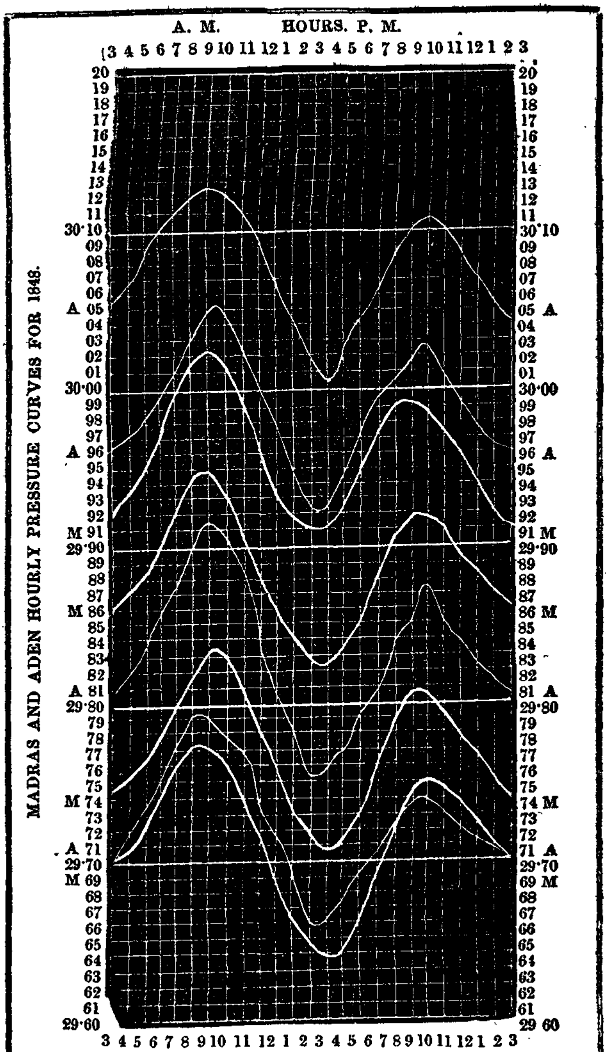
The following outline, taken from the *Annals of India* for 1848, of the Researches in Physical Geography of the Bombay Geographical Society, will explain the objects they have had for a long time in view on this subject, and the nature and ends of the researches in which they are now engaged :—

The Bombay Geographical Society came into existence at a period when a remarkable degree of activity began to prevail throughout the world in the prosecution of enquiries in Physical Geography, and its able and enlightened founders resolved largely to share in what was then the favorite study of the day. Having provided themselves with magnetic and meteorological instruments, they set about attempting to determine with precision the climate of Bombay ; and though it does not appear that they at this time had any view of endeavouring to establish other observatories under their own immediate charge, they resolved to encourage others to observe,—to supply instruments where these were wanted, and to avail themselves to as large an extent as possible of the researches of amateurs. The investigation of the climate of Bombay does not, so far as the records show, appear to have been proceeded with—the cause of the failure is not known; but the Transactions are rich in observations at other points, which only required to be collected in sufficient abundance, and to be compared with some point of reference, for the purpose of generalization. Such a point as that desired first made its appearance in 1842, when the meteorological and magnetic observatory was fairly established at Colaba. The operations of this establishment having for a time been interrupted, the records of an entire year of continuous observation were first completed in September 1843 ; when, as a second year was proceeded with, it became apparent that the phenomena of climate here were so marked and so beautifully uniform, that the records of one year would almost suffice in times of tranquillity for the observations of another, and that, therefore, the anomalies at the spot were the things that required from thenceforth chiefly to be attended to.. Now came the time for extending the investigations the Society had from the beginning had in contemplation, when a somewhat more systematic and comprehensive plan should be adopted, and more extended and varied results might be looked for.

For the information of the general reader it may be shortly explained, that in meteorology the first point generally attended to is the pressure of the atmosphere, by which at the level of the sea a column of mercury from 29 to 30 inches long can be supported in every quarter of the world. This is determined by the well-known instrument called the *Barometer*, or measurer of weight. At the Equator the pressure is somewhat less than at the higher latitudes. At Melville Island, in Lat. 74° N., it is 29.870 ; at Ingloobeck, lat. 69°, it is 29.770 ; and at Winter Island, 66° N., it is 29.798. At Plymouth it is 29.90; and at Bombay, 19° N., it is 29.860. At the equator it is 29.974 ; 13° S., 30.016 ; 43° S., 29.950 ; from this decreasing rapidly to the southward, till at latitude 66°, when it is no more than 29.078. The cause of this remarkable decrease in the southern latitudes, remains to be explained, and all information regarding it is of the very highest interest.

The Barometer in the higher latitudes is so sensibly affected by the weather, that its prognostications as a weather-glass are of the highest value, scarcely a farmhouse in England being without an instrument of this sort. Between the tropics it moves sensibly on the approach of change, but to a very small extent : at home a fall of three inches would scarcely excite more surprise, or occasion greater alarm, than a fall of three-tenths of an inch in the torrid zone. Throughout the world the barometer has two daily tides, being highest at 10 A. M. and P. M. nearly, and lowest at 3 A. M. and 4 P. M. nearly. At home, the fluctuation rarely exceeds the hundredth part of an inch, and is so masked and concealed by the larger irregularities due to the weather, that it requires the means of a vast number of observations to enable us to detect at all: at Bombay, during the fair season the daily fluctuation constantly exceeds the tenth of an inch—it is so regular in its form that the curve of a single day might serve for the mean of the month, and so punctual in the time of its arrival that a watch might be set by it without material error. The following diagram will at once place the matter before the reader's eye in a form more perspicuous and intelligible than any description.

The months are grouped together according to their relations,—the means of November, December, and January, or the cold season months, making one curve : February, March, and April, or the spring months, a second : May June, and July, the summer months, a third, forming the lowest group : August, September, and October, a fourth. We are indebted for the abstracts on which these are constructed, to Lieutenant K. Worster, of the Madras Artillery, presently in charge of the Observatory, who supplied all the information asked for the moment he was applied to ; and to the papers of the Bombay Geographical Society. The Madras rainy season begins in Oct., that of Bombay in June : rain rarely ever falls at Aden : we have not been able to obtain access to the Bombay registers—none have been published since 1845 : judging from these, however, and those preceding them, we should expect to find the Bombay curves for 1848 exactly similar to those at Madras. So are the Calcutta curves now before us, but for which we have no room at present. The light lines marked A at the extremities, indicate the pressure curves at Aden in Arabia near the mouth of the Red Sea, as taken by the observatory under Mr Moyes, established at the recommendation of the Geographical Society, and now superintended by them—the months arranged in the same groups as in the case of Madras, which are marked M.

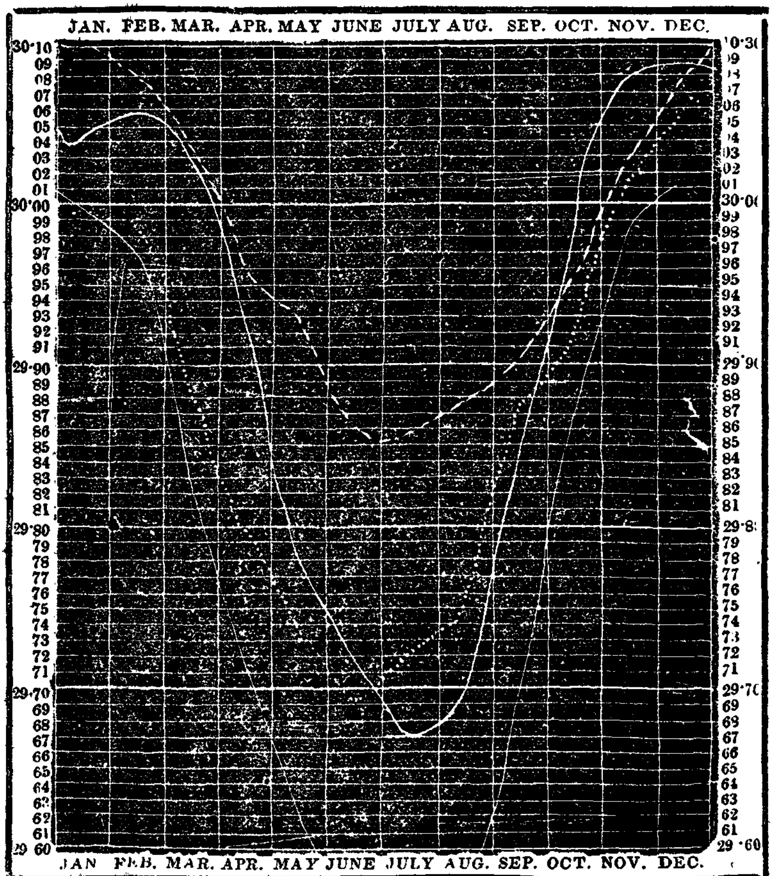


Besides this daily fluctuation, the height of the barometer varies with the greatest regularity at different seasons of the year, and is generally highest near the shortest, and lowest about the longest, day,—and this without any relation to the wetness or dryness, the storminess or tranquillity, of the season. At Madras, as at Bombay, for example, it reaches its minimum in June and its maximum in December, though at the former place the weather during the first named month is dry and steady, during the last it is showery and wet,—the heaviest of our rains occurring here in June, and our steadiest weather in

December. The same law holds pretty nearly at Aden, where no rain falls for long periods of years; and so probably throughout the torrid zone. The daily tide or fluctuation makes its appearance with the same regularity in wet and stormy as in dry and steady weather, and at all seasons of the year alike, only the fluctuation decreases by about a half when the mean altitude of the mercury is least.* The following diagrams will illustrate what is stated:—

The two dotted lines represent the Madras mean curves for each month in the year—the lower is for 1848—the upper is from results by the late Mr Taylor—I do not know how attained.

The strong line is the Aden curve, the fine one that for Calcutta—both for 1847. The Calcutta barometer is eighteen feet above the sea, the Madras one twenty five—neither has been corrected for level; the Aden curve has been corrected to mean tide—the barometer is 187 feet above the sea.



* The above is not to be accepted as strictly and uniformly true, but it would occupy too much space to enumerate the exceptions, which hardly however invalidate the law. [illegible] one of the most notable of these.

The great decrease of pressure as we proceed towards the Antarctic has been noticed as amongst the things requiring to be explained: the fact that the daily fluctuation is very nearly as great at the elevation of 5,000 feet—or, so far as we know, at any greater elevation,—where the total pressure is 25 inches, —as at the level of the sea, where it is 30, is amongst the meteorological perplexities which still require solution.*

Besides these two grand classes of movements, due to the hour of the day or time of the year, there is a third of the deepest interest, which is now in process of examination in Europe, and which, from the extreme regularity of the seasons in India, we are much better situated for examining than they are beyond the tropics. A general progressive fall and subsequent rise is found to take place in the mercury all over Europe at different places in succession, as if mighty waves of air, like the long swell of the sea after a storm, were sweeping over the upper surface of our atmosphere, following each other in solemn and stately march, and crossing each other at intervals. Though these general laws obtain with the most astonishing regularity, there are numberless minor variations requiring to be watched with the strictest attention, with a view to their explanation. There is a slight variation of some minutes as to the time when the turning points are attained, and as yet we are ignorant whether this is at all times the same in corresponding months of different years, or whether it is uniform at different points on the earth's surface. At Robbin Island, Cape of Good Hope, the diurnal oscillation is much less than on the mainland, and in place of recovering in the evening from the afternoon depression, a further though trifling fall in the mercury takes place.† Captain Haines as far back as 1844 had observed a remarkable discrepancy betwixt the barometers at Steamer Point and the Camp at Aden,—yet the distance is only four miles; and the pressure curve of Seerah Island, close off the shore, is far less smooth and symmetrical than the curves supplied by the Calcutta, Madras, and Bombay observatories. At Aden there is a departure from the law which seems to obtain in nearly all parts of India,—the maximum depression for the year occurring—not in January, but—in February, the minimum in July instead of June. It is much the highest in December, but makes a plunge down in January to recover itself again in February, and so afterwards descending regularly to its minimum. This at all events has obtained uniformly for three years, and we should therefore infer it to be the rule—it is quite possible it may be attended with exceptions. We have certain classes of disturbances, again, which are preceded by a rise in the barometer: then follows a fall, and then the mercury jumps up all at once when the wind is at its wildest. Whether these belong to any peculiar class or sub-class, or are merely affected to this extent by incidental circumstances, remains to be determined. There are doubtless other discrepancies which will by and bye make their appearance, all following a law not yet eliminated.

To determine the various essentials of climate, the temperature and the wetness of the air, the heat of the sun, the aspect of the sky, the character of the clouds, and direction and force of the wind, are all essential, and formed of course part of the Society's scheme. At Bombay a self-registering tide-gauge was put up at Colaba, which recorded by clock-work the rise and fall of the tide at every hour and minute of the day. We have not only the ordinary rise and fall due to the influence of the sun and moon, but by connecting the means together we have a fine annual curve swelling up as the waters of

* The observations at Dodabetta, 8500 feet above the level of the sea, which have been printed since the above was written, in a great measure invalidate the statement in the text, and go far to show that betwixt 6° and 18° N., in fine weather at all events, the daily fluctuation forms a definite fraction of about 1-250th of the whole pressure.

† Report of the Meteorological Committee of the South African Literary and Philosophic Institution, January 1836. The objects of the Institution seem very closely allied to those of the Bombay Geographical Society.

the ocean are pressed to the northward by the south-east monsoon. The character of our tides once determined here, it became of much importance to ascertain at what rate they swept along our shores, and what was the altitude they attained at different points during the different seasons of the year. Strange irregularities were known to exist in the Gulphs of Cutch and Cambay, and might be expected to be met with at the mouths of the Persian Gulf and Red Sea, and the peculiarities of these formed special subject of interest and investigation.

The Society, reflecting on these things, resolved to apply to Government to provide instruments for the establishment of small local observatories for the purpose of tidal and meteorological observation at Vingorla, Porebunder or Mandavie, Kurrachee, and Aden,—a well-organized establishment already existing at Bombay. The application was at once complied with, but the working out and supervision of the scheme was for a time estranged from the Society, and up to the present moment the Aden observatory is the only one in full operation. In 1845, H. M. Lords of the Admiralty were applied to for assistance: it was now proposed to extend the number of observatories from four to twelve, and their Lordships at once granted £350 for the purchase of instruments—the other charges were to devolve on the local Government; the Society to work out and superintend the scheme, and publish the results in their transactions. In 1847 the supervision originally contemplated by the Society was restored to it—their operations were to commence with the 1st of January 1848, and Government now most liberally undertook the expense of publication, which it was feared might press too heavily on the funds of the Society. Besides this, the British Association had meanwhile (1847) applied to the Court of Directors for a continuation of the tidal researches which had many years before been conducted on the other side of India; and in 1848 it was reported that on this point full instructions had been given the local Government. The scheme was now, as *originally intended, in the hands of the Society, who at once set about its execution with becoming zeal. Besides the* establishment of regular observatories along the whole line of coast from Ceylon to Suez, the Society expected to derive the most valuable aid from amateur observers.

India is sprinkled over with military stations: wherever there is an hospital, registers are duly kept for the service of the Medical Board, and there is scarcely a station of any magnitude where officers are not to be found in abundance most anxious to pursue any branch of intellectual research that may be suggested, and ready to make their exertions available to science. The officers of the Indian Navy—navigating vessels and constantly moving about in all directions from Suez to the Persian Gulf, along the shores of Africa, Arabia, and both sides of the Peninsula of India South to the Line and East as far as China—have always held the most honorable place amongst the promoters of physical research; and the extent to which they had beforehand contributed to other departments of geography, led the most sanguine expectations to be formed of the aid they were likely to afford in this. The port of Bombay, besides, is frequented by vessels trading with nearly every quarter of the world, and for the most part commanded by men of great ability and zeal in all matters bearing on their profession; and as most ships are on all occasions provided with a certain supply of instruments, and in the habit of keeping a sort of meteorological register, all that seemed necessary to convert every vessel, the Commander of which seemed willing to give assistance, into an observatory, was to see the rating of its instruments attended to, and to have the registers kept in such a form as seemed most desirable. Free access to the logs of all our vessels was expected as a matter of course, as in these a vast amount of important information is generally to be found,—which, when the various extracts are compared together, is often of the utmost value and interest. It was by this species of investigation, since so admirably turned to account by Mr. Piddington and others, that Colonel Reid originally discovered the great law of Whirling Storms or Cyclones; and if the movements of the most steady of our breezes, such as our Trade winds, our monsoon and our land and sea breezes, as well as the most furious of our tempests, can be shown to obey the most rigid laws of motion, and to operate with the utmost harmony, order, and beauty, a strong presumption arises that the progress of all our ærial currents everywhere may be laid down with similar exactitude and system. Lieutenant Maury, of the U. S. Navy, has constructed, and is constructing, wind charts for the Atlantic, by attention to which vessels may reach their destination with comparative certitude and celerity. The late Captain Young, of the Indian Navy, was engaged in the same promising task when he was lost at sea: and if we have succeeded in mapping out the currents of the ocean, in laying down the dip and direction of the needle, and the intensity of magnetic force all over the globe, the investigation of the laws of the winds, so deeply affecting the interests of commerce, and in reference to which every ship that sails can supply her contingent of information, would seem a comparatively easy, at it must prove a most important, work.

The tides and local currents in our gulphs and larger estuaries—the temperature and depth of these and of the great ocean itself, and the relative temperatures at different depths, form subjects of the deepest interest. It appeared, indeed, that in a climate such as India, where the heat for the greater part of the day renders exercise or amusement out of doors impossible—where those not engaged in office daily have a large portion of leisure at their disposal—where the whole European community belong to the well educated or upper classes of society—every ship and steamer, every collector's office and military hospital, every garrison and cantonment, might, with suitable instruments and instructions, a point of reference, and the means of publication such as the Society proposed to provide, be made to supply its regular contingent of information in physical geography, and to take a formal and valuable share in the general labour: so far as matters have yet proceeded, these anticipations appear to have been by no means too elevated or sanguine.

Each fixed observatory was intended to be provided with a self-registering wind and rain-gauge—this being fitted up as a tide-gauge for those near the sea,—with a good barometer and two pairs of thermometers: and these amongst them for ordinary purposes were expected to suffice. Once a month (on the 22nd,) or oftener if convenient, all the instruments, especially the barometer, were to be read every hour for twenty-four hours on end, commencing at 3 A. M.; throughout the rest of the month, readings at ¼ to 10 A. M., 4 P. M., and 10 P. M., being the points of greatest and least pressure, were all that was desired. It was too much to expect amateurs to rise at 3 A. M., to read the instruments for the morning minimum, however desirable observations on the subject might be considered; and the twenty-four hour readings would determine the matter with as great an approximation to accuracy as could be looked for. The more observations that could be supplied at regular and stated intervals, the better; and when any unusual appearances were observed, or atmospheric perturbations apprehended, the instruments were expected to be read hourly at least for as long a period as this could be overtaken—if possible, indeed, till a state of repose returned.

The observers, besides having journals of scale-readings, are provided with tables and schedules for making their own reductions, as well as for diagramizing the results of their observations. The performance of these tasks by the observers themselves involves them in but a small amount of labour at the time, and is troublesome only when allowed to accumulate: it places before them at once the laws desired to be discovered, and so interests the understanding in the work of the hands, while it indicates errors and points to corrections which might otherwise have remained unnoticed, and which can only be dealt with satisfactorily at the time the observation is made and by the party who makes it.

One of the most beautiful discoveries in physical geography we have lately seen noticed, is that mentioned by Mrs Somerville in reference to the temperature of the Sea. There is, it would appear, from the Pole to the Equator, a level at and beneath which the waters of the ocean always maintain an uniform temperature, scarcely rising above or falling below 39·5° of Fahrenheit's scale. The depth of this varies according to the latitude: at the equator it is 7200 feet; at 56° it rises to the surface, the temperature of the sea being from top to bottom uniform: from this towards the pole the sea is warmest at bottom,—the ice-cold-water and ice-bergs floating above. This striking fact, which was indicated by Kolzebue, was established by Sir John Ross; and now that it has been ascertained by observation, it seems strange that it should not have long since been pointed at from theory. It is dependent on the fact that water in process of cooling acquires its maximum density betwixt 39 and 40°; down to this it contracts with considerable regularity—beyond this it expands until it reaches the freezing point, when it assumes the form of ice, and all at once greatly encreases in bulk, so that solid masses congealed always float upon the surface. The ends subserved by this law are as numerous as beautiful. Were water to contract regularly down to 32°, the polar ocean would throughout its whole mass be always at the freezing point, and would by the slightest accession of cold be soldified throughout. Ice conducts heat so slowly and feebly that the ocean once consolidated could never again be thawed; and the polar seas, now abounding in living things in proportion as the lands around are devoid of them, would be like so much impenetrable rock. As it is, the lower portions of icebergs and floes of ice are subjected to constant wearing away, from the warmer fluid beneath, till, liberated from the regions in which they were produced, and in which, but for this, they must have remained anchored immoveably for ever, they are dispersed by regularly established currents into the warmer latitudes to temper and mitigate the heat which dissolves them.

This of course can only apply to the great ocean itself, the waters of which communicate freely with either pole, but the same principle operates everywhere, and it would be curious and most interesting to know what law obtains in the Bay of Bengal, or Great Arabian Sea, both opening towards the Equator, but cut off at about Lat. 25° from communication with the colder regions. How this again is modified in the Red Sea, Persian Gulf, the Gulf of Cutch, &c. The influx of waters through the Straits of Gibraltar to supply the excessive evaporation over the southern shores of the Mediterranean, and the efflux from the Baltic by the Great and Little Belt from an excessive supply of river water, have furnished subjects of the most interesting speculation. How do matters stand in the Red Sea, the Gulfs of Acaba and Suez, surrounded by four thousand miles of arid shore from which not one single drop of water is ever discharged? Were the engineer to take a bucketfull of water from the ship's side every three hours when he has the thermometer and hydrometer in use at any rate for determining the gravity of the water in his boilers, he might, by the like means and the use of the same instruments, ascertain the temperature and saltness of the surface of the sea. Such occupations as these, so far from interfering with his duties on shipboard, would occupy the mind and keep it in a state of activity, while it lightened the tedium and alleviated the ennui of a tiresome and protracted cruize. How stand matters in the Persian Gulf, where the Tigris and Euphrates may in part at least be expected to compensate the loss? These seas are chiefly traversed by our ships and steamers, and the officers and engineers of the latter in particular are already provided with all the instruments required for such investigations, and familiar with their use. The evaporation must be enormous over a surface of water varying from 75° to 85°, where a fresh breeze blows, and the air is so arid that there is frequently a difference of 25° betwixt the wet and dry thermometers.

In the prosecution of this scheme it became of course of the utmost importance to secure as large a number of labourers in the cause as could be obtained, and to make the labours of each of these as efficient as possible.

As each successive observer was engaged, it became necessary to make out for him a set of instructions; and as in every case the great bulk of these were common to them all, it appeared expedient to provide some convenient vehicle for their dissemination. The Society having been applied to, directed a Manual of Observation to be drawn up for general use, taking upon themselves the charge of publication, in hopes that the sales would reimburse them for the expenses incurred: the result was the compilation of the present work.

PREFACE.

THE present Manual was resolved upon by the Bombay Geographical Society, for the guidance of those willing to observe, but who had enjoyed but few opportunities of familiarising themselves with the construction or use of even the simplest instruments, in employing these to the best advantage, after familiarity with the use of them had been acquired,—or in recording or arranging their observations, so as to confer the largest amount of benefit on Science.

It was at first meant to be little more than a compilation from existing Manuals, the selections being so made, arranged and modified, and so interlarded with small portions of original matter, as to meet the wants of all for whom the instructions were intended. The Manual of Observation published under the authority of H. M.'s Lords of the Admiralty, advertised after all our plans had been laid, was afterwards expected to have furnished almost without alteration all that was required; and the publication of the Society, not unlikely to be found superfluous, was accordingly delayed till this should appear.

On its appearance, it became at once apparent, that, from the nature of the facts desired to be enquired into, but much more from the character of the observers available amongst us, something altogether different from any existing publication required to be prepared, however largely publications already in existence might be drawn upon.

In India, the great bulk of those able and willing to undertake the task of observation have left home without acquiring any knowledge whatever of Natural Philosophy, Chemistry, or Natural History; these sciences forming no part whatever of the course of study at Haileybury,—the bare rudiments of them only, if even this much, being thought of at Addiscombe. In India there are but few means available of arresting or extending the little that has been acquired, and this generally is the first part of the knowledge learnt at home which is forgotten in India, where few if any of our home acquirements are permanently retained.

The disadvantages the Officers of the Indian Navy, who have done such service to Geography, suffer under, are much greater than those by which the path of Civilians or Military men is beset. Our Naval Officers join just as they leave school: the principal part of their time immediately after joining is devoted to gunnery instruction and practical seamanship: the system of instruction of the naval instructor is confined to Mathematics and Astromony, and their application to Navigation.

But these are by far the most highly educated and accomplished of our observers: much of solid and invaluable work has been performed, and is yearly in course of performance, by Privates and Non-Commissioned Officers—men of large intellects but small acquirements, who devote their energies to tasks altogether new to them; and who, though they can sometimes neither write three sentences grammatically, nor set down a dozen of words correctly spelt, quickly learn the use of instruments, and observe, notice, and record, facts, and perform good service as pioneers in Science —service doubly valuable, as at once extending the boundaries of knowledge, and improving the tastes and habits, and adding to the virtuous enjoyments, of a large class of men often supposed to have too few gratifications that are elevating or virtuous.

Our Engineer and Medical Officers are the only men who have received anything deserving the name of a scientific education: though there is also a large body of men amongst us who, by educating themselves, have reached a high and distinguished measure of scientific attainment. These form, however, so small a minority of those from whom service is expected, and themselves require so little instruction, that no account of them has been taken in the following Hints: in most cases they stand in no need of the assistance of any Manual whatever—where they do stand in need of it, those prepared for a more intellectual and more highly instructed class than that for which these Hints are designed, will suffice. The Admiralty's Manual refers to all manner of subjects likely in any way to come under the cognizance of British Naval Officers in any part of the world; and is meant to meet all the exigencies of the voyager, of whatever kind.

To have gone over a field so wide as this, would have implied a reprint of the work referred to, from which a few extracts will in reality suffice, in addition to the matter altogether new and of a character infinitely more simple and elementary than that there to be found, or that extracted from other sources.

Magnetism, Earthquake Phenomena, Astronomy, Botany, Geography, Mineralogy, Statistics, Ethnology, and Zoology, have been almost altogether omitted, and attention confined to Meteorology, Hydrography—in so far as the temperature, depth, and currents, of the Ocean were concerned,—and Geology.

The views taken of these matters are, besides, in a great measure restricted to India,—the Local Society aspiring only to the enlightenment of those of whose services it expected to be able to avail itself.

These remarks have been deemed necessary to clear the projectors of the charge of presumption in attempting to add to the number of Manuals on Physical Research already in existence, as if something more perfect than these, for the general purposes of instruction, was expected to be accomplished; as also to account for the publication of instructions in the use of the simplest instruments, in the reading of scales and use of the Vernier, such as would be considered superfluous and out of place for a young man who had perfected himself in the curriculum of a common Commercial Academy, or become familiar with the subjects usually treated of at a Mechanics' Institution. In Europe, the labourers in the field of Science are men trained and accomplished for the performance of their tasks : if the field be large and fertile, there are on all sides abundance of implements and cultivators. In India, we have to deal with an almost unlimited expanse of unbroken and untrodden ground: our labourers are active and willing, but are scattered, few, and uninstructed : they have no means of communicating with each other, of learning what is mainly desired of them, or of becoming trained for the task proposed to be executed ; and, in want of implements, must resort to whatever contrivances or makeshifts may chance to be available. We must learn "to saw with a gimlet, and bore with a saw"—to make a couple of bottles serve for a sand-glass, a foot rule and a string for a Goniometer or a Clinometer, a Tobacco Pipe for a Retort when whole, or a Crucible when broken, and a Cocoanut-shell to perform the task of Rain-Gauge and Evaporating Dish in turns. Instruments of some sort are always procurable, even in India ;* really good instruments are seldom so, unless in Government stores : our object is to make the most of what can be got ; to sacrifice anything rather than time ; to employ all the resources, however rude, at our command ;—in hopes that we may discover some truth—disclose a glimmering, at least, of light ; and even if we do little or nothing to illuminate directly to any useful purpose,

* Of late years, Bombay has been very liberally supplied with Thermometers, and the simpler varieties of instruments, by the enterprising and highly respectable Firm of TREACHER and Co., Druggists and Chemists ; and Calcutta seems always to be in this way sufficiently well off.

that by the perseverance and promise of our efforts, and the perversity of their results, we may provoke or entice others into the path we are endeavouring to tread.

We never dream by these means of attaining accuracy, but we view knowledge, rude and vague as it is, better than absolute ignorance, and we have no third alternative for selection.

When it is remembered how many there are of those from whom assistance is expected, who have never seen a more complex instrument than a Thermometer—how few there are of those who have known this, in its simplest form, who have seen one which registers itself, or who knows how to put it to rights when out of order,—no amount of instruction will be deemed too minute for their advantage.

The writer of these instructions is not an instructor of philosophers, or of instrument-makers; and has no means of resorting to such for counsel: he must make the best use he can of his own experience, and do his uttermost to interest others still more ignorant than himself, not for a moment doubting that he may have fallen into many errors, and given many prescriptions which may be open to censure, and very inferior in value to those of a professional man. He at the same time feels satisfied, that in a large majority of cases he will be found to have saved those who seek his counsel much trouble and perplexity, though not in all likehood so much as they might have been saved by more experienced and skilful advisers.

Here again it is not the best, but the best under the circumstances, that must be looked for.

INSTRUMENTS.

Before proceeding to examine the processes and kinds of observation to be pursued, a short account of the construction and uses of the Instruments generally made use of may be given. As the contrivance called the Nonius or Vernier is common to all in which double readings are required, an account of this is below extracted from *Simms* :—

THE VERNIER.

This is a contrivance for measuring parts of the space between the equidistant divisions of a graduated scale. It is a scale whose length is equal to a certain number of parts of that to be subdivided, depending on the degree of minuteness to which the subdivision is intended to be carried; but it is divided into parts, which in number are one more or one less than those of the primary scale taken for the length of the vernier: in modern practice, the parts on the vernier are generally one more than are contained in the same space on the primary scale.

If it is required to measure to hundredths of an inch, the parts of a scale which is graduated to 10ths, it may be done by means of a scale whose length is nine tenths of an inch and divided into 10 equal parts; or by one whose length is eleven tenths of an inch, and divided into 10 equal parts; for in either case the difference between the divisions of the scale so made and those on the primary scale is the hundredth of an inch. Such a scale made to move along the edge of that to be subdivided, is called a vernier; and we shall explain how by its application, either to straight lines or arcs of circles, the subdivisions of graduated instruments are read off. For this purpose, let us take as a general example the method of reading the sextant, as a person acquainted with the graduations upon this instrument will find no difficulty in becoming familiar with those on any other.

It will be observed,* that some of the divisional lines on the limb of the instrument are longer than others, and that they are numbered at every fifth, thus, 0, 5, 10, 15, &c., the 0 being the starting point, or zero. The spaces between these lines represent degrees; and they are again subdivided by shorter lines, each smaller space representing a certain number of minutes. For instance, if the spaces are subdivided into four parts, then there will be three short lines, each of which will indicate the termination of a space of 15 minutes; if there are six parts, there will be five short lines, and each will be at the end of a space of 10 minutes, reckoned from the commencement of the divisions. Likewise it will be observed, that some of the divisions on the vernier are longer than others: these indicate in the same manner single minutes, and they are numbered from right to left: the extreme right one is the zero, or commencement of the index divisions, and it is marked 0 or ⊙; the shorter divisions show fractions of minutes. If the spaces between each minute (or long division) contain three lines, each space will be 15 seconds, and if five, 10 seconds; the number of subdivisions between the minutes of the vernier is usually, but not necessarily, the same as between the degrees on the limb, so that if the limb is divided into 20′, the vernier is divided into 20″; if the former is divided to 10′, the latter is divided to 10″, &c.

The limb of the instrument now before us is divided to 10′, and the vernier reads to 10″, and by shewing the manner of reading it off, we shall explain sufficiently the method of reading verniers in general. If the zero division of the vernier coincide (or form a straight line) with any line on the limb, then that line indicates the required angle; thus, if it coincide with the line marked 60, then sixty degrees is the angle; if with the next long division, then 61 degrees will be the angle; but if it coincide with one of the shorter lines between 60 and 61, then the angle will be 60 degrees and a certain number of minutes, according to which of the short lines it coincides with. If it be the first, (of the instrument before us) the angle will be 60° 10′, but if it coincide with the second, it will be 60° 20′, if with the third, 60° 30′, &c. But

* The reader is supposed to have an instrument before him while perusing these instructions.

when it happens that the zero division of the index does not coincide with any division upon the limb, but stands between two of them, we must observe how many degrees and minutes are denoted by the division it has last passed, and look for a line on the vernier that does coincide with one on the limb; and the number of minutes and seconds from that line to the zero of the index, added to the number read off upon the limb, gives the angle required. Thus, supposing the index to stand between 10′ and 20′ beyond 60°, and the line on the vernier denoting 6′ 10″ (which is the line next beyond the one marked 6) coincides with any one on the limb, then this quantity, added to 60° 10′, gives 60° 16′ 10″, the angle required.

When the arc of excess on the limb of the sextant (the nature of which will be explained hereafter) is required to be read off, observe what quantity is passed to the right of zero by the zero division of the vernier, and find the remaining minutes and seconds to be added to it, by reading the vernier backwards; that is, consider the last numbered division to the left hand as the zero: thus, suppose that (on our instrument) the index stood beyond the third short division on the arc of excess, this would be 30′, and if the third long division from the last numbered one on the left hand (marked 10) coincided with a line on the limb, this would denote 3′ to be added to the former, making 33′ for the reading on the arc of excess.

On the limbs of small theodolites, the spaces between the degrees are generally divided into two parts, consequently the short division represents 30′, and the divisions on the vernier are single minutes; a smaller subdivision must be estimated by the eye, which by a person accustomed to the instrument can be done to 15″.

The subdivision of a straight line, as the scale of a mountain barometer, is likewise effected by a vernier, and is read off in the following manner. The scale is divided into inches, which are subdivided into 10 parts; these tenths are again divided into two, by a shorter division, which will be 5 hundredths of an inch. The long divisions upon the vernier shew each of them one hundreth of an inch, and they are numbered at every fifth; these are again subdivided by shorter lines, representing thousandths. Now, to read it off, observe where the zero division of the vernier stands on the scale; suppose a little above 30 inches and 4 tenths, and as it does not reach the short line denoting 5 hundredths, observe what line on the vernier coincides with one on the scale: if it is a long division, then it is so many hundredths to be added, and if a short division, it will be so many hundredths and thousandths to be added to make up the measurement, and the readings are written decimally thus, 30·435 inches.

In the subjoined figures, which are given for the purpose of illustration, A B represents a portion of the graduated limb of an instrument, and C D a portion of the vernier scale, the zero point being at C.

Fig. 1.

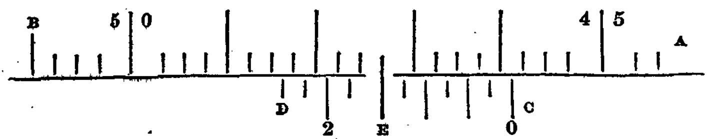


Fig. 2.

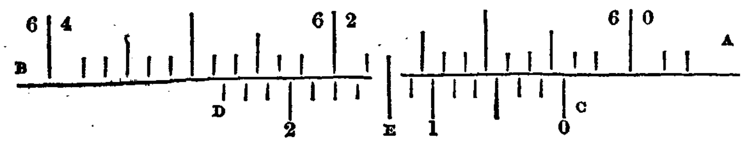


Fig. 3.

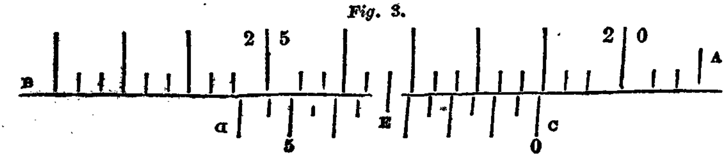


Fig. 4.

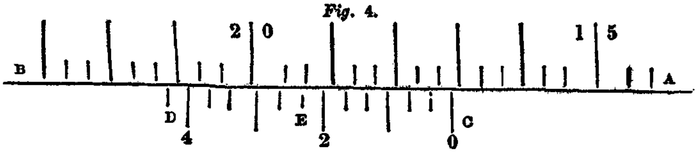
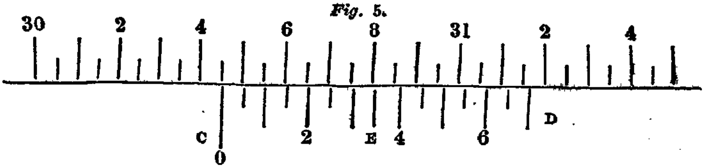


Fig. 5.



In the first figure, the limb is divided to 15′, and these divisions are subdivided by the vernier to 15″. In the second figure, the limb is divided to 10′, and subdivided by the vernier to 10″. In the third, the limb is divided to 20′, and subdivided by the vernier to 30″; and in the fourth, the limb is divided to 20′, and subdivided by the vernier to 20″. E, on each figure, is placed where a division on the vernier coincides with one on the limb. In the first, the reading is 45° 46′ 30″: in the second, 60° 21′ 20″; in the third, 21° 23′ 30″; and in the fourth, it is 17° 2′, and between 0′ and 20″, and as the 2′ line is about as much in advance of the one on the limb near to it, as the 20″ line is behind the one near to it, the reading may be taken as 17° 2′ 10″. The fifth figure represents the scale of a barometer, reading 30·435 inches, and is drawn much larger than the reality, to render it more intelligible.

The application of the Vernier is common to all instruments; and the determination of specific gravities is so important to so large a number of investigations, that the process may be here described:—

The specific gravities of bodies are as their weights, bulk for bulk; thus a body is said to have two or three times the specific gravity of another, when it contains two or three times as much matter in the same space.

A body immersed in a fluid will sink to the bottom, if it be heavier than its bulk of the fluid. If it be suspended therein, it will lose as much of what is weighed in air, as its bulk of the fluid weighs. Hence, all bodies of equal bulks, which would sink in fluids, lose equal weights when suspended therein. And unequal bodies lose in proportion to their bulks. *

The *hydrostatic balance.*

The *hydrostatic balance* differs very little from a common balance that is nicely made; only it has a hook at the bottom of each scale, on which small weights may be hung by horse-hairs, or by silk threads. So that a body, suspended by the hair or thread, may be immersed in water without wetting the scale from which it hangs.

How to find the specific gravity of any body.

If the body thus suspended under the scale, at one end of the balance, be first counterpoised in air by weights in the opposite scale, and then immersed into water, the equilibrium will be immediately destroyed. Then, if as much weight be put into the scale from which the body hangs, as will restore the equilibrium (without altering the weights in the opposite scale), that weight, which restores the equilibrium, will be equal to the weight of a quantity of water as big as the immersed body. And if the weight of the body in the air be divided by what it loses in water, the quotient will shew how much that body is heavier than its bulk of water. Thus, if a guinea, suspended in air, be counterbalanced by 129 grains in the opposite scale of the balance, and then, upon its being immersed in water, it becomes so much lighter as to require 7¼ grains put into the scale over it, to restore the equilibrium, it shews that a quantity of water, of equal bulk with the guinea, weighs 7¼ grains, or 7.25; by which divide 129 (the weight of the guinea in air), and the quotient will be 17.793; which shews that the guinea is 17.793 times as heavy as its bulk of water. † And thus, any piece of

* The losses of weight sustained by bodies suspended in different fluids, is in the compound ratio of their bulks, and the density of the fluids;—and when any body is suspended in a fluid, so as not to touch the bottom of the vessel, the fluid gains as much weight as is lost by the suspended body.—*Ed.*

† Since a quantity of water equal in bulk to a guinea weighs 7¼ grains, while a guinea weighs 129 grains, the specific gravities of these bodies must be in the ratio of 7¼ to 129. But 7¼ : 129 = 1 : 17·793, the answer, or fourth term of this analogy, is therefore found by dividing the product of the second and third terms by the first; or by dividing 129 by 7¼.—*Ed.*

gold may be tried by weighing it first in air, and then in water; and if, upon dividing the weight in air by the loss in water, the quotient comes out to be 17.793, the gold is good; if the quotient be 18, or between 18 and 19, the gold is very fine; but if it be less than 17, the gold is too much alloyed, by being mixed with some lighter metal.—*Ferguson's Mechanics*, Vol. I., p. 115.

The following table gives the specific gravities of a number of bodies most familiar :—

A Table of the Specific Gravities of several solid and fluid Bodies.

A cubic inch of	Troy weight. Oz.	Pwt.	Gr.	Avoirdupois. Oz.	Drams.	Comparative weight.
Very fine gold	10	7	3.83	11	5.80	19.637
Standard gold	9	19	6.44	10	14.90	18.888
Guinea gold	9	7	17.48	10	4.76	17.793
Moidore gold	9	0	19.84	9	14.71	17.140
Quicksilver	7	7	11.61	8	1.45	14.019
Lead	5	19	17.55	6	9.08	11.325
Fine silver	5	16	23.23	6	6.66	11.087
Standard silver	5	11	3.36	6	1.54	10.535
Copper	4	13	7.04	5	1.89	8.843
Plate Brass	4	4	9.60	4	10.09	8.000
Steel	4	2	20.12	4	8.70	7.852
Iron	4	0	15.20	4	6.77	7.645
Block tin	3	17	5.68	4	3.79	7.321
Spelter	3	14	12.86	4	1.42	7.065
Lead ore	3	11	17.76	3	14.96	6.800
Glass of antimony ...	3	15	16.89	3	0 89	5.280
German antimony ...	2	2	4.80	2	5.04	4.000
Copper ore	2	1	11.83	2	4.43	3.775
Diamond	1	15	20.88	1	15.48	3.400
Clear glass	1	13	5.58	1	13.16	3.150
Lapis lazuli	1	12	5.27	1	12.27	3.054
Welsh asbestos	1	10	17.57	1	10.97	2.913
White marble	1	8	13.41	1	9.06	2.707
Black ditto	1	8	12.65	1	9.02	2.704
Rock crystal	1	8	1.00	1	8.61	2 658
Green glass	1	7	15.38	1	8.26	2.620
Cornelian stone	1	7	1.21	1	7.73	2 568
Flint	1	6	19.63	1	7.53	2.542
Hard paving stone ...	1	5	22 87	1	6.77	2.460
Live sulphur	1	1	2.40	1	2.52	2.000
Nitre	1	0	1.08	1	1.59	1.900
Alabaster	0	19	18.74	1	1.35	1.875
Dry ivory	0	19	6.09	1	0.89	1.825
Brimstone	0	18	23.76	1	0 66	1.800
Alum	0	17	21.92	0	15.72	1.714
Ebony	0	11	18.82	0	10.3	1.117
Human blood	0	11	2.89	0	9.74	1.054
Amber	0	10	20.79	0	9.54	1.030
Cow's milk	0	10	20.79	0	9.54	1.030
Sea water	0	10	20.79	0	9 54	1.030
Pump water	0	10	13.30	0	9.26	1.000
Spring water	0	10	12.94	0	9.25	0.999
Distilled water	0	10	11.42	0	9 20	0.993
Red wine	0	10	11.42	0	9.20	0.993
Oil of amber	0	10	7.63	0	9.06	0.978
Proof spirits	0	9	19.73	0	8.62	0.931
Dry oak	0	9	18.00	0	8.56	0.925
Olive oil	0	9	15.17	0	8.45	0.913
Pure spirits	0	9	3.27	0	8 02	0.866
Spirit of turpentine ...	0	9	2.76	0	7.99	0.864
Oil of turpentine ...	0	8	8.53	0	7.33	0.772
Dry crabtree	0	8	1.69	0	7.08	0.765
Sassafras wood	0	5	2.04	0	4.46	0.482
Cork		2	12.77	0	2.21	0.240

Take away the decimal points from the numbers in the right hand column, or (which is the same) multiply them by 1,000, and they will shew how many avoirdupois ounces are contained in a cubic foot of each body.—*Ferguson's Mechanics*, Vol. I., p. 118.

Of course the first thing requisite for this is a tolerable balance and good set of weights. An apothecary's beam, or any one not too dull or heavy,—that is, which will turn easily with a fourth part of a grain,—will suffice. Where this cannot be obtained, the most ordinary balance may be adjusted to serve the purpose, in the following manner. First take and sharpen the fulcrum by a file or whetstone to nearly a knife edge,—then bend up one or both the arms till the fulcrum and points of suspension for the scales are within a little of being in the same line. If they have been bent too little, the balance when turned will adjust itself too quickly : if too much, it will give a tottering equilibrium. It is so troublesome to make both arms exactly of the same length, that it is much better to mark the one, and use it always for the weights, employing the other always for the substances to be weighed. The amount of error occasioned by the inequality of the length of the two arms may be ascertained by placing weights of equal magnitude in each —say pins, as about to be described. If 100 pins in the one scale weigh 90 in the other, then the one arm is one-tenth longer than the other : if 100 counterpoise 95, then it is one-twentieth : and so on. If a memorandum of this be kept, it will enable a correction to be added when true weights of any given denomination are desired to be arrived at.

The following description of a highly delicate and scientifically constructed balance, which any neat-handed person of mechanical skill by the use of a few simple tools may construct for himself, is taken from the *Transactions of the Madras Literary Society* :—

A description of a set of Balances made for the purpose of delicate weighing ; illustrated by drawings. By Lieut. J. Braddock.

EDITOR OF THE MADRAS JOURNAL OF LITERATURE & SCIENCE.

SIR.—I have the pleasure to send you a description and drawings of a set of balances which I made a few years ago for the purpose of delicate weighing. My object in constructing them being efficiency with simplicity of parts, they are not so elaborately finished as delicate balances usually are, but they are fully adequate to all the purposes of the private experimentalist, who is not supposed to have his finer balances in continual daily use.

2. The mechanical principles of the balance are too well understood to require a detail of them. I shall therefore simply mention that the knife edge of the fulcrum and the points suspending the scale pans must lie in a right line ; and that the centre of gravity of the beam must not be above this line or the beam will overset : nor must it be too much below the line, or the vibrations of the beam will be too rapid, and the delicacy of the balance will be diminished and impaired.

3. I have four balances for weighing all quantities from one grain to ten thousand. They have one support and one glass case in common to them all: the beams not required are kept in a box fitting in at the back of the glass case, so that they are always at hand. Fig 12 is a perspective sketch of the case with one of the balances mounted. The figure speaks for itself.—It has a glass slide to close the front, and the usual contrivances of an assay balance for relieving the beam and scale pans, and for adjusting the level.

4. The most delicate balance that I have is used for weights not exceeding 10 or 20 grains. It is made simply of a piece of well seasoned, clean, straight-grained fir; and figure 1 is a representation of it. The knife edge works on a plane of agate; it is made of steel, and was tempered as a workman would say " dead hard," being afterwards very carefully sharpened on a hone, and examined by a microscope. The edge is a perfectly straight line, smooth, well defined, not wiry, not a sharp cutting edge but rather slightly round, so that it may be firm enough to withstand the wear and tear that may be required of it, and yet be nothing more than a line, presenting no resistance, but acted on when in the beam by the slightest weight. Figure 2 represents the fulcrum and the centre part of the beam of the real size: the brass a is screwed down by the screws b b having a plate of brass c under them to prevent the heads penetrating the wood. The beam d is notched out for the fulcrum e to lay in, and the brass a very securely fixes it in its position, care being taken that the notch is made at a right angle, and that it is not too deep. The fulcrum should project a little above the beam, so that the securing brass a may press firmly upon it. The points a. a, fig. 1, were put in at as nearly equal distances from the centre as could be measured by a pair of compasses; for I did not intend the beam to be a balance of perfect equipoise, knowing the extreme difficulty of adjustment to quantities so minute as 1-2000th or 1-3000th part of a grain.

5. Fig. 3 shews one end of this balance of the real size. The point a is a piece of hardened steel wire with a screw on it, screwing up tight through the wood of the beam b, and being further secured by the tightening nut c. The point is extremely fine and sharp, but carefully made, and proved or tested by pressing it upon a piece of wood to ascertain that it neither bent, nor broke; being afterwards examined by the miscroscope.—The wire d is the pointer, the point of it being a continuation of the right line of the fulcrum and the points of suspension for the scale pans. The end of this wire entering the beam, was hammered flat; a slit was cut down the end of the beam, and the wire thrust in and tied securely with a piece of waxed silk thread as at g.

6. The scale pans of this balance are supported in the simplest manner I could devise. The crank piece e, fig. 3, is a piece of common brass wire flattened on the top, hammer hardened, and polished underneath where it rests on the beam point a. This crank piece has a hook or hole at the bottom, i. e. at f, and another piece of brass wire, fig. 4, hooks on it, the lower end of this wire, fig. 4, being bent at right angles into a triangular shape for the purpose of supporting the scale pans, which are small thin dishes one inch in diameter.—The ball over the fulcrum f, Fig. 2, is common to all the balances, i. e. each balance has one; it is for the purpose of raising or lowering the centre of gravity, and the wire g is for the porpose of adjusting the equilibrium of the balance before it is used.

7. The sensibility of this balance is very great,—in fact so much so, that it is extremely difficult and tiresome to weigh with it. When 20 grains are in each scale, the 1-1000dth part of a grain occasions the pointer to move over 3 divisions of the index, which is graduated in 10ths of an inch; supposing with 20 grains in each scale the index points at nonius, or nothing, the addition of 1-1000dth of a grain causes the pointer to move over a space of 3-10ths of an inch, so that the balance indicates decisively to 1-6000th part of a grain, which causes the pointer to move over ½ a division or 1-20th of an inch, a quantity quite large enough to produce an indication that may be depended on. In fact, half that quantity or 1-12000dth part of a grain may be estimated, but all who know the difficulties of such minute weighing are aware that such statements appear much finer and more scientific on paper than they are to be depended on in practice.

8. A balance like this must be used with the utmost possible care, not as I once saw a gentleman use an assay balance, giving it a good hearty shake " because its indications were sluggish." The least accident deranges so delicate an instrument—the slightest breath of air, a particle of dust, or unskilful management. The difficulty in delicate weighing is to make a balance always agree with itself, which it will not do unless it is in perfect order, and unless it is under the sole care of one who is completely master of its peculiarities. Few practical men who have a good balance, like another to use it.

9. I must add, that the way to use this balance is this: suppose you wish to ascertain the accuracy of a given weight. Place a known accurate weight in the right hand scale, and equipoise it by counterweights in the other. When perfectly equipoised, take it out and put in the weight you wish to verify; then if on the second trial an equipoise is produced, the two weights are equal. Or if you wish to ascertain the exact weight of any small substance, place

it in one scale and balance it by counterpoise weights in the other: remove it and by real weights produce an equipoise, and the true weight results. This is in fact the only accurate method of weighing, for the best balances are seldom *perfectly* correct, particularly after they have been in use for some time.—It is very difficult to adjust delicate balances so as to be *perfect equipoises*, though the adjustment may be made so very near the truth as to be a matter of no consequence for any ordinary practical purpose.

10. My second balance weighs any quantity not exceeding 200 grains, and indicates to the 1-thousandth part of a grain. Figs. 5, and 6, represent the central portion, and the index end of this balance of the full size. The length of the beam is the same as in Fig. 1.—The general construction is the same in principle as the balance just described, but being designed for more frequent use the beam is made of steel, which by means of linseed oil put on it and burned off over a fire, was blackened and covered with a sort of varnish that prevents its rusting. The fulcrum is a piece of square steel wire, made dead hard by heating it cherry red, and plunging it into cold water. Then as in the former case working it to a proper edge on the hone. In Fig. 5, a is a piece of brass screwed down upon the beam b, securing the fulcrum c, which is further fastened by the bottom end of the upright wire d entering a hole made to receive it on the upper part of the fulcrum. This prevents side motion, the wire being screwed through the brass a —The ends of the beam, Fig. 6, are tipped with brass, and the point a slides in a small groove made to receive it, and is secured by the tightening nut b. The thick end of the pointer c is screwed through the end of the brass d, and abuts against the point a, affording the means of adjustment by thrusting the point a towards the centre of the beam :—e is the tightening nut to make the pointer c secure.—A plain piece of wire with a screw on it, is used also at the other end of the beam for the same purpose.—I shall presently state the method I used for adjusting the beam to make it an equipoise.

11. The scale pans of this balance are suspended by a loop, Fig. 7, where a is a small steel screw passing through the top of the loop, having a shallow cup or dish at the bottom to prevent its sliding off the point, which with the end of the beam is shewn inside the loop. This small concavity is finely polished, and is intended by being concave simply to secure the loop from *wandering*, or slipping off the point, but it does not at all interfere with the delicacy or sensibility of the balance, which it might do were it not carefully formed, and made as shallow as possible with reference to the use required. The wire bent into the figure of an 8 with the three lines attached to it, represent the manner in which the scale pans are secured, the lines being merely silk thread.—This balance is a very good instrument, and its indications are satisfactory and may be depended on with from 100 to 200 grains in each scale to the 1-hundred thousandth part of the weight.

12. To make this balance an equipoise, I proceeded thus. I adjusted the points in the beam as nearly as I possibly could to equidistances from the fulcrum, and then made the beam balance or point to nonius on the index.—The scale pans with the loops complete were then made perfectly equal in weight. They were then attached to the beam, and two perfectly equal weights of 100 grains each were put into the pans, one in each pan, and the balance tried. The end that was the heaviest was adjusted by thrusting the point by means of the beforementioned screws nearer to the centre of the beam. When it was correct, or very nearly correct, I took off the scale pans and reversed them by placing them on the opposite ends of the beam, and on trying them in this position I found they gave the same indication, which was a proof that the two scale pans and weights were equal, and one not heavier than the other. After a whole day's trial, however, I found I could not adjust to perfect accuracy, and so I left the balance out of equipoise about 2-thousandths of a grain in 100 grains. This error is equal to the 50,000th part of the weight, which is quite accurate enough for even delicate purposes, but the error being known, it is obvious that subtraction or addition is all that is required in order to arrive at a perfectly correct result should a greater degree of accuracy be required.

13. Fig. 8 represents my third balance, which is adapted to weighing quantities from 100 to 2000 grains. Though not so sensible in its indications as the last described balance, it is fully adequate to most experimental purposes falling within the weights just specified. Its sensibility at first was very great, but having been in considerable use, its delicacy of indication has become considerably diminished ; 2-hundredths, or the 50th part of a grain, however, still gives a decided result with 2000 grains in each scale, which is equal to the 1-hundred *thousandth* part of the weight. Sir M. Farraday in his chemical manipulation tells us that a balance is an exceedingly good one if it indicates to the 50 or 60 thousandth part of the weight.

14. It will be perceived by Fig. 8, that the central portion of this balance, which is represented of the real size, is exactly similar to the last. It requires therefore no description

—the former description in para. 10 will answer for both. The means of adjustment however, and the bearing points are different. The balance is equipoised before using it, not by a small moveable wire as g, figure 2, but by means of a small ball, a, screwing along the wire b, b, figures 9 and 10 :—and the bearing or suspending points at each end of the beam are double. Fig. 9, is a plan, and figure 10 is a front view, of the manner in which the points are fixed: these views are sketches of the left hand end of the beam, or the end opposite to the pointer end. In both figures c, and d, are pieces of brass, the piece d being firmly and securely fixed in the end of the beam, and the piece c sliding in a groove and having liberty to move a small space to and fro as shown in fig. 10. Small screws, e e, pass through the brass d, and thrust the brass c, which carries the points, towards the fulcrum ; the wire b, fig. 9, has a shoulder abutting against the end of the beam, and passing into the beam is screwed and tapped into the brass c, so that when the screws e e are loosened, this screw acts in the opposite direction or pulls back the points away from the fulcrum, the brass c having liberty as before stated to move to and fro in the groove ; it is evident therefore that this contrivance is competent to the adjustment of the balance, although the brass carrying the points at the other or pointer end is permanently fastened in the beam. I have only to add that f, in figs. 9 and 10, is a tightening screw, to fix more securely the brass c, after the adjustment has been effected. The adjustment was made as before, only with 1000 instead of 100 grains in each scale.

15. The scale pans are supported in the manner exhibited by figure 11 : the points enter small polished concavities in the screws a a, as described in figure 7, para. 11. (which see.)—I have adopted double points, because the weights for which this balance is used are heavier, and because they are more convenient in practice, there being no wandering, or twisting of the scale pans. My fourth balance is precisely similar to the 3rd, only stronger, and calculated to weigh from 1,000 to 10,000 grains. J. B.

This will afford a balance of very great delicacy, but it requires considerable mechanical skill for its construction. Where nothing better can be had, a perfectly straight and even piece of deal will serve. In place of a knife-edged fulcrum, three sewing needles will suffice—one at the middle as an axle, and one at each extremity for the suspension of the pans : the fulcrum or centre needle ought to be supported by bits of window-glass set on edge—I have made up very neat and serviceable balances from slips of bamboo such as are used in chicks. Balances of this sort may be made to turn with a grain, and are within the reach of every one possessed of any manual dexterity at all.

The mode of taking the specific gravities of bodies heavier than water, is that most important to be known. It is one of the most beautiful and simple indexes of the characters of minerals ; and when the observer once becomes familiar with a few of these, it is singular with what ease the hand may be trained to determine specific gravities to within a fraction of accuracy, without the use of instruments at all.

The specific gravities of bodies lighter than water may be determined by loading them till they sink ; of fluids by weighing them in a measure of known capacity, and which holds a given weight of water—or by the Hydrometer, an instrument which comes afterwards to be noticed.

The ordinary balance, which will turn with half a grain, will in general serve the purpose of taking specific gravities with sufficient precision. Rain, snow, or pure distilled water, must be used for immersion: the following is the process. Hang the body to be operated on by a horse hair, or film of silk, from a hook in the bottom of one of the scales—a noose will in general be found the easiest mode of suspension. Counterpoise it by weights in the opposite scale, and note the number of grains it weighs: then place under it a wineglass, tumbler, or teacup of pure water, and remove as many weights as will permit it to sink entirely under the surface of the water,—or what is the same thing, throw weights into the scale from which the body is suspended. Then subtract the weight of the body in water from its weight in air, and divide the original weight by the difference—the quotient will be the specific gravity.

The following is an example:—

A small piece of stone weighs in Air............	160	grains.
Weighs in Water....................................	110	„
Difference......	50	

Divide 160 by 50 = 3·2, the specific gravity required.

The specific gravities of fluids are found by an instrument called the Hydrometer, which sinks to a certain mark in pure water: in fluids lighter than water it sinks deeper—in those heavier, not so deep, the gravity being marked on the stem A flask, bottle, phial, or other transparent measure, marked to contain say 10000 grains of water, will give the specific gravity of any other fluid. Fill it, say with oil, up to the mark of this weight 9000,—then the specific gravity is 0·9; or say with brine, which weighs 12500, in which case the specific gravity is 1·25, no computation being in this case required.

The weights usually supplied, even for medical purposes, are so incorrect and untrustworthy, that unless a really good set be purchasable it is better for the observer to make them up for himself. No attempt should be made to make them fractions or aliquots of an existing standard—it is quite enough that they be aliquots of each other. I have found very carefully selected shot to serve tolerably, but each shot must be weighed against another—then tens against tens, before they are to be trusted. The fineness of the balance should regulate the size of the smallest weight, which should be small enough just to turn the balance sensibly—there is no use for making it less. Fine wire makes the best weights. It may be rolled around another wire, or a piece of uniform stick the thickness of a crow-quill, and then, when fastened at both ends, a sharp knife run along it, and a cut made so that the rings may be broken,—or a piece may be stretched along a foot rule and cut to tenths or twentieths of inches : they should always be made decimals of each other. Pins answer very well, as being of nearly uniform weight—those of any given denomination not differing more than one-twentieth of a grain from each other.* So soon as all this is arranged, the observer should see how many of his weights are equal to some recognized standard—a grain, drachm, or ounce,—and then construct for himself a little table of relations or equivalents, to enable him to explain himself, or to understand other parties. We have always a rupee at hand, and this when new, or nearly so, weighs one tola, or 180 grains.

As our observers, however, may not always have a table of weights and measures at their command, or carry them at their finger's ends, the following may be useful for them :—

IMPERIAL STANDARD MEASURES.

In the Imperial system, introduced January 1, 1826, the legal measures of extension and weight are continued as before ; but a variety of corn, wine, and beer measures, previously in use, are superseded by a new measure of capacity called the "Imperial standard gallon," containing 277.274 cubic inches, or 10 lbs. avoirdupois, of distilled water, at 62° Fahrenheit, the barometer being at 30 inches. The following tables exhibit the Imperial standards, and their usual multiples and divisions.

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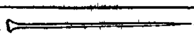
* Light pins, of the following length  (·95 of an inch) weigh 86 to 100 grains—8·6 pins to 10 grains. The table requiring to be constructed, then, from weights of this sort, would be the following : 155 pins will weigh a tola nearly :—

Pins.	Grs.	Pins.	Grs.	Pins.	Grs.
1	1·1628	20	23·2560	300	348·8400
2	2·3256	30	34·8840	400	465·1200
3	3·6884	40	46·5120	500	581·4000
4	4·6512	50	56·1400	600	697·6800
5	5·8140	60	67·7680	700	783·9600
6	6·9768	70	81·3960	800	930·2400
7	8·1396	80	93·0240	900	1046·5200
8	9·2924	90	104·6520	1000	1112·8000
9	10·4652	100	116·2800	2000	2225·6000
10	11·6289	200	232·5600	3000	3338·4000

Of course the pins must be weighed to begin with : it is very likely that this table will answer with a considerable portion of those made use of, the most common variety having been selected on purpose,—but this must not on any account be taken for granted. Once weighed, the pins should be set aside, that they may not get mixed with others.

I.—MEASURES OF LENGTH.

12 Inches	=	1 Foot.
3 Feet	=	1 Yard.
$5\frac{1}{2}$ Yards	=	1 Pole or Perch.
40 Poles	=	1 Furlong.
8 Furlongs or 1760 Yards	=	1 Mile.

The hand = 4 inches; the English ell = 45 inches: the pace =5 feet; and the fathom = 6 feet. The geographical degree = 20 nautical leagues, or 69.121 miles. In land measure, the chain of 100 links = 66 feet.

II.—MEASURES OF SURFACE.

144 Square inches	=	1 Square foot.
9 Square feet	=	1 Square yard.
$30\frac{1}{4}$ Sq. yards, or $272\frac{1}{4}$ sq. feet	=	1 Square pole.
40 Square poles	=	1 Rood.
4 Roods, or 4840 square yards	=	1 Acre.

And 640 acres make 1 square mile.

III.—MEASURES OF CAPACITY.

I.—GENERAL MEASURES OF SOLIDITY.

1728 Cubic Inches	=	1 Cubic foot.
27 Cubic feet	=	1 Cubic yard.

The ton measurement = 8 barrel bulk, or 40 cubic feet.

II.—MEASURES FOR LIQUIDS, CORN, AND DRY GOODS.

8.665 Cubic inches	=	1 Gill.
4 Gills	=	1 Pint.
2 Pints	=	1 Quart.
4 Quarts	=	1 Gallon.
2 Gallons	=	1 Peck.
4 Pecks	=	1 Bushel.
8 Bushels	=	1 Quarter.

The peck, bushel, and quarter, are used for dry goods only: there are besides, the coom = 4 bushels; the wey or load = 5 quarters; and the last = 2 loads or 10 quarters.

In Beer Measure, the barrel contains 4 firkins or 36 gallons; and the hogshead $1\frac{1}{2}$ barrels or 54 gallons.

In Wine Measure, besides the gallon and its subdivisions, various denominations are used, as the butt, pipe, &c., but these are now to be considered rather as the names of casks than as expressing any definite number of gallons. The *standard gauges* in trade are as follow:—Pipe of Port, 115 Imp. galls.; pipe of Lisbon, 117 do.; pipe of Cape or Madeira, 92 do.; pipe of Teneriffe, 100 do.; butt of Sherry, 108 do.; hogshead of Claret, 46 do.; aum of Hock, 30 do.

Herrings are measured by the barrel of $26\frac{2}{3}$, or cran of $37\frac{1}{2}$ gallons.

IV.—MEASURES OF WEIGHT.

I.—AVOIRDUPOIS OR COMMERCIAL WEIGHT.

27.34375 Troy grains	=	1 Dram.
16 Drams	=	1 Ounce
16 Ounces, or 7000gr.	=	1 Pound
14 Pounds	=	1 Stone
2 Stones, or 28 lbs.	=	1 Quarter
4 Qrs., or 112 lbs.	=	1 Cwt.
20 Cwts.	=	1 Ton

Flour Weight.—1 stone = 14 pounds; 1 boll = 140 pounds; 1 sack 280 pounds, or $2\frac{1}{2}$ cwt.; 1 barrel = 196 lbs.

II.—TROY WEIGHT.

24 Grains	=	1 Pennyweight
20 Dwts	=	1 Ounce
12 Ounces	=	1 Pound

The use of this weight is confined to the precious metals.

The fineness of gold is expressed in carats and grains, the unit of reference being divided into 24 carats, and the carat into 4 grains. The standard of gold coin is 22 carats, that is, the pound or other weight should contain 22 parts pure and 2 alloy. The mint-price of gold is £3. 17. 10 d. per ounce; and hence the full weight of a sovereign is 5 dwts. 3.274 troy grains; but the sovereign of 5 dwts. $2\frac{1}{2}$ grains, and the half sovereign of 2 dwts. $13\frac{1}{2}$ grains, are allowed currency (*Proclamation, June* 7, 1842). Wrought gold has two legal standards, one is 22 carats, the same as the coin, and the other 18 carats. The latter, instituted in 1798, is used chiefly for watch-cases and rings.

The fineness of silver is expressed in ounces and pennyweights; the standard fineness is 11 oz. 2 dwts. of pure metal and 18 dwts of alloy, making together 1 pound troy. Prior to the recoinage in 1816, a pound of standard silver was minted into 62 shillings, and was thus issued at 5s. 2d. per oz.; but although the market price of standard silver bullion has for many years varied little from 5s. per ounce, the new coin is minted at 5s.6d. per oz., as 66 shillings are coined from a pound of bullion. The Act of 1816, however, declares "that silver coins shall be a legal tender for 40s. only at one time," and "that gold coins shall be in future the sole standard measure of value and legal tender for payment without any limitation of amount."

Wrought silver has two legal standards: one is the same as that of the coin, and the other 8 dwts. *better*, or 11 oz. 10 dwts. But the latter, called new sterling, is seldom used.

Diamond Weight.—Diamonds are weighed by carats, $151\frac{1}{2}$ of which make one ounce troy; this carat is therefore equal only to $3\frac{1}{6}$ troy grains.

Pearl Weight.—The troy ounce contains 600 pearl grains, and hence one pearl grain is 4-5ths of a troy grain.

Apothecaries' Weight.—20 troy grains make 1 scruple; 3 scruples make 1 dram; and 8 drams make 1 ounce. The ounce and pound are the same as in troy weight. This weight is used in medical prescriptions only.

New Indian Weights established in Bengal by Regulation VII. of 1833; and adopted by the Government of Bombay, at the recommendation of the Tariff Committee in the New Tariff valuation.

1 Tola	=180 Grains Troy.
80 Tolas=1 Seer.	=14,400.
40 Seers=1 Indian Maund	=576,000.

		lbs. Avoirdupois
Then as=7,000	Grains Troy are *exactly equal to*	1
1 seer of=14,400	Grains Troy are *exactly equal to*	2—2-35ths.
1 md. of=576,000	Grains Troy are *exactly equal to*	82—2-7ths.

And it follows therefore,

			lbs. Avoirdupois.
That 35 Seers are *exactly equal to*			72 „ „
„ 7 Indian Maunds=wt. 57	or		576 „ „
„ 41 do. = „ 36	or		4.032 „ „
„ 245 do.=Tons 9 = „ 180	or		20,160 „ „

The following simple and accurate Rules for the conversion of new Indian weight into avoirdupois weight, and vice versa, deduced from the foregoing data, are given in the volume of useful Tables, published by Mr. James Prinsep, in Calcutta in 1834, page 66.

Rule 1.—*To convert Indian weight into Avoirdupois weight.*

1. Multiply the weight in seers by 72, and divide by 35, the result will be the weight in lbs. avoirdupois.

Rule 2.—*To convert Avoirdupois weight into Indian weight.*

1. Multiply the weight in lbs. avoirdupois by 85, and divide by 72, the result will be the weight in seers.

2. Or, Multiply the weight in cwt. by 49, and divide by 36, the result will be the weight in maunds.

Since the foregoing Memoranda and calculations were made, I have been able to obtain a copy of the Bengal Regulation VII. of 1833, on which the new system of Indian weight is founded, and subjoin the following further memoranda connected therewith, in the belief that they will be found useful at this time.

The first Section of the Regulation in question, after reciting the reasons that render it expedient to adopt the weight and standard of the Furruckabad Rupee (which are the same as that of the Madras and Bombay Rupee) in the Calcutta Mint as well as in the Saugor Mint, where they had been introduced as far back as the year 1824-25, continues as follows: "It is further convenient to introduce the weight of the Furruckabad Rupee as the unit of a general system of weights for Government transactions throughout India, under the Native and well-known denomination of the *Tola.*"

And Section IV.—in ordering the discontinuance of the use of the Sicca weight of 172·666 grains heretofore employed for the receipt of Bullion at the Calcutta Mint, states that "in its place the following unit to be called the *Tola* shall be introduced, which from its immediate connection with the Rupee of the upper Provinces, and of Madras and Bombay, will easily and speedily become universal throughout the British Territories."

The *Tola*, or Sicca weight, to be equal to 180 Grains Troy, and the other denominations of weight to be derived from this unit, according to the following scale.

8 Rutties=1 Masha=15 Troy Grains.
12 Mashas=1 Tola=180 ditto.
80 Tolas (or Sicca weight)=1 Seer=2½ lbs. Troy.
40 Seers=1 Maund (or Bazaar Maund)=100 lbs. Troy.

Mr. James Prinsep says, with reference to the foregoing change, in pages 62 and 63, of his very useful Tables already alluded to in these memoranda—"The Tola is chiefly used in the weighing of the precious metals and Coin; all Bullion at the Mints is received in this denomination, and the Tables of Bullion produce are calculated per 100 tolas. It is also used at the Mints to make the sub-division of the Tola into annas (sixteenths) and pie, in lieu of Mashas and Ruttees."

THE THERMOMETER.

One of the most portable, useful, common, and universally understood, instruments, is the Thermometer: it is one which no one ever travels without,—with which every one is familiar, and which is so simple and easily understood that an explanation of its structure and uses is almost superfluous. For a large range of temperatures, either above or below the boiling point, Mercury is the fluid always made use of—spirit is employed when great degrees of cold are required to be measured.

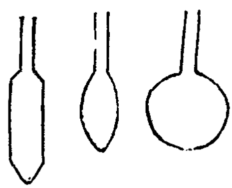
The smaller sized Thermometers, and those made up for bathing and gardening purposes, are in general so negligently cut that little dependence is to be placed upon them. In India, we have often no choice but to make use of whatever we can lay our hands upon. To make a bad Thermometer available, it ought to be carefully rated, and its errors marked. Compare it for each degree over the whole of its scale with some really good Thermometer, by immersing both in water of different temperatures, and note the amount of their differences or agreements, and enter the observations of the incorrect Thermometer along with the corrections,—or, if these be considerable, have a correct paper scale pasted over the original scale of the instrument. Where a trustworthy Thermometer cannot be secured for the purposes of comparison, take the best that presents itself: if the two instruments correspond at any considerable number of points, the probability is that both are right,—the chances against their erring at the same points in the same way, being very great indeed. If they quite agree, the most perfect confidence may be felt in both.

Instruments are not to be valued according to their appearance: pretty looking ivory-scaled Thermometers will often be found useless, and a large supply of common-looking Thermometers, such as are used by gardeners only, for determining the temperature of boiling water, were lately sent out to the Bombay Medical Board, so extremely accurate that on dozens of comparisons with a standard, I could not discover them to be more than a quarter of a degree out on any point of the scale. They were made by Newman, Regent Street, and only required to have the lines a little more delicately out to be fit for any philosophical purposes whatever. As they were, they far surpassed the average of more pretending instruments.

The fault of the Thermometers sent to India is, that they are generally cut below the freezing point to a temperature unknown to us, and stop at 120 or 130°—our heat in the sun often ranging to 140 or 160° near the surface of the ground, where an instrument of this range will burst at once.

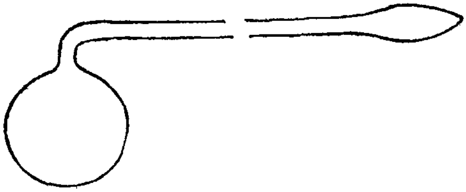
It is not easy to say whether wooden, ivory, or metal, scales are the best: in the case of ivory scales, the glass should only be fast at one point, the scale being so much affected by damp that if screwed tight at both clamps, and allowed no play, it is sure to break the tube.

Tubular or pear-shaped bulbs are better than globes, as being at once more sensitive and less liable to accidents. A Thermometer ought always to be divided into degrees large enough to allow half or quarter degrees to be estimated.



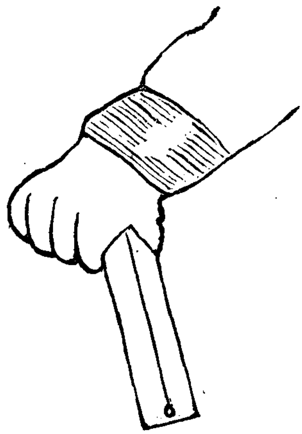
Registering Thermometers are those which are provided with an index, which the Mercury pushes before it, or the spirit draws back with it, and so leaves it, indicating the maximum or minimum temperature since last observation.

Instead of having a perfect vacuum in the unoccupied part of the tube, a little air is always left in it, to prevent the enclosed fluid from dividing, and a secondary supplementary bulb is provided at the upper end as a receptacle for this in cases of extremity.



Self-registering Thermometers are extremely liable to get out of order. The mercurial or maximum is most apt to go wrong, and most troublesome to put to rights. When the two are in one scale, detach the one of them when anything is wrong, as the treatment best for the one is ruinous for the other.

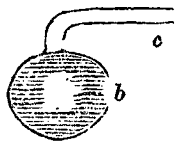
The spirit Thermometer can always be easily put to rights by grasping it firmly in the right hand, and giving it a violent swing or two bulb undermost, when the spirit rejoins, and the air is disengaged : the index will fall into its place by a little tapping.



The index of the Maximum Thermometer is generally a piece of porcelain or steel: both are very apt to get entangled amongst the mercury, and are very troublesome to get out. Sometimes careful tapping will separate them: in general the best way is to subject the bulb to a degree of cold sufficient to draw the quicksilver past the index, and then to tap the upper end of the Thermometer sharply and rapidly on a piece of wood or other similar substance—stone or metal will break it. When the Index is in the upper bulb, retain it there till all is right. If air has got far down into the stem, cool the bulb with ice, or a freezing mixture, so as to draw as much of the mercury into it as possible, and let the air extricate itself. Then allow it to resume the temperature of the atmosphere, and warm it gently with hot water till a considerable quantity of the mercury has got into the upper bulb, when the air will probably be found to have disengaged itself, and the metal to return in one continuous column. The operation is tedious and troublesome, but when care is taken it never need be unsatisfactory. If an air-bubble which cannot be extracted in any way gets into the bulb, either open the upper bulb with a file or blowpipe—tap it freely now, and heat the mercury so as to expel fairly all the air—return the metal if any escapes ;—allow a little air to get in, and hermetically seal with a blowpipe.

The air-bulb should be held to the lamp, and a bit of glass attached to it: it should then be drawn outwards and upwards thus, and the entire point broken off. As the scale is seldom cut higher than 180, by immersing the bulb

b in water, and raising the temperature gradually, holding the instrument so that all the air shall on the expansion of the mercury pass into the tube *c*, the whole may be made to ascend, and the expelled air may be made to pass on and escape, while the metal lodges itself in the upper bulb. When a considerable part of it is thus got rid of,—assuming the instrument to have been very much out of order,—the tube should now be held vertically, so as to allow the mercury to descend into



the main bulb *b*, which ought to be cooled as much as possible, when probably the bulk of the mercury will return to it, and the air get uppermost: a repetition of the operation will leave all right. At the conclusion, and just before sealing up the tube, the bath in which the bulb is placed should be heated about twenty or thirty degrees higher than the tube bulb under repair reads to, leaving a little space for air—the lamp should then be applied to the portion drawn out, and the whole sealed up; the glass should be cooled very slowly, and all will be right. During all these operations, every care should be taken to get the index into the upper bulb if possible, and to retain it there. Should it have got entangled again, the mercury should be drawn back into the tube, by a freezing mixture, and the index got out by gentle tapping. There is scarcely any case where a register Thermometer may not by these means be put to rights if sufficient care and pains be taken. It is to be remembered that these instructions are meant for parties little familiar with the use of instruments, and without the means of replacing them, or getting them put to rights by an optician.

Six's Thermometer, though a very excellent instrument, is so exceedingly troublesome to put to rights when out of order, that they are altogether unsuited for India.

The following extracts are from the *Admiralty Manual*:—

In placing the *External Thermometer*, an exposure should be chosen perfectly shaded both from direct sunshine, and that reflected from the sea, or radiated from any hot object. It should be especially guarded from rain and from spray, so that the bulb should never be wetted; also from warm currents of air and local radiation; completely detached from contact with the ship's side, and fully exposed to the *external* air.

In reading it, the observer should avoid touching, breathing on, or in any way warming it by the near approach of his person; and in night-observations particular care should be taken not to heat it by approach of the light. The quicker the reading is done the better. At night it should be completely screened from the sky, so as to annihilate all loss of heat by upward radiation; a light frame-case of double wire-gauze will perhaps be found a secure and efficient protection both from injury and obnoxious influences.

The *Self-registering Thermometers* should be placed with the same precautions as the external thermometer, and in similar exposures, and so fastened as to allow one end to be detached and lifted; so that the indices within the tubes may slide down to the ends of the fluid columns, which they will readily do on gentle tapping. They are apt to get out of order by the indices becoming entangled, or by the breaking of the column of fluid. When this happens to the spirit-thermometer, it is easily rectified by jerking the index down to the junction of the bulb and tube; then, by cautiously heating and cooling alternately the bulb, tube, and air-vessel at the top, the disunited parts of the spirit may be distilled from place to place till the whole is collected into one column in union with that in the bulb.

When the steel index of the mercurial thermometer becomes immersed in the mercury, first cool the bulb (by evaporation of ether, if necessary) till the mercury is either fairly drawn below the index, or the column separates, leaving the index with mercury above it. Loosen the index by tapping, by a magnet, or by heating the tube, then apply heat to the bulb, and drive the index with its superincumbent mercury up into the air-vessel. When there, hold the instrument bulb downwards, and, suspending the index by a magnet, effect a union between the globule of mercury and the column below, by continuing to apply the heat till the latter rises into the air-vessel. As the bulb cools, the whole mercury should descend in an unbroken column, after which the index may be restored to its place. Much patience and many trials are often required for success. An oil-lamp with a very small clear flame should be used.

Both the self-registering thermometers should be read off at the time of the 9 h. A. M. observation, as it is very improbable that the temperature at that hour should be such as to obliterate either record of the preceding 24 hours. Double maxima and minima, when they occur, if remarkable, should be recorded as supernumerary and separately in a diary, and their accompanying circumstances noted.

The observer should be furnished with several other thermometers, all of sufficient delicacy to allow of estimating tenths of degrees, for observation of the temperature of the sea, or of the earth (when on shore,) of falling rain, &c., and for a reserve in case of accident. All should be compared with the standard. That in habitual use for the sea temperature should be defended from accident in the act of immersion by a wire guard.

The thermometer for solar radiation should have its bulb blackened with a coat of Indian ink. It should be defended from currents of air by enclosure in a glass tube; and it would add infinitely to the value of a series of observations made with it, if this tube were exhausted and hermetically sealed. Its exposure to the sun should be perfectly free and full, and it should be suspended in free air, quite out of reach of any support or object heated by the sun's rays.

In India there are few instruments more difficult to manage than the thermometer—hot currents of air, radiation, and reflection, are constantly interfering with temperature observations. The air will stagnate in the corners of a room well supplied with venetians, or in the over sheltered parts of a verandah, so as to raise the thermometer much above the temperature of the breeze around. I have seen a thermometer enclosed in a glass case rise twenty degrees higher in the sun than one of precisely similar construction with the glass removed. A thermometer on the ground will rise to 160°, when one a couple of feet higher up will not stand higher than 120°. I believe it not impossible to raise one to the boiling point by the sun's rays, by merely covering it from currents of air, and making the dispositions around favourable for the accumulation of heat. With these precautions fully before him, the observer must be left to act for himself, as no rule can be laid down calculated under all circumstances to meet the occasions which present themselves. The requirements for accuracy are a free exposure to air, and protection from the reflection of the earth or surrounding bodies, and the radiation of the sky.

The following description is given by Mr Adie of the Mountain Thermometers sent out by him for the use of the Society :—

The *Thermometers* for the determination of altitudes by the boiling point of water are constructed as follows : A piece of tube is selected of perfectly equal calibre throughout its length ; the section of the bore is round and fine, for the purpose of giving long degrees without having a very large bulb, which renders the carriage of such Thermometers very dangerous for breakage ; the bulb is made of glass cylinder-tube, which can be made more equal and stronger than a round blown bulb : and the proper size having been determined for each tube, the scales are determined by the following process : each tube with its finished bulb is weighed by a fine balance to 1-100th of a grain ; they are then fitted with pure dry mercury, and regulated, so that 62° shall have the same position as 212° is to have when the Thermometer is finished.

Temporary scales, divided into inch and decimal parts, are then fixed to each tube, and the point 32° obtained from melting ice, and 62° from a fine Standard Thermometer, and carefully read off on these temporary scales. This gives the length of 30° at these temperatures. But it is evident that this length would be greater than 30°, if we drive out a portion of the mercury, to make 212° stand at the point where 62° stood when the scales were measured. This is corrected by carefully weighing the tubes before and after regulating them for 212°, and the proportion is stated : If the larger quantity of mercury give the length noted, the diminished quantity of mercury from regulation to 212°, will give a diminished scale, which scale is the true or corrected one, to be divided on the thermometer ; each degree is subdivided into fifth or tenth parts, and cut on the glass stem of the thermometer ; or may be laid down on an attached scale.

When the Thermometer is to be used, the bulb must be carefully inspected, to see that there are no small detached globules of air attached to the interior of the bulb ; should such be found, they are to be removed by shaking in a larger globule from the contracted part of the bulb, and making it pass over the smaller globules, which it will take with it ; it is then to be returned to the contracted part ; and should any small portion of the mercury lodge in the tube, it is to be joined to the column by heating the bulb till it rise to the small bulb at the top of the Thermometer, where the detached portions will unite.

The best *method of using* these Thermometers is to have the bulb and column of mercury up to the reading point brought to the boiling temperature ; this is best done by a boiler provided with telescope-slide-tubes, which can be regulated to any required length ; or where such an apparatus is not at hand, the same length of column, as nearly as possible, should be kept out of the water. Professor J. D. Forbes (Philosophical Transactions, Edinburgh, vol. xv., page 409) has with great care determined the difference of altitude due to a change of 1° in the boiling point of water, and found it to be 549.5° for each degree of Fahrenheit. Thermometers used for this purpose should be frequently compared one with another and their differences noted ; or, where one only is used, the instrument should be noted as frequently as possible, both for the purpose of obtaining more perfect results from a mean of the observations, and for correcting small changes in the indication which go on in course of time.

For security in carriage, the Thermometer is enclosed in a brass case and supported at all points by woollen stuffing, and is removed from its case by screwing off the top and bottom, and pushing out the bulb, when the Thermometer may be drawn out.—(For tables and directions, see *Appendix*.)

The Thermometer made use of in England is that of Fahrenheit, the scale of which from freezing to boiling is divided into 180°—the zero or bottom of the scale being 32° below freezing,—this being the greatest degree f cold known to Fahrenheit, and supposed to be the greatest that existed. Freezing is marked 32°, and boiling 212°. The Centigrade again commences at freezing, and makes boiling 100° : every degree of Fahrenheit's scale is 1·8 of that of the Centigrade. The following table gives the relations of the two to each other: Reaumur's thermometer, inserted in the table, is seldom met with :—

COMPARISON OF THE THERMOMETERS OF FAHRENHEIT AND REAUMUR, AND THAT OF CELSIUS, OR THE CENTIGRADE THERMOMETER OF THE MODERN FRENCH CHEMISTS.

Fahr.	Reaum.	Celsi.	Fahr.	Reaum.	Celsi.	Fahr.	Reaum.	Celsi.	Fahr.	Reaum.	Celsi.
212	80·0	100·0	148	51·5	64·4	85	23·5	29·4	22	44·0	55·0
211	79·5	99·4	147	51·1	63·8	84	23·1	28·8	21	48·0	61·0
210	79·1	98·8	146	50·6	63·3	83	22 6	28·3	20	53·0	66·0
209	78·6	98·3	145	50·2	62·7	82	22·2	27·7	19	57·0	72·0
208	78·2	97·7	144	49·7	62·2	81	21·7	27·2	18	62·0	77·0
207	77·7	97·2	143	49·3	61·6	80	21·3	26·6	17	66·0	83·0
206	77·3	96·6	142	48·8	61·1	79	20·8	26.1	16	71·0	88·0
205	76·8	96·1	141	48·4	60·5	78	20·4	25·5	15	75·0	94·0
204	76·4	95·5	140	48·0	60·0	77	20·0	25·0	14	80·0	10·0
203	76·0	95·0	139	47·5	59·4	76	19·5	24·4	13	84·0	10·5
202	75·5	94·4	138	41·1	58·8	75	19·1	23·8	12	88·0	11·1
201	75·1	93·8	137	46·6	58·3	74	18·6	23·3	11	93·0	11·6
200	74·6	93·3	136	46·2	57·7	73	18·2	22·7	10	97·0	12·2
199	74·2	92·7	135	45·7	57·2	72	17·7	22·2	9	10·2	12·7
198	73·7	92·2	134	45·3	56·6	71	17·3	21·6	8	10·6	13·3
197	73·3	91·6	133	44·8	56·1	70	16·8	21·1	7	11·1	13·8
196	72·8	91·1	132	44·4	55·5	69	16·4	20·5	6	11·5	14·4
195	72·4	90·5	131	44·0	55·1	68	16·0	20·0	5	12·0	15·0
194	72·0	90·0	130	43·5	54·4	67	15·5	19·4	4	12·4	15·5
193	71·5	89·4	129	43·1	53·8	66	15·1	18·8	100	12·8	16·1
192	71·1	88·8	128	42·6	53·3	65	14·6	18·3	2	13·3	16·6
191	70·6	88·3	127	42·2	52·7	64	14·2	17·7	1	13·7	17·2
190	70·2	87·7	126	41·7	52·2	63	13·7	17·2	...	14·2	17·7
189	69·7	87·2	125	41·3	51·6	62	13·3	16·6	1	14·6	18·3
188	69·3	86·6	124	40·8	51·1	61	12·8	16·1	2	15·1	18·8
187	68·8	86·1	123	40·4	50·5	60	12·4	15·5	3	15·5	19·4
186	68·4	85·5	122	40·0	55·0	59	12·0	15·0	4	16·0	20·0
185	68·0	85·0	121	39·5	49·4	58	11 5	14·4	5	16·4	20·5
184	67·5	84·4	120	39·1	48·8	57	11·1	13·8	6	16·8	21·1
183	67·1	83·8	119	38·6	48·3	56	10·6	13·3	7	17·3	21·6
182	66·6	83·3	118	38·2	47·7	55	10·2	12·7	8	17·7	22·2
181	66·2	82·7	117	37·7	47·2	54	97·0	12·2	9	18·2	22·7
180	65·7	82·2	116	37·3	46·6	53	93 0	11·6	10	18·6	23·3
179	65·3	81·6	115	36·8	46·1	52	88·0	11·1	11	19·1	23·8
178	64·8	81·1	114	36·4	45·5	51	84·0	10·5	12	19·5	24·4
177	64·4	80·5	113	36·0	45·0	50	78 0	10 0	13	20·0	25·0
176	64·0	80·0	112	35·5	44·4	49	75·0	94·0	14	20·4	25·5
175	63·5	79·4	111	35·1	43·8	48	71·0	88·0	15	20·8	26·1
174	63·1	78·8	110	34·6	43·3	47	66·0	83·0	16	21·3	26·6
173	62·6	78·3	109	34·2	42·7	46	62·0	77·0	17	21·7	27·2
172	62·2	77·7	108	33·7	42 2	45	57·0	72·0	18	22·2	27·7
171	61·7	77·2	107	33·3	41·6	44	53·0	66·0	19	22·6	28·3
170	61·3	76·6	106	32·8	41·1	43	48·0	61·0	20	23·1	28·8
169	60·8	76·1	105	32·4	40·5	42	44·0	55·0	21	23·5	29·4
168	60·4	75·5	104	32·0	40·0	41	40·0	50·0	22	24·0	30·0
167	60·0	75·0	103	31·5	39·4	40	35·0	44·0	23	24·4	30·5
166	59·5	74·4	102	31·1	38·8	39	31·0	38·0	24	24·8	31·1
165	59·1	73·8	101	30·6	38·3	38	26·0	33·0	25	25·3	31·6
164	58·6	73·3	100	30·2	37·7	37	22·0	27·0	26	25·7	32·2
163	58·2	72·7	99	29·7	37·2	36	17 0	22·0	27	26·2	32·7
162	57·7	72·2	98	29·3	36·6	35	13·0	16·0	28	26·6	32·3
161	57·3	71·6	97	28·8	36·1	34	8·0	11·0	29	27·1	33·8
160	56·8	71·1	96	28·4	35·5	33	4·0	5·0	30	27·5	34·4
159	56·4	75·0	95	28·0	35·0	32	...	...	31	28·4	35·0
158	56·0	70·0	94	27·5	34·4	31	4·0	5·0	32	28·0	35·5
157	55·5	69·4	93	27·1	33·8	30	8·0	11·0	33	28·8	36·1
156	55·1	68·8	92	26·6	33·3	29	13·0	16·0	34	29·3	36·6
155	54·6	68·3	91	26·2	32·7	28	17·0	22·0	35	29·7	37·2
154	54·2	67·7	90	25·7	32·2	27	22·0	27·0	36	30·2	37·7
153	53·7	67·2	89	25·3	31·6	26	26·0	33·0	37	30·6	38·3
152	53·3	66·6	88	24·8	31 1	25	31·0	38·0	38	31·1	38·8
151	52·8	65·1	87	24·4	30·5	24	35·0	44·0	39	31·5	39·4
150	52·4	65·5	86	24·0	30·0	23	40·0	50·0	40	32·0	40·0
149	52·0	65·0									

THE RAIN-GAUGE.

The *Admiralty Manual* recommends a square box as a Rain-gauge: in India, few things are so difficult as to obtain correct right angles, exact straight lines, or definite proportions of any sort. To construct correctly or accurately a square box such as would serve the purposes of delicate observation, is nearly as hopeless a task as could be undertaken: were such a thing once made, it would be almost certain to have its shape or size affected by careless treatment. We can, however, always resort to the turning-lathe, and though we cannot make sure of a rectangular figure, we can command a perfect circle. The receptacles of our rain-gauges are all funnel-shaped—they ought to be measured with the utmost care, and the area then computed. This being multiplied by 253·183 grains, the quantity of water in a cubic inch, the result will give the weight of a cylinder of water one inch axis, and of a base equal to the mouth of the gauge. Thus, for example, suppose the funnel of the gauge six inches in diameter—then the circumference will be found by multiplying 6 into 3·1416=18·8496. The areas of circles are found by multiplying half the circumference into half the diameter—that is 3×9·4248=28·2744 superficial inches: this multiplied into 253·183 the number of grains contained in a cubic inch of water at the temperature of 62°, will give 7158·5994152. Of course in graduating the measure, the following will be the rule for subdivisions:—

7158·5994152	Grains of Water	=One inch.
715·8599415	ditto	=One tenth.
71·5859941	ditto	=One hundredth.
7·1585994	ditto	=One thousandth.

This is given merely as an example of the method of finding the area of the receptacle of a rain-gauge; and upon the accuracy with which this is determined, the whole of the value of the instrument depends: of this, however, I shall have occasion to speak presently.

The simplest form of a rain-gauge is a cylinder of uniform diameter throughout: this requires no computation. If of glass, it may be graduated at once outside; if of metal or any other opaque material, a float is made use of, the stalk of which may be divided into inches at once by a Gunter scale or foot rule. The following very simple form of gauge is described by Dr Fleming in the *Edinburgh Philosophical Journal* for July 1849 :—

On a Simple Form of Rain-Gauge. By the Rev. JOHN FLEMING, D. D., &c., Professor of Natural Science, New College, Edinburgh. Communicated by the Author.*

The defects with which rain-gauges may be charged, at present, seem referable to inattention to the influence of the wind on the falling *rain-drop.* If the drop was influenced only by gravity in its descent to the earth, the form and position of the rain-gauge would be comparatively of little importance. But in addition to its centripetal tendency, regulated in velocity by its size and the height of the fall, the rain-drop is frequently acted upon by the wind, and deflected more or less from its normal path, according to the velocity and direction of the current. While the wind thus influences the rain-drop, it likewise, in its turn, is modified in its horizontal direction by every projecting obstacle, and deflected, according to circumstances, laterally, upwards, or downwards, carrying the rain-drop along with it in its course. Whoever has watched the falling of rain under the influence of wind, and in the neighbourhood of houses, walls, or other obstacles, must have observed, as the result of the eddies generated, that it is deposited in defect in some places, and in excess in others. In the case of falling snow, the derangement is of the same character, but more obvious. Had these influences been duly attended to, there would have been fewer confident assertions respecting the smaller quantity of rain which *falls* on elevated buildings than at lower levels, and more inquiry respecting the cause of a less quantity being *collected* in such circumstances.

When a rain-gauge is elevated three or four feet above the level of the ground, it is easily observed and emptied of its contents, and in calm weather, may be considered trustworthy. During a moderately stiff breeze, however, the rain-drops may be seen whirled about in the funnel, and even carried out and lost after they had nearly reached their destination. But independent of the eddies in the funnel, there are deflections of the current produced externally, which exercise corresponding influence.

The late Mr Thom of Ascog, Bute, a well-known and judicious hydraulic engineer, was in the habit of measuring the fall of rain, in order to predicate respecting the quantity of water which might be derived from a natural or artificial lake or pond, as a motive power for mill purposes. The gauge which he employed was similar to the one figured by Cavallo, in his "Natural Philosophy," vol. ii., p. 424, tab. xv., p. 3. It was defective, however, in the want of a rim to the funnel, so as to prevent the dispersion of any drops impinging directly on the sloping sides. But if defective in respect of the rim, the *position* which he assigned to the gauge itself, namely, placing it in a grass plot, and on a level with the surface, constituted a decided improvement. The mouth of the funnel, although unnecessarily large, does not present space enough to permit any perceptible acceleration of the current of wind, on the free surface, which had been uniformly retarded on the grass plot, and consequently receives a fair proportion of the falling rain.

The body of the gauge, for receiving the water collected by the mouth or funnel, by being placed in the ground, is protected against changes of temperature ; little or no evaporation can take place, so that the emptying and adjusting may be effected at distant intervals.

Having employed for several years, at Aberdeen, an instrument presented to me by Mr Thom, I was satisfied that it fulfilled nearly all the conditions of a trustworthy instrument, differing, however, in its humble appearance, from those eye-traps or gimcracks usually set up as *rain-gauges.* The process of emptying, however, was a troublesome one, as the funnel required to be removed, the float lifted out, and then the water in the cylinder taken up by means of a cup or sponge, at the end of every month or two, according to circumstances.

To remedy this evil, it occurred to me, that by employing an external cylinder, permanently placed in the ground, for receiving the cylinder forming the rain-gauge, a considerable improvement might be effected. 1. The necessity of removing the funnel at every adjustment, might be got rid of by having a stop cock at the bottom of the receiver, so that upon the gauge being lifted out of the ground, or rather out of its external case, the water might, without trouble, be let off, and the float adjusted to zero, by the addition of the requisite quantity of water by the mouth of the instrument. 2. By getting quit of the funnel, the whole gauge may be a single cylinder, with the mouth of the same diameter as the body of the instrument, whereby errors of workmanship, producing unequal areas, may be avoided. 3. By simplifying the instrument, and thereby greatly reducing the expense, it is expected that observers will be increased, and additional data procured for determining the distribution of rain over the globe, by details furnished by comparable gauges.

The preceding remarks will render any minute description of the instrument unnecessary, but the following notices may be of use.

* Read before the Royal Society of Edinburgh, 16th April, 1849.

Fig. 1 is the external cylinder, closed at bottom, and sunk perpendicularly into the ground, with its margin on a level with the earthy surface Fig. 2 is the inner cylinder or rain-gauge, open at top, to act as a funnel for receiving the rain, but closed at the bottom, except the central stop-cock, fig. 3, for letting off the water. This inner cylinder or gauge, is no narrower than its case, unless in so far as to allow of its being easily lifted out for the purposes of adjustment. This inner cylinder is furnished with a shoulder or flange, fig. 4, to close upon the mouth of the *case*, and prevent the entrance of any earth, sand, or leaves, so as to obstruct the easy elevation of the gauge.

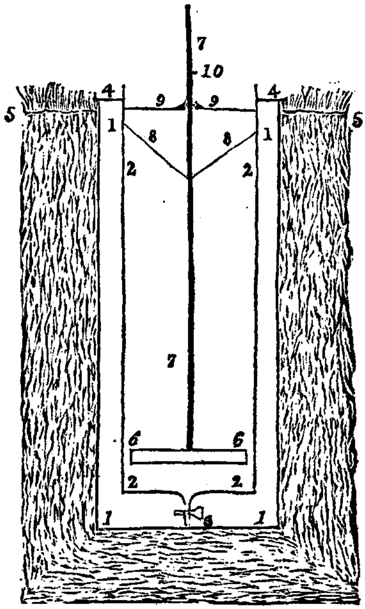


Fig. 5 is the surface of the grass plot in which the gauge is placed, and which must be kept in a trim condition in its immediate neighbourhood.

Fig. 6 is the hollow float to which the index-rod 7 is attached. The rain which falls into the mouth of the cylinder will be conducted by the funnel, fig. 8, situate an inch and a half within the margin (to which it is soldered) into the receiver, fig. 2, and raise the float to a corresponding degree.

Fig. 9 is a thin vertical strip extending across the middle of the mouth, with a sheath at the centre to embrace the rod, as a *guide*, and to serve as determining the zero of the scale and the indications of change. When the stop-cock, fig. 3, has been open, and the water let off, the beginning of the scale on fig. 10 will usually be a little lower than the marking edge, fig. 9 In this case, a little water is poured into the cylinder, in order to bring the commencement of the scale to zero, or fig. 10, and, on the falling of rain, the index rises, and, being divided into inches and tenths, numbered downwards on the rod, the quantity is readily seen by inspection.

The *position* of the gauge in a well-trimmed grass plot, at a distance from houses, walls, or trees, seems to me to obviate all risk of any extra water getting in, as the points of the grass effectually prevent any such occurrence. Those observers, however, who are particularly fastidious on the subject, may adopt a brush to be placed around the margin of the gauge, as recommended by Mr Thomas Stevenson, civil engineer, in this Journal for July 1842.

The *size* of the gauge, or the area requisite for receiving a fair amount of the falling rain, can scarcely be said to have attracted sufficient notice. If we assume that the acceleration of the current would take place, by passing from a grassy surface over the open space of the mouth of the gauge, and a corresponding derangement of the motion of the rain-drop, then it must follow, that the larger the area, the greater will be the amount of error from this source. In order to put this to the test, I placed in the same grass-plot with a Thom's gauge of seven inches in diameter, three other gauges of one, two, and three inches in diameter, and obtained the results for three months, viz :

					1842. Sept.	Oct.	Nov.
No.	1.	Diam.	= 1	inch,	3·689	3·086	5·3255
	2.	...	= 2	...	3·551	3·261	5·2589
	3.	...	= 3	...	3·921	3·346	5·1829
	4.	...	= 7	...	3·750	3·300	5·3750

The grass-plot was not free from eddies, arising from buildings, trees, and walls ; but as all the gauges were nearly similarly exposed, and as they gave nearly similar results, I am inclined to think, that a receiver of one inch in diameter is as trustworthy as one of seven inches. When the instrument is to be made of copper (the most suitable ingredient), the small size reduces the expense. I have noticed the index-rod as divided into inches and tenths. The eye, after a short practice, has little difficulty in halving or quartering the tenths ; and this is a degree of accuracy as great as the circumstances of the case warrant us in aiming at. The inequality in the fall of rain, at two places within less than a mile of each other, forbids us to expect any very accurate correspondence among gauges, even at moderate distances apart, although similar in form and position. The gauge exhibited to the Society, and which was three inches in diameter, and two feet in depth, was constructed for me by Mr James Bryson, Princes Street, Edinburgh, who has furnished several similar instruments, now in operation in different parts of the country.

In conclusion, I may add, that the average annual fall of rain at Aberdeen, according to six years' observations with Mr Thom's gauge, was =30·4 inches. According to Mr Thom, the average of thirty years at Rothesay, in Bute, was =48·29 inches. The maximum annual quantity =71·37 inches, fell in 1811, and the minimum quantity =38·45, in 1803.

NEW COLLEGE, EDINBURGH, *June* 18, 1849.

Unfortunately we can never depend on getting a cylinder correctly made, and we must therefore resort to measurement, computation, and gauging. When it becomes essential, as it always is with us, to resort to this, then it is convenient where a float is used to have the funnel wider than the cylinder or receptacle, for the sake of encreasing the divisions of the scale. The following varieties of gauges, all of them excellent, are described in the *Bombay Almanac* for 1845:—

IT is singular, considering the importance which is attached by Government to the returns of the various revenue Collectors as to the state of the weather, especially during the rainy season, that the use of instruments for determining with any thing like precision, the amount of rain which falls in any district, seems never to be thought of—the information being taken from the vague and general statements of the natives. Recent investigations in this department of Meteorology have given an interest and importance to observations of the rain gauge and evaporating dish, such as that no one who feels any curiosity in these enquiries will willingly omit a register of their indications, however rude may be the instruments that are employed. Any vessel whatever that will hold in water may be used for either a rain gauge or an evaporating dish, especially for the former. Suppose a tub, a beer barrel, cooking pot, or any other vessel with a true circular aperature, is desired to be employed: measure the diameter of the vessel with a foot rule and multiply this by 3·1416 to find its circumference. Then the area may be found by multiplying half the diameter into half the circumference. A cubic foot of water weighs exactly a thousand ounces avoirdupois at a temperature of 62°, and by consequence a cubic inch of water will weigh 57,304-100,000ths of an ounce, or 253·18 grains nearly. If, then, the area of the mouth of the vessel be multiplied by 253·18, this will give on the scale the amount of water corresponding to one inch of fall, whatever be the size of the vessel in which it is received. If a good balance and pair of scales can be procured, weigh the whole or a half quarter, or any other fraction of this, and mark the space it occupies in a phial bottle or any other narrow-mouthed vessel made to serve the purposes of a measure. The contents of the gauge may either be poured into this as collected, or the guage itself measured off and marked by pouring successive fills of this into the receptacle, and marking off the points to which the water rises by each successive fill. If a vessel of an unequal form at the mouth be employed, such as a bathing tub or box, then the area of this may be ascertained by dividing it into squares by threads and pins, and then measuring the irregular corners of the portions ruled in the offset by a foot rule. The other portions of the operation may be performed as already explained. If weights cannot be had, then measures may be resorted to, keeping the following table in view:—

Cubic Inches.	lbs. Avoir.	Water.			
8,665	5-16ths	1 gill.			
24,659	$1\frac{1}{4}$	4	1 pint.		
69,381	$2\frac{1}{2}$	8	2	1 quart.	
277,274	10	32	8	4	1 gallon.

Weighing is always more accurate than measurement where much delicacy is required. Vessels similar to those employed as rain gauges may be used as evaporating dishes if filled up to a given mark, say at morning, noon and evening—the quantity of water required to compensate the evaporation being noted; this being divided by the number of feet or inches comprised in the evaporating surface, will give the amount of evaporation since last observation. Two evaporating dishes—one in the shade and another in the sun—should always be made use of, and the results noted separately.

The following are some of the forms of the rain gauge.—Fig. 1st is a large funnel to be placed in the neck of a common bottle or other receptacle : a measure accompanies it, into which the water is poured once a day or so, and which gives at once the number of inches and decimals of an inch which have fallen. This is a very convenient form of gauge for remote stations, where observations are infrequent. If placed in the bunghole of a good beer barrel, the fall of an entire rainy season might be collected—the instrument requiring no attention whatever from the commencement to the close of the rains.

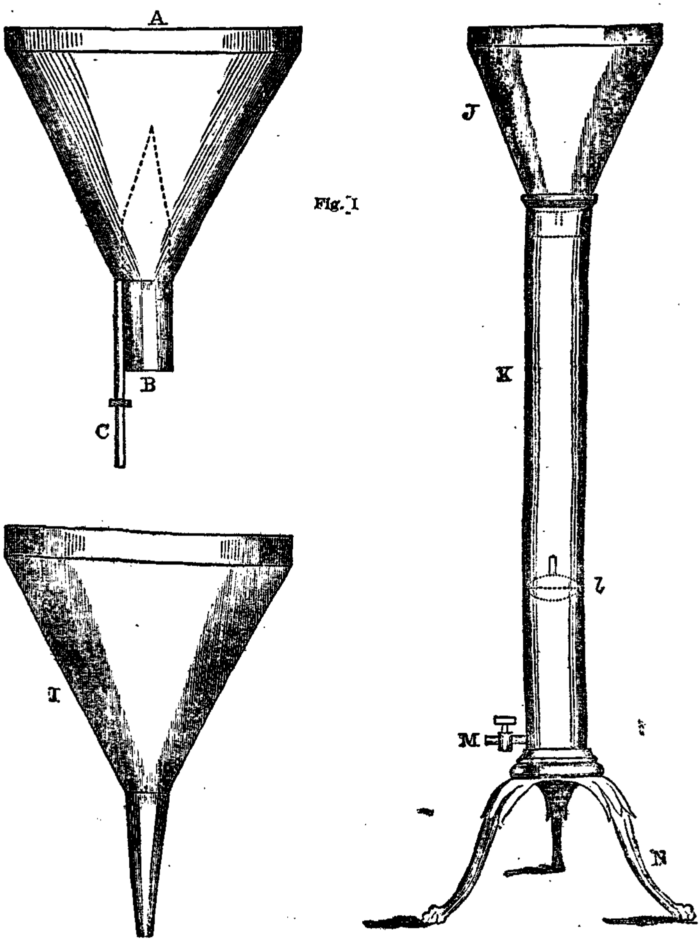
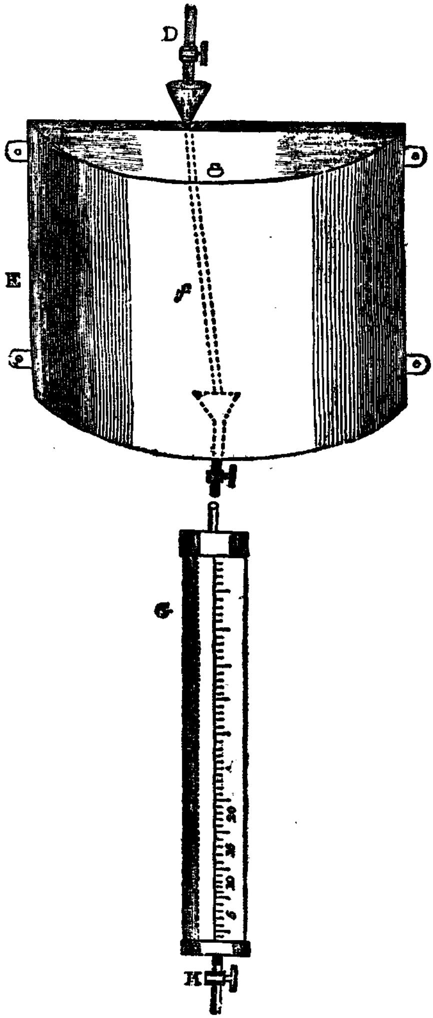
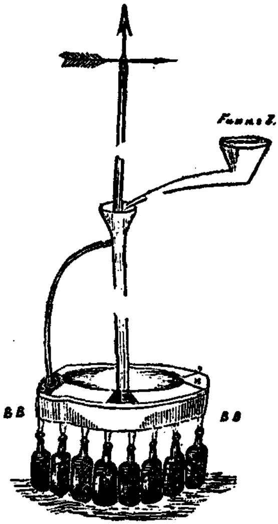


Fig. 1

The gauge represented by the adjoined diagram J, is one very generally in use. The mouth piece, which is funnel shaped, can be removed : a stick divided into inches, tenths, and hundredths, or rather into graduations corresponding to these, is moved up and down by a float inside, which gives the fall of rain at once. The gauge will contain about a foot : it should be measured at least once a day, and the water run off by the stop-cock M. at bottom. The observations lately made at York, shewing that the amount of rain collected by the gauge regularly decreased as the square root of the distance as we ascended from the ground, has of late caused much attention to be paid to gauges situated near each other but at different elevations. The following represent the portions of a gauge intended for the top of a pole or flag-staff, the summit of a high building, or any other elvated position. Fig. 1 consists of a simple funnel fitted up with a socket for the reception of a stick to fasten it on; it is supplied with couplings and a flexible tin tube 30 feet in length : successive tubes can of course be united to this to any extent that may be desired. The tin tube is taken, we shall suppose, inside a building, where it discharges itself into a cistern fitted up with a graduated glass tube terminating in a waste pipe for the efflux of the rain. The tub is divided into inches, tenths, hundredths, and thousandths. The lower stopcock H. being shut, and the upper one left open, the rain falls at once into the tube G, and may be observed accordingly : when this is full, the surplussage is received and retained in the cistern E. When about to be measured off, the upper stop-cock is shut, and the lower one H. opened till the tube empties itself : this is noted, and the lower cock shut and upper one opened; and the operation repeated till the whole is discharged. Instead of the cistern and tube, a common measure of any sort may be employed, or the rain be made to discharge itself into a cylindrical vessel with a float and measuring stick. Besides the question of the amount of diminution of rain found to obtain as we ascend from the surface of the earth, and which can only be solved by the observation of numerous rain gauges placed at different elevations,—two other points in Ombrometry are almost of equal interest—1st, the direction of the wind, and 2nd, the hours of the day in which our principal falls of rain occur. Where Ostler's self-registering wind and rain-gauge cannot be come by, two methods may be resorted to, both eminently practicable at military stations, where there are at all times sentinels on duty. For determining the fall of rain each hour, a funnel should be placed on a stand two or three feet high, at a properly exposed station. Two dozen of beer bottles should be provided, each dozen bottles being marked with the hours of the day thus—I., II., III., IV., V., VI., &c. &c. The dozen for night use may be painted white—that for day use



red or some other distinguishing colour. Let the sentry remove one and substitute another of these every hour—the contents of each being measured will indicate the amount of rain that has fallen each hour of the twenty-four; the total amount will give the quantity that falls daily. To determine the fall which occurs with any given direction of the wind, a strong vane should be made fast to the spindle, on which there should be a revolving funnel into which the water from the receiver is discharged with a discharge-tube bent claw-form, as in the accompanying diagram; the tube discharges its water into an annular receptacle B. B. divided by 8, 16 or 32 partitions, corresponding to the points of the compass. From each of these a tube passes to a separate bottle noted with the direction corresponding to the partition: the amount contained in each bottle will indicate the quantity which has fallen throughout the season while the wind was in any given direction.



A large number of these are now in use,—they are strong, well put together, and not apt to get out of order. They should however be carefully gauged at the mouth every season, in case they may have met with any accident to impair their circularity: when they have suffered in this way, they should be justified on a circular piece of wood, cut or turned to fit the mouth as it originally stood. The stalk of the cylinder-gauge should always be tried with the measure every season, in case the cylinder may have become dented.

To get rid of one of these varieties of risk—that arising from the imperfect circularity of the mouth of the funnel,—I have had some rain-gauges made up with cast-iron mouth-pieces, very nicely and correctly turned inside. As these neither warp nor yield, it is impossible for them to get out of order. The following is the most correct mode of graduating a rain-gauge. Having ascertained that the mouth of the receptacle is perfectly circular, determine its dimensions with the utmost accuracy; then compute the area and quantity of water required to fill it an inch deep, as already described. Weigh as much as makes the tenth or hundredth part of an inch, according to the size of your gauge, into a narrow glass tube, phial, or other vessel, and carefully mark the upper edge of the water by making a scratch with a flint, file, or a diamond, on the glass—keep this for your fundamental measure. A beer or claret bottle may be taken as a check measure for a whole inch. If your gauge has a cylinder, fit your float and float-stick, shut the stop-cock,* and then pour as much water as makes the float rise say half an inch from the bottom of the cylinder: consider this the zero, or lowest point on your scale. Pour in a measure of water, corresponding say to a tenth of an inch, and make a pencil mark on the stick to where it rises: pour in successive measures till the cylinder is full —then withdraw the stick, and make notches at the pencil marks for inches and tenths: if the division is meant to be carried further, it may be done with a pair of compasses without any risk of error. When a bottle or any similar receptacle is used, a separate measure is convenient: a claret, castor oil, or beer, bottle, the more roomy the better, will serve. This may be gauged by the inch to serve without second measure: slips of paper should be gummed on the two opposite sides, and the rise of the water marked off at first with pencil: the bottle ought not to be moved from its position while this is being done. The lines and figures may then be scratched or painted on: this must be done on at least three sides of the bottle, so that in measuring, the water may be seen to rise to the opposite markings all round. If a measure of metal or any compressible material, is made use of for ordinary purposes, it ought from time to time to be tested with the glass measure: this should always be kept as a standard of reference. It is not expected that observers should require to prepare their own instruments—these may be had made up and repaired at the presidency,—but it is well they should know the way in case of emergency. For a full account of this variety of rain-gauge, the reader may turn forward to evaporation—the cast-iron mouthed funnel forming one of the best and safest evaporating dishes to be met with.

The following table for the measurement of rain-gauges, may save some trouble. The temperature of the weather is assumed at 62°, —the evaporation betwixt this and 80 or 85°, our average temperature, not being such as materially to affect the measure. I have given the area of gauges from one inch to a foot, for every tenth of an inch: this seems sufficient—for other sizes, a separate computation may be made. It may save time to take the area from the table nearest to that desired to be found, and then to remember that the areas of circles are to each other as the squares of their diameters. Say for example, that the receptacle of a rain-gauge to be computed measures 6·47—then the nearest to that is 6—we have the following proportion :—As 6 : 6·47 : : 28·2744=30·489228.

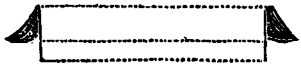
* In India, stop-cocks are very apt to get rusty and immoveable, and are often destroyed in the attempt to force round the key by twisting or hammering. The simple remedy is to turn the stop-cock upside down, undo the small screw which keeps the key down in its place: a slight tap will then displace the key altogether, when the key-seat may be greased or oiled and the key replaced. This is a simple and perfectly safe and unfailing remedy.

TABLE showing the Areas in inches and decimals of Circular Apertures from 1 to 12 inches in diameter, with the number of grains of water in cylinders of 1 inch axis and diameter, from 1 to 12 inches,—it being assumed that there are 253·183 grains of water in a cubic inch, temperature 62°.

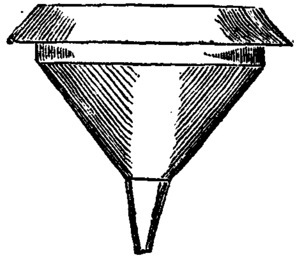
Diameter in inches.	Areas.	Grains.	Diameter in inches.	Areas.	Grains.	Diameter in inches.	Areas.	Grains.	Diameter in inches.	Areas.	Grains.
1·0	0·785400	198·8499282	3·8	11·341176	2871·3929632	6·6	34·212024	8661·9028724	9·4	69·397944	17570·3796557
1·1	0 950334	240·6084131	3·9	11·945934	3024·5074079	6·7	35·256606	8926·3732769	9·5	70·882350	17946·2060290
1·2	1·130976	286·3438966	4·0	12·566400	3181·5988512	6·8	36·316896	9194·8206800	9·6	72·382464	18326·0093829
1·3	1·327326	336·0563787	4·1	13·202574	3342·6672930	6·9	37·392894	9467·2450816	9·7	73·898286	18709·7897443
1·4	1·539384	389·7458593	4·2	13·854456	3507·7127334	7·0	38·484600	9743·6464818	9·8	75·429816	19097·5471043
1·5	1·767150	447·4123384	4·3	14·522046	3676·7351724	7·1	39·592014	10024·0248805	9·9	76·977054	19489·2814629
1·6	2·010624	509·0558162	4·4	15·205344	3849·7346099	7·2	40·715136	10308·3802779	10·0	78·540000	19884·9928200
1·7	2·269806	574·6762925	4·5	15·904350	4026·7110460	7·3	41·853966	10596·7126738	10·1	80·118654	20284·6811757
1·8	2·544696	644·2737674	4·6	16·619064	4207·6644807	7·4	43·008504	10889·0220682	10·2	81·713016	20688·3465299
1·9	2·835294	717·8482408	4·7	17·349486	4392·5949139	7·5	44·178750	11185·3084612	10·3	83·323086	21095·9888827
2·0	3·141600	795·3997128	4·8	18·095616	4581·5023457	7·6	45·364704	11485·5718528	10 4	84·948864	21507·6082341
2·1	3·463614	876·9281834	4·9	18·857454	4774·3867761	7·7	46·566366	11789·8122430	10·5	86·590350	21923·2045840
2 2	3·801336	962·4336525	5·0	19·635000	4971·2482050	7·8	47·783736	12098·0296317	10·6	88·247544	22342·7779325
2·3	4·154766	1051·9161202	5·1	20·428254	5172·0866325	7·9	49·016814	12410·2240190	10·7	89·920446	22766·3282796
2·4	4·523904	1145·3755864	5·2	21·237216	5376·9020585	8·0	50·265600	12726·3954048	10·8	91·609056	23193·8556252
2·5	4·908750	1242·8120512	5·3	22·061886	5585·6944831	8·1	51·530094	13046·5437892	10·9	93·313374	23625·3599694
2·6	5·309304	1344·2255146	5·4	22·902264	5798·4639063	8·2	52·810296	13370·6691722	11 0	95·033400	24060·8413122
2·7	5·725566	1449·6159766	5 5	23·758350	6015·2103280	8·3	54·106206	13698·7715537	11·1	96·769134	24500·2996535
2·8	6·157536	1558·9834371	5·6	24·630144	6235·9337483	8·4	55·417824	14030·8509338	11·2	98·520576	24943·7349934
2·9	6·605214	1672·3278962	5·7	25·517646	6460·6341672	8·5	56·745150	14366·9073124	11·3	100·287726	25391·1473318
3·0	7·068600	1789·6493538	5·8	26·420856	6689·3115846	8·6	58·088184	14706·9406897	11·4	102·070584	25842·5366689
3·1	7·547694	1910·9478100	5·9	27·339774	6921·9660006	8·7	59·446926	15050·9510655	11·5	103 869150	26297·9030044
3·2	8·042496	2036·2232648	6·0	28·274400	7158·5974152	8·8	60·821376	15398·9384398	11 6	105·683424	26757·2463386
3·3	8·553006	2165·4757181	6·1	29·224734	7399·2058283	8·9	62·211534	15750·9028127	11·7	107·513406	27220·5666713
3·4	9 079224	2298·7051700	6·2	30·190776	7643·7912400	9·0	63·617400	16106 8441842	11·8	109·359096	27687·8640026
3·5	9·621150	2435·9116204	6·3	31·172526	7892·3536503	9·1	65·038974	16466·7625542	11·9	111·220494	28159·1383324
3·6	10·178784	2577·0950695	6·4	32·169984	8144·8930591	9·2	66·476256	16830·6579228	12·0	113·097600	28634·3896608
3·7	10·752126	2722·2555171	6·5	33·183150	8401·4094664	9·3	67·929246	17198·5302900			

In cases where the circularity of the mouth of the funnel and uniformity in the section of the cylinder may be relied on, a much simpler rule will suffice. If, for example, the diameter of the funnel be eight inches, and the diameter of the cylinder four inches, then as the areas of circles are to each other as the squares of their diameters—or in this case, as 64 : 16,—one inch of fall in the funnel will raise the float in the cylinder four inches, and this might be cut on the stick without more ado,—the float-stick being so divided all along from end to end. The correctness of a cylinder may be tested in a way analogous to that in which thermometer tubes and test glasses and measures are gauged. Fit it up with a float and stick, place a couple of cross sticks over its mouth, with two pins through, or one stick with a hole in it, so as in either case to guide the eye. Then take a narrow-necked phial or bottle, no matter of what capacity, as a measure, and pour in successive fills of this till the cylinder is full: if the float rises, as indicated by the scale, the same distance on the addition of each fill, then the cylinder is uniform.

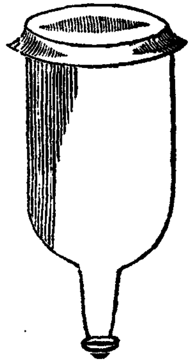
There is scarcely an implement so universal, or so simple in its form, as the Native Turning Lathe, or so perfectly trustworthy in the work it turns out. The native turner is always familiar with the application of lacquer in the lathe. Brass casting and turning are almost universally understood, and a brass mouthpiece will serve as well as a cast iron one. When brass is not to be had, a well lacquered wooden mouthpiece may be procured, and will be found to answer perfectly either for a rain-gauge or evaporating dish. The native turner will for that matter make an excellent wooden funnel without trouble, only care must be taken to have it thoroughly lacquered to prevent absorption. A mouthpiece may be fitted to a broken bottle, if nothing else is obtainable: the size is matter of little consequence, as the indications may be computed from the tables.



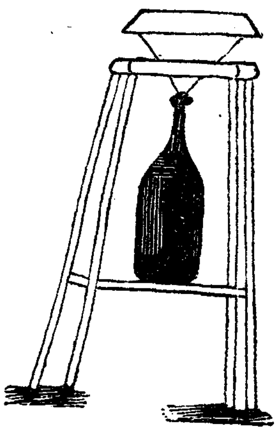
A SECTION OF MOUTH-PIECE TO FUNNEL.



FUNNEL, WITH CAST-IRON MOUTH-PIECE.



BROKEN BOTTLE USED AS A FUNNEL, WITH TURNED MOUTHPIECE.



FUNNEL AND BOTTLE ON A STAND.

THE BAROMETER.

THE Barometer is the most important, troublesome, and delicate, instrument the Meteorologist has to deal with. It is next to impossible to make it strong, or other than liable to accidents: instruments of more ordinary construction, and in perfectly good order, may be source of amusement, but are of no value to science. Barometers are of various kinds: the Standard Barometer, used in all the great Magnetic Observatories at Bombay, Simla, Lucknow, Calcutta (the Surveyor-General's office,) Madras and Trevandrum, is a very large and ponderous instrument. The frame consists of two heavy brass side-pieces, which are hollow. They are coupled together at top, and fixed at the bottom to the cistern cover. The tube is half an inch in bore, and nearly an inch thick: it is naked from end to end. The cistern consists of an upper and lower chamber, as in the case of Newman's portable Barometers. When the instrument is meant to be moved, it is carefully inverted, so as to permit all the mercury lodged in the lower to flow into the upper chamber. The lower end of the Barometer is then turned half a circle round, and the communication previously existing betwixt the two cut off. The mercury is now confined in the tube, into which no air can conveniently find admission. The scale is metal: it is attached by a brass rod, terminating in an ivory point, which extends from the top of the mercury in the tube, the lower part terminating in that of the cistern. The sides of the upper cistern are glass. In adjusting this instrument for observation, the scale is moved up and down till the ivory point just comes in contact with the surface of the quicksilver as seen through the glass. The reading is then made in the usual way by the vernier. The attached thermometer, both in this case, and in that of Newman's portable Barometer, is inserted in the cistern—an arrangement now condemned by Sir J. Herschell,—it is continually fraught with risks to the instrument when it is taken to pieces. The following comparisons of Barometers provided in 1840 by the East India Company with the Standards of the Royal Society, is extracted from the Report on Physics for 1840 :—

Comparisons of Standards with the Royal Society's, made for the Honourable the East India Company, in April, 1840.

Royal Society's Standard.			Standard, No. 48.		Standard, No. 49.	
Barom. Flint Glass.	Barom. Crown Glass.	Att. Ther.	Barom.	Att. Ther.	Barom.	Att. Ther.
30·408	30·400	48·2	30·426	45·7	30·400	45·9
30·368	30·360	47·8	30·380	46·6	30·364	46·6
30·346	30·338	48·0	30·356	47·0	30·340	47·0
30·258	30·250	50·0	30·274	46·2	30·250	46·3
30·134	30·128	48·8	30·150	47·8	30·130	48·0
29·918	29·912	49·2	29·938	48·7	29·924	48·8

Comparisons made with the Royal Society's Standard, of various Standard and Mountain Barometers, for the Honourable the East India Company, (made in February, 1840.)

Royal Society's Standard.			Standard, No. 37.		Standard, No. 38.		Standard, No. 40.		Standard, No. 41.		Standard, No. 42.		Standard, No. 43.	
Barom. Flint Glass.	Barom. Crown Glass.	Att. Ther.	Barom.	Att. Ther.	Barom.	Att. Ther.	Barom.	Att. Ther.	Barom.	Att. Ther.	Barom.	Att. Ther.	Barom.	Att. Ther
30·450	30·442	37·9	30·458	38·6	30·440	38·4	30·466	38·7	30·458	38·4	30·458	38·0	30·456	38·8
30·450	30·444	37·6	30·456	38·2	30·442	37·9	30·468	38·5	30·458	37·9	30·458	37·7	30·452	38·4
30·458	30·450	37·2	30·460	38·0	30·454	38·2	30·468	38·5	30·468	38·0	30·462	37·5	30·458	38·4
30·452	30·446	36·6	30·456	37·2	30·452	37·0	30·472	37·3	30·464	37·0	30·458	36·7	30·452	37·2
30·434	30·426	36·9	30·438	37·3	30·428	37·5	30·452	37·7	30·444	37·3	30·436	37·0	30·436	37·6

Comparisons of Mountain Barometers corresponding with the above Standards.

Mountain, No. 40.		Mountain, No. 41.		Mountain, No. 42.		Mountain, No. 43.		Mountain, No. 44.	
30·380	38·6	30·438	38·9	30·350	38·8	30·426	38·8	30·424	39·0
30·392	38·2	30·432	38·4	30·348	38·3	30·432	38·3	30·426	38·6
30·390	37·8	30·432	38·2	30·346	38·2	30·340	38·4	30·422	38·3
30·390	36·9	30·432	37·5	30·350	37·2	30·438	37·3	30·426	37·4
30·384	37·0	30·420	37·6	30·432	37·4	30·424	37·5	30·418	37·6

What is called the portable, or Mountain Barometer, differs only from the others in having a longer scale, so as to read under very low pressures—it being cut with great accuracy, and prepared in all respects with the utmost care.

The following is the description of Newman's Barometer, given by himself: it is a very popular instrument, and is generally neatly finished; but the correction for capacities is troublesome, and is apt to burst when the mercury is shut up at a low temperature and then exposed to a high one. The mercury sometimes leaks at the screws of the lower cistern, which are often pierced through, but never should be so. The remedy for this, when it occurs, is to invert the Barometer and turn it to "not portable," take out the screws, and fill the thread with a little bees-wax—if this is not sufficient, with a fine film of flax. The instrument is troublesome to take to pieces when it gets out of repair.

This instrument differs in its construction from the Englefield Barometer, in the adoption of a double iron cistern with a solid bottom, in lieu of the wooden cistern and leather bag; and a few instructions for its use will be necessary, as the method of rendering it portable differs also. In the old instrument a screw at the bottom compresses the whole of the mercury in the cistern, as well as in the tube, frequently forcing it through the pores of the wood, and rendering the barometer useless: in the new instrument this defect has been remedied; and with great simplicity the mercury is secured for travelling, or set at liberty for use, by holding the instrument with the cistern end upwards, and moving the upper part from left to right, making the word *portable*, engraved on the cistern, coincide with the *stop*; or by a contrary motion, bringing the words *not portable* opposite the *stop* when the instrument is intended for use.

The instrument also varies from the common barometer, being a *standard* of itself, the actual distance between the height of the mercury in the tube and the level in the cistern having been measured without a reference to any other barometer; so that by applying the corrections as hereafter mentioned, you obtain the actual height of the column. Care should be taken to hold the instrument with the cistern end upwards, when it is intended to be made portable for travelling, otherwise the mercury will be left at liberty, which will endanger the instrument. And it is important, when the barometer is moved or carried, that it be retained either in a horizontal position, or with the cistern end extremely raised; this prevents the oscillation of the mercury in the tube.

To observe with the instrument, it is most advisable to suspend it, by the ring on the top, from some fixed and steady projection, in a perpendicular position; but, if such a situation do not offer, it may be suspended with the hand, letting the lower end rest lightly on the ground, and then, by kneeling on one knee, the index may be brought to a level with the surface of the mercury, being at first moved by the small projecting piece on the edge to nearly its correct situation; and finally adjusted by means of the tangent screw on the top. Great care should be taken in placing the index accurately, with respect to the surface of the mercury, and it is advisable to use a magnifier, when the situation will allow.

When the index has been made to coincide accurately with the surface of the mercury, the inches are of course read off upon the numbered scale; the tenths are read off upon those divisions, which extend from the first to the third perpendicular line, counting upwards from the top of the inch, and reckoning as many tenths as occur short of the index: if any portion remain between this tenth and the index, it may be estimated in hundredths; this space will include one of the half-tenth graduations, if the hundredths be more than five in number; but a half-tenth will not be included if they be less than five in number; the half-tenth in fact being equal to five hundredths. For the estimation of the hundredth, pass the eye up the graduations of the vernier, looking for that *numbered* degree which coincides or nearest coincides, with any graduation upon the large scale, and such degree will express the number of hundredths upon the vernier; thus, if the line, marked 3, coincide, it indicates three hundredths, and this is the correct expression if there be no half-tenth as before mentioned; but, if there be a half-tenth, then the five hundredths of which it is composed are to be added to the three in the vernier, making eight hundredths, which are to be added to the inches and tenths before observed, and noted.

By means of the divisions on the vernier, each of the hundredths is divided into five parts, or five hundredths, and are here read off; thus it may happen that the coincidence of a line on the vernier, with a line on the scale, does not take place with any of those numbered on the vernier, but with one of the smaller unnumbered divisions; it may happen, for instance, with a line between the third and fourth hundredth on the vernier, and then it is evident that three hundredths are too little, and four hundredths too much; in this case, read upwards from the lowest hundredth, to the line which coincides, and it will express the five hundredths; each of which, if written as decimals, will count as two thousandths.

But in most cases the mercury will stand either above or below the neutral point; if above, a portion of the mercury, which has entered the tube, must have left the cistern, and consequently have altered and lowered the surface there; or if below, a quantity of mercury must have left the tube, and, entering the cistern, have raised the level of the mercury to it.

For the corrections of observations thus circumstanced, the area of the mercury in the cistern, and that in the tube, have been experimentally ascertained, and are expressed by the number marked on the instrument, and called capacities: thus capacity 1-50 indicates that the surface of the mercury in the cistern is fifty times that in the tube; hence it is evident, that for every inch of elevation of the mercury in the tube, that in the cistern will be depressed 1-50 of an inch: for this, correction is made in the following manner:—When the mercury in the tube is above the neutral point, the difference between it and the neutral point is to be divided by the capacities, and the quotient *added* to the observed height, the result being the true height; or if the mercury, at the time of observation, is below the neutral point, the difference of the two is to be divided by the capacities as before, and the quotient is to be *subtracted* for the observed height, the result is the true height. Thus suppose the capacity 1-50, the neutral point 30 inches, and the observed height 30.500, the difference between 30 and 30.5, is 0.5 inches, which divided by 50 gives .010 inches, and this added to the observed height, =30.510 the true height; or if the observed height be 29 inches, then the difference, 1 inch, divided by 50 gives .020, which subtracted from the observed height, gives 28.980 inches, as the true height.

The Grand Arsenal at Bombay is provided with them: they have a stock of unfilled tubes, with wooden cistern covers, and Thermometers attached, to supply the place of those that may be broken; but as these are charged Rs. 25 each, and are very apt to be destroyed in process of fitting, it is almost as well to obtain a new Barometer at once as to incur the expense, the trouble, and the risk, of repairing an old one.*

Four Barometers by Newman were in November 1849 lent to the Bombay Geographical Society : the following are their ratings, as compared with a portable Barometer by Adie, (No. 3 in the table) the ratings of which, with the Observatory Standard (58) in 1843, are also given at page 36. I had no means of comparing Newman's Barometer directly with the Observatory Standard in 1849 :—

The manner of rating them was the following :—They were hung up beside each other on a stone wall, where the fluctuations of temperature were small and slow, and read at intervals of an hour or so as undernoted. The Standard, as already described, is a very excellent instrument by Adie : it was brought out in 1843, and by comparing a register of ratings then made for 24 hours on end with the Observatory Standard, and comparing this again with the reports published in the newspapers, it does not appear to have deteriorated, or changed its ratings. The results were the following : three readings are given to begin with without correction : the first trial was in the *Times* Office :—

No. I.—Capacities $\frac{1}{62}$—Neutral Point, 29·720.

May 30.		10 A. M.	4 P. M.	6 P. M.	Mean.
	Standard	29·796	.742	.784	.772
	No. I.	.808	.768	.778	.778
		+.012	+.026	—.006	+.006

Correcting for capacities the following will be the result. Newman's Mountain Barometers are not mentioned. The instruments used are indicated by the figures denoting the neutral points and capacities. The correction in this case requires to be added, and so brings the corrected above the uncorrected reading.

Capacity...	·720		·768		·778	
Reading....	·801	·808	·720	·768	·720	·778
	62) ·081(	·010	62) ·048(	·008	62) ·058(	·009
		·818		·776		·787
	Standard....	·796	Standard...	·742	Standard...	·784
		+·022		+·034		+·003

* Any one ordering instruments from home ought to specify the packing, and bargain that unless his orders in the matter were attended to the risk should devolve on the maker. I have opened packages without number from nearly every maker of note—they are all equally culpable—they pay no heed to the instructions sent them, and it is quite inconceivable the unskilfulness, not to say the gross negligence, with which instruments are put up. Frequently nearly a third of them are unserviceable when they arrive, and here we have no means of repairing them. I have purchased first-rate register thermometers in the bazar for two rupees, so little out of order that in an hour's time I repaired them: so it is with barometers and all other instruments. I believe matters are comparatively well managed in Calcutta: I know not how they are in Madras, but to a stranger, or to any one who for the first time enters into scientific researches, our helplessness at Bombay is absolutely inconceivable. The subject of providing or repairing instruments of any sort is one to which no human being ever seems to have turned his attention. No wonder that research should be behind, considering the difficulties it has to encounter.

The mean difference by this series would be .026.

Second trial, same instruments, June 6th.—In this case the trial was made at Airy Cottage, Byculla, about 40 feet lower than before.

June 6.

	9 a. m.	10 a. m.	12	1 p. m.	3 p. m.	4 p. m.
Standard	29.913	916	890	870	846	852
No. I.	924	922	900	862	828	848
	+011	+006	+010	—008	—018	—004

Or, with correction for Capacities, as follows :—

924	922	900	862	828	848
720	720	720	720	728	720
204	202	180	142	100	128
.030	.030	.029	.028	.019	.020
954	952	929	890	847	868

The mean difference on the two sets of readings amounts to .024, and at this the rating may be set down—to be subtracted from No. I. to bring it into harmony with the Standard.

Taking the same examples for the other—out of a multitude of hourly readings to which they were subjected—all of which are kept on record, we find the following result :—May 30.

No. II.—Cap. 54—N. P. 29.850.

	½ P. 1.	4	6	Mean.
Standard	796	742	784	771
No. II.	774	743	772	727
	—022	+001	—012	—044

Or, corrected for capacities, which in this case must be subtracted, the Neutral Point being higher than the Scale Readings, the following :—This gives the mean correction at about .030 for No. II.—No. III., the instrument sent to Phoonda Ghaut, was only a few hours in my possession—its difference from the standard in two readings at ½ P. 1 and 4, on the 30th May, was .004 and .030 respectively—corrected for capacities .000 and +.008 : this instrument may be set down therefore as not differing more than .006 from the Standard, a correction so trifling as not to be worth note. It is at Phoonda Ghaut.

No. IV., as before stated, is at Kurrachee. It has been correected with the utmost care : the results arrived at are anomalous and perplexing. A single day's readings out of the many to which it was subjected may suffice. It was obtained from the Grand Arsenal in January, the time when directions had been given to place the Tide-Gauges received on the 9th April at our disposal.

No. IV.—$\frac{1}{64}$—Neutral point 29.852.

Jan. 25th		10	½ p. 10	11	1	2	4
	Standard	30.150	160	092	070	062	052
		182	192	115	100	100	084
		+032	+032	+023	+030	+038	+032

The mean difference here is +.030 nearly—to this must be added the correction for capacities, giving a total of ·026 to be subtracted from the readings of No. IV. The correction for the barometer by Adie, used by Mr Mayes at Aden, is—·032 as compared by Mr Orlebar with the Observatory Standard No. 58.

The following are the ratings of eight of Adie's Barometers, taken with the Observatory Standard in 1843. These instruments were all brought out together for the use of gentlemen at the presidency :

they are now in use, and dispersed up and down the country—those possessing them may refer to this table for corrections, it having already been printed in the Transactions of the Asiatic Society :—

OBSERVED READINGS OF EIGHT BAROMETERS (HALF-HOURLY), FROM 4 A. M. 20TH JUNE TO 3½ P. M. 21ST JUNE 1843.—Colaba Observatory, Long. 72° 49′ 53″ E., Lat. 18° 53′ 52″ N. Elevation above the sea, 36 feet.

B.M.T.		Standard.		No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.		Sympiesomr.	
		Bar.	Thr.	Bar.	Thr.	Bar.	Thr.	Bar.	Thr	Bar.	Thr.	Bar.	Thr	Bar.	Thr.	Bar.	Thr.	Bar.	Thr.	Symp.	Thr.
A.	M.		deg.		deg.		deg.		deg.		deg.		deg.		deg.		deg.		deg.		deg.
4	0	29·580	83·5	29·694	82·0	29·698	81·8	29·698	81·8	29·650	81·7	29·700	81·7	29·700	81·6	29·730	81·8	29·684	81·5	29·24	82·5
4	30	·590	83 2	·712	81·7	·720	81·5	·714	81·6	·658	81·5	·712	81·5	·716	81·5	·728	81·6	·690	81·3	·28	82·3
5	0	·590	83·1	·720	81·5	·720	81 5	·720	81·5	·680	81·5	·720	81·6	·716	81·5	·710	81·5	·712	81·1	·26	82·0
5	30	·600	82·8	·742	81·2	·760	81·0	·760	81·2	·736	81·2	·760	81·2	·760	81·2	·736	81·2	·720	81·0	·28	81·8
6	0	·614	82·4	·748	81·1	·762	88·0	·768	81·1	·746	81·1	·768	81·0	·772	81·0	·750	81·0	·732	81·0	·30	81·7
6	30	·626	82·3	·752	81·2	·768	81·2	·774	81·0	·750	81·0	·774	81·2	·780	81·2	·782	81·2	·742	81·0	·30	81·8
7	0	·630	82·2	·762	81·8	·770	81·9	·776	81·8	·754	81·9	·776	81·9	·784	82·0	·784	82·0	·746	81·8	·31	82·0
7	30	·632	82·7	·768	82·5	·778	82·5	·780	82·5	·760	82·4	·780	82·4	·790	82·5	·790	82·2	·750	82 1	·30	82·6
8	0	·634	83·2	·774	82·6	·780	82·7	·784	82·7	·766	82·7	·784	82·6	·794	82·7	·792	82·7	·758	82·8	·28	82·9
8	30	·640	83·7	·778	82·8	·784	82·9	·790	82·8	·770	82·8	·790	82·8	·798	82·8	·799	83·0	·770	83·0	·28	83·2
9	0	·646	84·6	·782	84·0	·780	84·0	·792	84·5	·774	84·2	·792	84·3	·799	84·4	·800	84·7	·774	84·9	·28	84·6
9	30	·632	85·2	·760	85·2	·770	84·8	·760	84·2	·756	84·9	·774	84·8	·776	84·8	·780	84·9	·760	85·0	·24	85·0
10	0	·622	85·7	·740	84·9	·744	84·8	·742	84·8	·709	84·7	·756	84·7	·750	84·8	·760	84·7	·750	85·4	·22	85·1
10	30	·620	86·0	·728	84·8	·739	84·5	·739	84·5	·700	84·5	·743	84·5	·744	85·0	·758	85·0	·746	85·3	·20	84·1
11	0	·610	86·2	·723	85·5	·736	85·3	·728	85·5	·690	85·4	·734	85·4	·736	85·6	·746	85·6	·740	86·0	·17	85·5
11	30	·610	86·6	·728	85·0	·738	84·8	·728	85·0	·698	84·8	·736	84·8	·736	85·2	·740	85·4	·737	86·0	·17	85·7
P.	M.																				
0	0	·602	86·5	·719	85·5	·725	85·0	·730	85·0	·680	85·2	·730	85·2	·729	85·7	·738	85·7	·730	86·2	·16	85·7
12	30	·587	87·0	·702	86·1	·705	85·8	·711	85·8	·665	86·0	·712	86·0	·711	86·3	·728	86·3	·719	86·8	·13	86 3
1	0	·574	87·3	·692	86·5	·700	86·3	·700	86·3	·688	86·3	·700	86·3	·700	86·5	·712	86·5	·718	87·0	·11	86·7
1	30	·575	87·6	·690	86·5	·700	86 3	·700	86·5	·688	86·3	·700	86·3	·700	86·5	·710	86·5	·706	87·1	·10	86·9
2	0	·570	87·8	·686	85·8	·691	85·7	·695	85·8	·678	85·5	·696	85·5	·694	85·9	·703	86 0	·702	86·5	·10	86·5
2	30	·560	87·5	·673	85·5	·678	85·3	·684	85·3	·671	85·2	·680	85·2	·681	85·5	·691	85·5	·690	86·2	·11	86·2
3	0	·561	87·2	·672	85·5	·680	85·3	·684	85·6	·673	85·2	·688	85·3	·684	85·5	·698	85·5	·692	86·2	·11	86·0
3	30	·552	87·2	·664	85·4	·670	85·1	·670	85·2	·656	85·1	·680	85·2	·676	85·5	·690	85·5	·688	86·0	·11	86·0

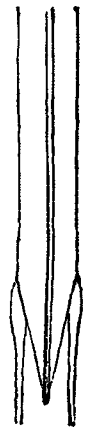
The Standard was found by this report to contain an air-bubble, and to be 00·125 too low.

OBSERVED READINGS OF EIGHT BAROMETERS (HALF-HOURLY), FROM 4 P. M. 20TH JUNE TO 4 A. M. 21ST JUNE, 1843.—Colaba Observatory, Long. 72° 49′ 53″ E., Lat. 18° 53′ 52″ N. Elevation above the sea, 36 feet.

B.M.T.		Standard.		No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.		Sympidsemr.	
		Bar.	Thr.	Bar.	Thr	Bar.	Thr.	Bar.	Thr.	Bar.	Thr.	Bar.	Thr.	Bar.	Thr	Bar.	Thr.	Bar.	Thr.	Symp.	Thr.
P.	M.		deg.		deg.		deg.		deg.		deg.		deg.		deg.		deg		deg.		deg.
4	0	29·546	87·1	29·658	85·1	29·660	85·0	29·669	85·0	29·656	84·8	29·670	85·9	29·670	85·3	29·680	85·1	29·680	85 9	29·11	85·8
4	30	·542	86·8	·650	84·9	·654	84·8	·660	84·8	·642	84·7	·662	84·8	·658	84·8	·672	84·9	·674	85·0	·13	85·4
5	0	·548	86 6	·656	84 5	·660	84·6	·662	84·5	·650	84·2	·664	84·3	·662	84·4	·678	84·5	·680	84·6	·14	84·6
5	30	·544	85·8	·652	84·1	·660	84·2	·654	84·1	·654	83·9	·660	84·0	·658	84·0	·670	83·9	·672	84 0	·12	84·1
6	0	·544	85·2	·650	83·7	·658	83·6	·650	83·5	·658	83·7	·660	83·6	·660	83·7	·672	83·6	·672	83·7	·12	84·3
6	30	·558	85·0	·656	83·5	·662	83·5	·668	83·4	·668	83·4	·672	83·5	·672	83·5	·690	83·4	·686	83·5	·14	84·2
7	0	·570	84·9	·690	83·4	·692	83·4	·690	83·4	·686	83·3	·698	83·4	·700	83·5	·712	83·4	·708	83·4	·16	84·2
7	30	·574	84·4	·706	83·4	·704	83·4	·700	83·3	·710	83·3	·714	83·4	·716	83·3	·730	83·3	·720	83·4	·18	84·1
8	0	·578	84 2	·712	83·0	·698	82·9	·694	83·0	·708	83·0	·698	83·0	·724	83·3	·728	83·5	·704	83·8	·20	83·8
8	30	·583	84·0	·700	82·3	·700	82·4	·700	82 5	·692	82·5	·710	82·5	·710	83·3	·717	82·5	·708	82·9	·22	83·3
9	0	·590	83·2	·709	81·9	·706	81·9	·718	81·9	·700	82·0	·728	82·5	·720	88 7	·732	81·9	·704	82·9	·24	82·7
9	30	·613	83·0	·728	81·5	·720	81·5	·730	81·5	·718	81·7	·744	81·7	·735	82·9	·750	81·5	·735	82·0	·27	82·3
10	0	·612	83 0	·732	81·8	·730	81·5	·740	81·5	·721	81·8	·742	82·0	·744	82·0	·754	81·5	·735	81·8	·29	82·2
10	30	·600	82·7	·720	81·5	·723	81·5	·726	81·6	·722	82·2	·740	82 5	·732	82·3	·754	81·5	·730	81·9	·26	82·2
11	0	·602	82·7	·722	81·2	·726	81·4	·728	81·5	·726	82·4	·742	82·5	·736	82·8	·770	81·9	·738	81·8	·26	82 4
11	30	·600	82·8	·730	81·6	·736	81·8	·736	81·9	·736	82·4	·746	82·4	·740	82·7	·776	82·0	·742	82·0	·27	82·7
A.	M.																				
0	0	·593	83·0	·724	82·4	·724	82·3	·722	82·3	·726	82·5	·728	82·7	·726	82·8	·760	82·5	·732	82·4	·24	83·2
12	30	·576	83·0	·700	82·4	·710	82·4	·700	82·4	·700	82·6	·712	82·6	·704	82·7	·740	82·5	·722	82·2	·23	83·4
1	0	·560	83·1	·690	82·2	·688	82·2	·690	82·2	·696	82·4	·686	82·4	·684	82·5	·700	82·2	·700	82·1	·20	83·0
1	30	·550	83·0	·670	82·5	·660	82·4	·675	82·4	·668	82·5	·680	82·6	·680	82·5	·700	82·3	·690	82·1	·20	83·0
2	0	·562	83·0	·678	82·0	·667	82·0	·670	82·2	·658	82·5	·688	82·5	·689	82·5	·698	82·5	·683	82·2	·20	82·7
2	30	·555	83·0	·670	82·0	·672	82·0	·672	82·0	·658	82·3	·682	82·3	·670	82·3	·690	82 9	·688	82·0	·20	82·7
3	0	·548	82·9	·664	82·0	·668	81·9	·672	82·2	·660	82·3	·680	82·2	·670	82·2	·688	81·9	·680	82·0	·20	82·4
3	30	·550	82·7	·660	81·5	·660	81·5	·668	81·5	·660	82·0	·680	82 0	·676	82·0	·700	81·6	·680	81·8	·21	82·2
4	0	·550	82·8	·676	81·9	·676	81·5	·674	81·6	·660	81·9	·678	81·7	·674	81·9	·702	81·5	·682	81·8	·22	82·1

The Standard was found by this report to contain an air-bubble, and to be 00·125 too low.

The Marine Barometer differs from that used on shore chiefly in the circumstance of the tube betwixt the top of the cistern and the bottom of the scale being capiliary, to prevent the Mercury from jumping up and down by the movements of the ship. There is a neat contrivance, which may be termed an air-trap, a little way up : here the main tube is drawn out fine to a point, and a second one welded to it, so that the great likelihood is that any air entering from below will lodge between the two. So soon as the instrument is inverted, of course the air escapes. Air, notwithstanding this, is very apt indeed to get into the Marine Barometer, rendering it perfectly useless, the Mercury remaining fixed and immoveable. From the thinness of the tube, it is extremely troublesome to get rid of it. The following is the mode of setting it to rights when out of order.



First take off the cover of the cistern, which consists of two pieces of wood screwed together, with a slip of paper glued around them. The lower piece is a ring fitted up with a leather bottom. Take off the glued slip by the use of tepid water, and then screw off the ring and leather bag. Pour out the Mercury from the bag and clean it by filtration. It is very seldom indeed that tapping will remove the air, or produce any beneficial effect whatever. The cistern must be well filled with pure mercury, so as quite to cover the end of the tube, and as much of it shaken in as possible. Then put the tube in a bath of water or oil, and raise the temperature gradually till the air is expelled. On permitting the instrument to cool, the mercury will pass from the cistern into the tube. If necessary, the boiling of the Mercury within the tube must be resorted to.

The Marine Barometers sent out with the Antartic Expedition were of the same construction as the Mountain Barometer. I have heard of no others that have been made without the leather bag. Some very fine Mountain Barometers, both by Adie and Newman, in use at Bombay, of recent construction, are cumbered with this inconvenient contrivance, which prevents the possibility of correcting for capacities, and rarely permits an accurate correction for any definite pressure ; and which being, moreover, apt to expand in damp, and shrink in dry weather, gives a variable neutral point, the precise position of which cannot be discovered. The Barometers lately ordered out by the Geographical Society are provided with cast iron cisterns, of capacities so large that the correction would in the ordinary range of three inches, the extreme of which occurs at sea, scarcely be applicable, but which could be made with perfect accuracy where this was desired.

In some of Mr Newman's Mountain Barometers the scale traverses and the vernier remains at rest—the mode and results of ratings is unaffected by this. The scale is thus made completely to cover in the tube. The contrivance is very elegant,—as indeed are Newman's instruments altogether.

Where Newman's Barometers are made use of at a position where the entire range does not exceed an inch, and where the year may be divided into two parts, during one of which it never falls more than ·4 below the maximum, the rest of the depression being assigned to the rest of the year, it is much easier to construct a table and include all the corrections in one, reserving the trivial error for a separate correction if deemed necessary—it seldom exceeds 00·001, under the circumstances named, and may therefore be dispensed with. Take the following illustrations of what is meant. At Hay Cottage, Poonah, 1823 feet above the level of the sea, it was for the year 1830, 28·242 ; for the monsoon 28·080. Suppose the Barometer No. I. the instrument to be made use of there ; the mean correction for capacities for the fair season would be as follows—neutral point of the instrument 29·720 ; the difference betwixt this and the monsoon mean is 1·640 : this requires to be divided by 62 the capillarities, when the quotient will be ·264 ; which added to the reading of the instrument, would give the true reading for the monsoon. The correction for the year again would be ·238, or ·026 less than that for the monsoon ;* the difference betwixt the fair weather and monsoon mean would of course be greater than that betwixt the latter and the whole year. Corrections such as these added for those of temperature, will supply matter for a new table to be consulted by the observer,—the use of which at once will occasion little error and avoid a world of trouble. The capillarity correction is now generally introduced in the scale —in the case of Adie's instruments it is neutralized by the instru-

* Colonel Sykes's Atmospherical Tides of the Deccan. Royal Society's Transactions, 1834.

ment, as it is a certain quantity: when this is not the case, it ought to be included in the general table.

The following are Sir J. Herschell's directions for the use of the Barometer:—

THERE is no branch of physical science which can be advanced more materially by observations made during sea voyages than meteorology, and that for several distinct reasons. 1stly. That the number and variety of the disturbing influences at sea are much less than on land, by reason of the uniform level and homogeneous nature of its surface. 2ndly. Because, owing to the penetrability of water by radiant heat, and the perpetual agitation and intermixture of its superficial strata, its changes of temperature are neither so extensive nor so sudden as those of the land. 3rdly. Because the area of the sea so far exceeds that of the land, and is so infinitely more accessible in every part, that a much wider field of observation is laid open, calculated thereby to afford a far more extensive basis for the deduction of general conclusions. 4thly. The sea being the origin from which all land waters are derived, in studying the hygrometrical conditions of the sea atmosphere, we approach the chief problems of hygrology in their least involved and complicated form, unmixed with those considerations which the perpetually varying state of the land (as the recipient at uncertain intervals of derivative moisture) forces on the notice of the meteorologist of the continents. Nor ought it to be left out of consideration that this, of all branches of physical knowledge, being that on which the success of voyages and the safety of voyagers are most immediately and unceasingly dependant, a personal interest of the most direct kind is infused into its pursuit at sea, greatly tending to relieve the irksomeness of continued observations, to insure precision in their registry, and to make their partial or complete reduction during the voyage an agreeable as it always is a desirable object.

It happens fortunately, that almost every *datum* which the scientific meteorologist can require is furnished in its best and most available state by that definite, systematic process, known as the "*keeping a meteorological register*," which consists in noting at stated hours of every day the readings of all the meteorological instruments at command, as well as all such facts or indications of wind and weather as are susceptible of being definitely described and estimated without instrumental aid. Occasional observations apply to occasional and remarkable phenomena, and are by no means to be neglected; but *it is to the regular meteorological register, steadily and perseveringly kept throughout the whole of every voyage, that we must look for the development of the great laws of this science.*

The following general rules and precautions are necessary to be observed in keeping such a register:—

1. Interruptions in the continuity of observations by changes of the instruments themselves, or of their adjustments, places, exposure, mode of fixing, reading, and registering, &c., are exceedingly objectionable, and ought to be sedulously avoided. Whenever an alteration in any of these particulars is indispensably necessary, it should be done as a thing of moment, with all deliberation, scrupulously noted in the register, and the exact amount of change thence arising in the reading of the instrument (whether by alteration in its zero point, or otherwise) ascertained.

2. As far as possible, registers should be complete: but if, from unavoidable causes, blanks occur, no attempt to fill them up subsequently from general recollection, or (which is worse, and amounts to a falsification) from the apparent course of the numbers before and after, should ever be made. The entries in the register made at the time of observation should involve no reduction or correction of any kind, but should state the simple readings off of the several instruments, and other particulars, just as observed. This does not of course prevent that blank columns left for reduced and corrected observations should be filled up at any convenient time. On the contrary, it is very desirable that such should be the case—the sooner after the observation, consistent with due deliberation, the better, on every account, unless some datum be involved requiring subsequent discussion for its determination.

3. The observations of each kind should, if possible, all be made by one person; but as this is often impracticable, the deputy should be carefully instructed by his principal to observe in the same manner, and the latter should satisfy himself by comparative trials that they observe alike.

4. If copies be taken of registers, they should be carefully compared with the originals by two persons—one reading aloud from the original, and the other attending to the copy, and then exchanging parts—a process always advisable when great masses of figures are required to be correctly copied.

5. The registers should be regarded (if kept in pursuance of orders, or under official recommendation) as official documents, and dealt with accordingly. If otherwise, a verified copy, or the original (the latter being preferred), signed by the observer, should be transmitted to some public body interested in the progress of meteorological science, through some official channel, and under address "*To the Secretary of* &c. &c." Circuitous transmission hazards loss or neglect, and entails expense on parties not interested.

6. The register of every instrument should be kept in parts of its own scale as read off; no reduction of foreign measures or degrees to British being made. But it should of course be stated what scale is used in each. British observers, however, will do well to use instruments graduated according to British units.

7. The regular meteorological hours are 3 A. M, 9 A. M., 3 P. M. and 9 P. M., mean time, at the place. Irksome as it may be to landsmen to observe at 3 A. M., the habits of life on shipboard render it much less difficult to secure this hour in a trustworthy manner; and the value of a register in which it is deficient is so utterly crippled, that whatever care be bestowed on the other hours, it must on that account hold a secondary rank. The above hours, it must be borne in mind, are the fewest which any meteorological register pretending to completeness can embrace. By any one, however, desirous of paying such particular attention to this branch of science as to entitle him to merit the name of a meteorologist, a three-hourly register—viz., for the hours 3, 6, 9, A. M., noon; 3, 6, 9, P. M., midnight—ought to be kept; and in voyages of discovery, where scientific observation is a prominent feature, the register ought to be enlarged, so as to take in every *odd* hour of the twenty-four; thus including, *without interpolation*, the six-hourly or standard series.

8. Hourly observations should be made throughout the twenty-four hours on the 21st of each month (except when that day falls on a Sunday, and then on the Monday following), commencing with 6 A. M., and ending at 6 A. M. on the subsequent day, so as to make a series of twenty-five observations. At all events, if this cannot be done monthly, it ought not to be omitted in March, June, September, and December. These are called "term observations." If any remarkable progressive rise or fall of the barometer be observed to pervade this series, it will be well to continue it until the maximum or minimum is clearly attained, with a view to comparison with other similar series elsewhere obtained, and thus to mark the progress of the aerial wave effective in producing the change. These term observations should be separately registered under that head.

9. Occasionally *hourly* series of observations may be made with advantage under several circumstances, as, for instance—1stly. When becalmed for any length of time, especially when near the Equator, with a view to determining the laws and epochal hours of diurnal periodicity. 2ndly. When a party leaves the ship, furnished with a portable barometer or other instruments, for the measurement of heights of mountains, or with other objects. 3rdly. During threatening weather, and especially during the continuance of gales, and for some time after their subsidence, as will be more particularly specified under the head of "Storm Observations." 4thly. In certain specified localities mentioned in a subsequent article by Mr Birt. 5thly. Whenever a *continued* rise or fall of the barometer has been noticed as at all remarkable, it should be pursued up to and past the turn, so as to secure the maximum elevation or depression, and the precise time of its occurrence; and a register of such maxima or minima should be kept distinct from the regular entries.

Of Meteorological Instruments; and first of the Barometer and its attached Thermometer.

The barometer on shipboard should be suspended on a gimbal frame, which ought not to swing too freely, but rather so as to deaden oscillations by some degree of friction. Before suspending it, it should be carefully examined for air-bubbles in the tube and for air in the upper part above the mercury, by inspection, and by inclining the instrument from the vertical position rather suddenly till the mercury rises to the top with a slight jerk, when, if it do not *tap sharp*, the vacuum is imperfect; and if the sound be puffy and dead, or is not heard at all, air exists to an objectionable extent, and must be got rid of by inversion and gently striking with the hand to drive the bubble up into the cistern. The lower end of the tube, which plunges into the cistern in well-constructed marine barometers, is contracted so as to diminish the amount of oscillation produced by the ship's motion. The instrument should be suspended out of the reach of sunshine, but in a good light for reading, as near midships, and in a place as little liable to sudden changes of temperature and gusts of wind, as possible. The light should have access to the back of the tube, so as to allow of setting the index to have its lower edge a tangent to the convex surface of the mercury. In well-constructed barometers the slider has its lower part tubular, embracing the tube, and can be made to descend by the rack-motion of the vernier till it becomes an upper tangent to the mercury: the eye being on its exact level, a reflected light by day, or white paper strongly illuminated from behind at night, will throw the light properly for setting the vernier correctly. The exact height of the cistern above the ship's water-line should be ascertained and entered on the register.

The attached thermometer ought to indicate a temperature the exact mean of that of the whole barometric column. Its bulb, therefore, ought to be (though it seldom is) so situated as to afford the best chance of its doing so, that is to say, fifteen inches above the cistern, enclosed within the wooden case of the barometer, nearly in contact with its tube, and with a stem so long as to be read off at the upper level. To ensure a fair average and steady temperature, it were well to enclose the whole instrument, thermometer and all, in an outer case of leather, over a wrapper of flannel, leaving only the setting and reading parts above and below accessible, and that no more than is absolutely necessary*.

In choosing a barometer, select one in preference in which the lower level of the mercury in the cistern is adjustable to contact with a steel or ivory fiducial point, and *that* not by altering the height of the mercurial surface, but by depressing the steel point, *carrying down with it the whole divided scale*, the zero-point of which is of course the apex of the point itself. Care should be taken that air have free but safe access to the lower surface.

In transporting a compared barometer to its place of destination, great care is necessary. Carry it upright, or considerably inclined, and *inverted;* and over all rough roads in the hand, to break the shocks it would otherwise receive. A "portable barometer" strapped obliquely across the shoulders of a horseman travels securely and well; and with common care in this mode of transport its zero runs no risk of change. If merely fastened to any kind of carriage, and abandoned to its fate, it is almost sure to be broken.

To make and reduce an Observation of the Barometer.—First read off and write down the reading of the attached thermometer. Then give a few gentle taps on the instrument to free the mercury from adhesion to the glass, avoiding to give it any violent oscillation. Adjust the lower level to the fiducial point, if such be the construction of the instrument. Then set the index to the upper surface of the mercurial column, placing the eye so as to bring its back and front lower edges to coincidence, and to form a tangent to the convexity of the quicksilver. If the instrument have no tubular or double-edged index, the eye must be carefully placed at the level of the upper surface to destroy parallax. Whatever mode of reading is adopted, should be always adhered to. A magnifier should be used to make the contact and to read the vernier, and the reading immediately written down and carefully entered on the register.

As soon after the observations have been made as circumstances will permit, the reading of the barometer should be *corrected* for the relation existing between the capacities of the tube and cistern (if its construction be such as to require that correction), and for the capillary action of the tube; and then *reduced* to the standard temperature of 32° Fahr., and to the sea level, if on shipboard. For the first correction the *neutral point* should be marked upon each instrument. It is that particular height which, in its construction, has been actually measured from the surface of the mercury in the cistern, and indicated by the scale. In general, the mercury will stand either above or below the neutral point; if *above*, a portion of the mercury must have left the cistern, and consequently must have *lowered* the surface in the cistern: in this case the altitude, as measured by the scale, will be *too short—vice versâ*, if below. The relation of the capacities of the tube and cistern should be experimentally ascertained, and marked upon the instrument by the maker. Suppose the capacity to be $\frac{1}{50}$, marked thus on the instrument, "*Capacity* $\frac{1}{50}$:" this indicates that for every inch of variation of the mercury in the tube, that in the cistern will vary contrariwise $\frac{1}{50}$th of an inch. When the mercury in the tube is *above* the neutral point, the difference between it and the neutral point is to be reduced in the proportion expressed by the "capacity" (in the case supposed, divided by 50), and the quotient *added* to the observed height; if *below*, *subtracted* from it. In barometers furnished with a fiducial point for adjusting the lower level, this correction is superfluous, and must not be applied.

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* For a permanently suspended or fixed barometer, the best thermometer would be one with a tubular bulb of equal bore and thickness of glass with the barometer tube, and extending in length from the cistern to the exposed face of the instrument, and as close to the barometric column as is consistent with the structure of the upper works. Immersion of the ball of the attached thermometer in the cistern is the worst arrangement of any.

The second correction required is for the capillary action of the tube, the effect of which is always to depress the mercury in the tube by a certain quantity inversely proportioned to the diameter of the tube. This quantity should be experimentally determined during the construction of the instrument, and its amount marked upon it by the maker, and is always to be *added* to the height of the mercurial column, previously corrected as before. For the convenience of those who may have barometers, the capillary action of which has not been determined, a table of corrections for tubes of different diameters is placed in the Appendix, Table I.

The next correction, and in some respects the most important of all, is that due to the temperature of the mercury in the barometer tube at the time of observation, and to the expansion of the scale. Table II. of the Appendix gives for every degree of the thermometer, and every half-inch of the barometer, the proper quantity to be added or subtracted for the reduction of the observed height to the standard temperature of the mercury at 32° Fahr.

After these the index correction should be applied. This is the amount of difference between the particular instrument and the readings of the Royal Society's flintglass barometer when properly corrected, and is generally known as the *zero*. It is impossible to pay too much attention to the determination of this point. For this purpose, when practicable, the instrument should be immediately compared with the Royal Society's standard, and the difference of the readings of both instruments, when corrected as above, carefully noted and preserved. Where, however, this is impracticable, the comparison should be effected by means either of some other standard previously so compared, or of an intermediate portable barometer, the zero-point of which has been *well determined.* Suspend the portable barometer as near as convenient to the ship's barometer, and after at least an hour's quiet exposure, take as many readings of both instruments as may be necessary to reduce the probable error of the mean of the differences below 0·001 inch. Under these circumstances, the mean difference of all the readings will be the *relative* zero or index error, whence, if that of the intermediate barometer be known, that of the other may be found. As such comparisons will always be made when the vessel is in port, sufficient time can be allowed for making the requisite number of observations: hourly readings would perhaps be best, and they would have the advantage of forming part of the system when in operation, and might be accordingly used as such.

It is not only desirable that the zero point of the barometer should be well determined in the first instance; it should also be carefully verified on every opportunity which presents itself. And in the first instance, previous to sailing, after suspending the barometer on shipboard, it should be re-compared with the standard on shore by the intervention of a portable barometer, and no opportunity should be lost of comparing it on the voyage by means of such an intermediate instrument with the standard barometers at St. Helena, the Cape of Good Hope, Bombay, Madras, Paramatta, Van Diemen's Island, and with any other instruments likely to be referred to as standards, or employed in research elsewhere. Any vessel having a portable barometer on board, the zero of which has been well determined, would do well on touching at any of the ports above-named to take comparative readings with the standards at those ports, and record the differences between the standard, the portable, and the ship barometers. By such means the zero of one standard may be transported over the whole world, and those of others compared with it ascertained. To do so, however, with perfect effect, will require that the utmost care should be taken of the portable barometer; it should be guarded as much as possible from all accident, and should be kept safely in the "portable" state when not immediately used for comparison. To transport a well authenticated zero from place to place is by no means a point of trifling importance. Neither should it be executed hurriedly nor negligently. Some of the greatest questions in meteorology depend on its due execution, and the objects for which these instructions have been prepared will be greatly advanced by the zero points of all barometers being referred to one common standard. Upon the arrival of the vessel in England, at the termination of the voyage, the ship's barometer should be again compared with the same standard with which it was compared previous to sailing; and should any difference be found, it should be most carefully recorded.

The correction for the height of the cistern *above* or *below* the water-line is *additive* in the former case, *subtractive* in the latter. Its amount may be taken, nearly enough, by allowing 0·001 in. of the barometer for each foot of difference of level.

An example of the application of these several corrections is subjoined :—

Attached Therm. 54°·3.		
Barometer reading		29.409
Corr. for capacity ...	—	·017
		29.392
Corr. for capillarity ...	+	·032
		29·424
Corr. for temperature ...	—	·068
		29·356
Corr. for zero and waterline	+	·040
Aggregate = pressure at sea-level		*29·396*

Data for the correction of the Instrument.		
Neutral point		30·123
Capacity $\frac{1}{42}$		
Capillary action ...	+	·032
Zero to Royal Society .	+	·036
Corr. for altitude above water-line.	+	·004

The following is the description given by Mr Adie of the Barometers sent out for the Society : I have tried them under a vast variety of circumstances, and found them in all respects most excellent :—

The *Standard Barometers* are fitted in brass tubes, with cisterns of cast-iron. The cistern consists of a cylinder of cast-iron, open at one end and solid at the other : into the solid end screwings are made to receive the Barometer and syphon-adjustment tubes ; at the open end there is a square shoulder left, and a screwing made to receive a screwed iron ring ; through this ring passes a glass-plunger, turned and polished truly cylindrical ; this plunger is withdrawn or forced into the cistern by means of the finger-headed screw at the bottom of the Barometer ; and to prevent the escape of the mercury past the sides of the glass-plunger, a solid ring of thick doeskin leather, prepared with a compound of tallow, to resist the action of moisture, is pressed between the shoulder of the cistern and the screwed iron ring, which causes it to embrace the glass-plunger, and retains the mercury in its place when properly screwed up ; the iron ring is made to fit closely to the glass-cylinder, to prevent insects getting at the leather. The short syphon adjustment-tube is fixed in its iron cover, by an iron ring screwed down upon it, so that all cement, which might cause leakage from changes in temperature, and hygrometric changes of climate, is dispensed with. The Barometer-tube has an interior diameter of from two to three-tenths of an inch. The tube is carefully cleaned and filled with pure dry mercury, and the mercury is then boiled in it over its whole length, by which all moisture and air are expelled. The scale is laid off from a standard English measure in inches, from the reading edge of the syphon-tube, and irrespective of any other Barometer : thus each instrument becomes in itself a Standard, giving the length of the mercurial column in inches and parts.

The *method of using* the Barometer is as follows : When it is hung up, unturn the finger-screw at the bottom of the Barometer till the column falls to the height about which it may be expected to stand ; then unscrew the ivory knob at the syphon-tube ; this admits the action of air on the surface of the mercury in the tube ; and, by using the screw at the bottom, adjust it so as to bring the rounded surface of the mercury till its crown cuts off the light seen through the opening in the typhon-tube ; then by means of the pinion-head on the side of the Barometer, bring the under edge of the vernier to cut off the light in exactly the same way over the mercurial column in the Barometer-tube. In making this adjustment, the eye should be held exactly opposite to, or on a level with the crown of the mercury, to avoid parallax, and by moving the eye a little up and down, this point will easily be determined ; and the length is then to be read off the scale in inches and parts, and may be noted to the nearest thousandth part of an inch.

The scale is divided into half-tenths or twentieths of an inch ; the vernier is divided into twenty-five equal parts, and these twenty-five parts are equal to twenty-four on the scale, so that each division of the vernier is one-fiftieth part less than those on the scale, or equal to one five-hundredth or two thousandth parts of an inch, and is called a minimum vernier. In reading the height of the column, we get from the scale the inches and tenths ; the tenths are drawn longer than the halves ; and from the lower edge of the vernier these are read off. If, for example, the under edge of the vernier stand exactly at the fourth division, or second long division, above twenty-nine inches, the reading is 29·200; if, again, it stand a little above the third long division, we have to look along the vernier scale to find what division on it agrees with or forms a straight line with any of the divisions on the scale. Suppose we find this to be the twelfth line on the vernier, the reading is therefore 29·312; if the edge of the vernier be past the fourth long line on the scale, and exactly at the half-tenth, it is then 29·450; and lastly, if past the half-tenth, add fifty to the reading found from the vernier. As in the 29·312,—had the edge been past the half division, we would have noted 29·362.

The indication of the Thermometer attached to the Barometer, should be noted with each observation of the Barometer. A Thermometer exposed to the air, should be noted at the same time. And it is desirable that the Barometer should have hung for half an hour before an observation is made, in order that the mercury in the Barometer and the attached Thermometer may acquire nearly the same temperature.

As the syphon-tube becomes soiled from the action of air and moisture on the mercury, it should be cleaned from time to time, by removing the ivory knob from it, and passing down a piece of wood or whale bone with a little lint or cotton thread rolled on its point. Metallic wires should not be used for this purpose. The syphon-tube is formed of a piece cut from the Barometer-tube of each instrument, so that the capillary action in the Barometer-tube is exactly balanced by that of the syphon; consequently this quantity vanishes, and no correction is required.

When the Barometer is to be taken down for removal, the first thing to be done is to screw down the ivory knob at the top of the syphon, making it quite close; then, by means of the finger-screw at the bottom, force the mercury up the Barometer-tube, till it is within a quarter of an inch from the top; take the instrument from its suspension and turn it gently over, and carry it with the cistern uppermost, *i. e.*, with its head down.

Should at any time a leakage of the mercury be observed at the leather stuffing-ring, from exposure to great changes of temperature or humidity, it should instantly be corrected, by screwing the iron ring hard down on the leather ring. When this is to be done, the mercury should be allowed to fall half an inch in the Barometer-tube; then, taking hold of the cylindrical part of the cistern with one hand, lay hold of the milled part of the screwed iron ring with the other, and screwing them together with all the force the hands are possessed of, the cistern will again become tight.

When the Barometers are used for the determination of altitudes, various formulæ are given in most works treating of this subject. I think, however, the most convenient and easy of use are those published by William Galbraith, M.A., Edinburgh, 1833.

We make a Barometer more especially for the measurement of heights, and capable of reaching any known altitude, the instrument being divided down to 11 inches, and fitted in a tripod, which suspends it for observation,—fixing it in a perpendicular position, and preventing its being shaken by wind. The tripod forms a case for the Barometer when carried.

The *Marine Barometer* is fitted with a cast-iron cistern similar to that of the Standard Barometer, only being of greater diameter; and in place of the syphon-adjustment of the lower surface of the mercury, there is placed an ivory float, which, when in action, rests on the surface of the mercury in the cistern. On the stalk of this float a line is cut; there is also a line on the fixed piece of ivory through which the stalk of the float passes. This float is drawn up to make the Barometer tight for carriage, by screwing down the ivory nut on the upper part of the float stalk.

The interior diameter of the surface of the cistern, where the surface of the mercury stands when the Barometer is in action, is two inches, and the interior diameter of the upper part of the glass tube is marked, so that the ratio of the one to the other can easily be found. The upper part of the tube is generally about four-tenths of an inch in diameter, and below the scale it is made capillary, to prevent pumping or sudden oscillation of the column from the motion of the ship; and the better to correct this, the contracted part of the tube is made elliptical in its bore and twisted into the form of a spiral, thus causing greater friction of the mercury in passing up or down the tube, and allowing the use of a larger bore, to give more free but slow motion.

The tube is carefully cleaned and dried, then filled with pure mercury, which is boiled in it to drive out all air and moisture, and the scale is laid off from comparison with a Standard Barometer, corrected for the difference between it and the Royal Society's Standard Flint-Glass Barometer; the scales are therefore laid off to give the same reading as the Royal Society's Standard.

Method of using the instrument.—The Barometer should be put up in a situation where there is good light, and where a white screen, or sheet of white paper, can be placed behind the reading column: a good situation is about midships. When fixed in its place, slowly unscrew the finger-head at the bottom of the Barometer, about six revolutions of the head, and screw up the ivory nut on the stalk of the float; this will allow it to fall and float on the surface of the mercury. Should the float stick up, from being long held in that position, it may be pushed down by the finger, and when floating it is to be adjusted till the line on the float coincides with the line on the fixed ivory through which it passes. When the instrument has hung for half an hour (this time is required for the mass of mercury to pass down the capillary tube), the line on the float may again be adjusted, and the length of the column read off on the scale, by bringing the vernier to cut off the line of light in exactly the same way as in the Standard Barometer; but where this cannot be done, the Barometer is to be read by a point applied to the tube. The scale of the Marine Barometer is divided to be read by the vernier to one hundredth parts of an inch; the inches and tenths are got from the scale as in the Standard Barometer, and the hundredth parts from the coincidence of any line on the vernier with that of the scale: it is also a minimum vernier, nine parts on the scale being divided into ten on the vernier. In very stormy weather, when the motion is so great as to prevent the adjustment of the line on the ivory float at the time of observation, this adjustment may be neglected, and the instrument used as an ordinary Marine Barometer. The ratio of the area of the tube to that of the cistern is so small (about one twenty-fifth), that, except in cases of very great changes, the adjustment may be neglected, or if great accuracy is required, the correction for capacity may be made; and it is to be observed that this correction is only due to the difference of the observed height of the mercury from that at which it was when the last adjustment of the float was made.

When the Barometer is to be removed, the screw at the bottom is to be screwed in, first till it raises the float to the inner surface of the cistern, where it is to be fixed by screwing down the ivory nut on the float, and inclining the Barometer at an angle of about 45°, the screw is to be turned very slowly till it forces the mercury to nearly the top of the Barometer tube; it may then be slowly turned over, and carried top down. Should any leakage take place at the leather stuffing, it is to be corrected in the same way as in the Standard Barometer.

TABLE I.

Correction to be added to Barometers for Capillary Action.

Diameter of Tube.	Correction for Unboiled Tubes.	Correction for Boiled Tubes.
inch.	inch.	inch.
0·60	0·004	0·002
0·50	0·007	0·003
0·45	0·010	0·005
0·40	0·014	0·007
0·35	0·020	0·010
0·30	0·028	0·014
0·25	0·040	0·020
0·20	0·060	0·029
0·15	0·088	0·044
0·10	0·142	0·070

TABLE II. Correction to be applied to Barometers with *brass scales*, extending from the cistern to the top of mercurial column, to reduce the observation to 32° Fahrenheit.

Temp.	Inches.							
	20	20·5	21	21·5	22	22·5	23	23·5
	+	+	+	+	+	+	+	+
0°	·051	·053	·054	·055	·056	·058	·059	·060
1	·049	·051	·052	·053	·054	·056	·057	·058
2	·048	·049	·050	·051	·052	·054	·055	·056
3	·046	·047	·048	·049	·050	·052	·053	·054
4	·044	·045	·046	·047	·048	·050	·051	·052
5	·042	·043	·044	·045	·046	·048	·049	·050
6	·040	·042	·042	·044	·044	·046	·047	·048
7	·039	·040	·041	·042	·042	·044	·044	·046
8	·037	·038	·039	·040	·041	·041	·042	·043
9	·035	·036	·037	·038	·039	·039	·040	·041
10	·033	·034	·035	·036	·037	·037	·038	·039
11	·031	·032	·033	·034	·035	·035	·036	·037
12	·030	·030	·031	·032	·033	·033	·034	·035
13	·028	·029	·029	·030	·031	·031	·032	·033
14	·026	·027	·027	·028	·029	·029	·030	·031
15	·024	·025	·026	·026	·027	·027	·028	·029
16	·022	·023	·024	·024	·025	·025	·026	·026
17	·021	·021	·022	·022	·023	·023	·024	·024
18	·019	·019	·020	·020	·021	·021	·022	·022
19	·017	·018	·018	·018	·019	·019	·020	·020
20	·015	·016	·016	·016	·017	·017	·018	·018
21	·014	·014	·014	·015	·015	·015	·015	·016
22	·012	·012	·012	·013	·013	·013	·013	·014
23	·010	·010	·010	·011	·011	·011	·011	·012
24	·008	·008	·009	·009	·009	·009	·009	·010
25	·006	·007	·007	·007	·007	·007	·007	·007
26	·005	·005	·005	·005	·005	·005	·005	·005
27	·003	·003	·003	·003	·003	·003	·003	·003
28	·001	·001	·001	·001	·001	·001	·001	·001
	—	—	—	—	—	—	—	—
29	·001	·001	·001	·001	·001	·001	·001	·001
30	·003	·003	·003	·003	·003	·003	·003	·003
31	·005	·005	·005	·005	·005	·005	·005	·005
32	·006	·006	·007	·007	·007	·007	·007	·007
33	·008	·008	·008	·009	·009	·009	·009	·010
34	·010	·010	·010	·011	·011	·011	·011	·012
35	·012	·012	·012	·013	·013	·013	·013	·014
36	·013	·014	·014	·014	·015	·015	·016	·016
37	·015	·016	·016	·016	·017	·017	·018	·018
38	·017	·017	·018	·018	·019	·019	·020	·020
39	·019	·019	·020	·020	·021	·021	·022	·022
40	·021	·021	·022	·022	·023	·023	·024	·024
41	·022	·023	·024	·024	·025	·025	·026	·026
42	·024	·025	·025	·026	·027	·027	·028	·028
43	·026	·027	·027	·028	·029	·029	·030	·031
44	·028	·029	·029	·030	·031	·031	·032	·033
45	·030	·030	·031	·032	·033	·033	·034	·035
46	·031	·032	·033	·034	·035	·035	·036	·037
47	·033	·034	·035	·036	·036	·037	·038	·039
48	·035	·036	·037	·038	·038	·039	·040	·041
49	·037	·038	·039	·040	·040	·041	·042	·043
50	·038	·039	·040	·041	·042	·043	·044	·045

TABLE II. (continued.)

Temp.	Inches.							
	20	20·5	21	21·5	22	22·5	23	23·5
°	—	—	—	—	—	—	—	—
51	·040	·041	·042	·043	·044	·045	·046	·047
52	·042	·043	·044	·045	·046	·047	·048	·049
53	·044	·045	·046	·047	·048	·049	·050	·052
54	·046	·047	·048	·049	·050	·051	·052	·054
55	·047	·049	·050	·051	·052	·053	·055	·056
56	·049	·050	·052	·053	·054	·055	·057	·058
57	·051	·052	·054	·055	·056	·057	·059	·060
58	·053	·054	·055	·057	·058	·059	·061	·062
59	·055	·056	·057	·059	·060	·061	·063	·064
60	·056	·058	·059	·061	·062	·063	·065	·066
61	·058	·060	·061	·062	·064	·065	·067	·068
62	·060	·061	·063	·064	·066	·067	·069	·070
63	·062	·063	·065	·066	·068	·069	·071	·072
64	·063	·065	·067	·068	070	·071	·073	·075
65	·065	·067	·068	·070	·072	·073	·075	·077
66	·067	·069	·070	·072	·074	·075	·077	·079
67	·069	·071	·072	·074	·076	·077	·079	·081
68	·071	·072	·074	·076	·078	·079	·081	·083
69	·072	·074	·076	·078	·080	·081	·083	·085
70	·074	·076	·078	·080	·082	·083	·085	·087
71	·076	·078	·080	·082	·083	·085	·087	·089
72	·078	·080	·082	·084	·085	·087	·089	·091
73	·079	·081	·083	·085	·087	·089	·091	·093
74	·081	·083	·085	·087	·089	·091	·093	·095
75	·083	·085	·087	·089	·091	·093	·095	·098
76	·085	·087	·989	·091	·093	·095	·097	·100
77	·087	·089	·091	·093	·095	·097	·100	·102
78	·088	·091	·093	·095	·097	·099	·102	·104
79	·090	·092	·095	·097	·099	·101	·104	·106
80	·092	·094	·096	·099	·101	·103	·106	·108
81	·094	·096	·098	·101	·103	·105	·108	·110
82	·095	·098	·100	·103	·105	·107	·110	·112
83	·097	·100	·102	·104	·107	·109	·112	·114
84	·099	·101	·104	·106	·109	·111	·114	·116
85	·101	·103	·106	·108	·111	·113	·116	·118
86	·103	·105	·108	·110	·113	·115	·118	·120
87	·104	·107	·109	·112	·115	·117	·120	·123
88	·106	·109	·111	·114	·117	·119	·122	·125
89	·108	·111	·113	·116	·119	·121	·124	·127
90	·110	·112	·115	·118	·121	·123	·126	·129
91	·111	·114	·117	·120	·122	·125	·128	·131
92	·113	·116	·119	·122	·124	·127	·130	·133
93	·115	·118	·121	·124	·126	·129	·132	·135
94	·117	·120	·122	·125	·128	·131	·134	·137
95	·118	·121	·124	·127	·130	·133	·136	·139
96	·120	·123	·126	·129	·132	·135	·138	·141
97	·122	·125	·128	·131	·134	·137	·140	·143
98	·124	·127	·130	·133	·136	·139	142	·145
99	·125	·129	·132	·135	·138	·141	144	·147
100	·127	·130	·134	·137	·140	·143	146	·150

TABLE II. (continued.)

Temp.	Inches. 24	24·5	25	25·5	26	26·5	27	27·5	Temp.
°	+	+	+	+	+	+	+	+	°
0	·061	·063	·064	·065	·067	·068	·069	·071	0
1	·059	·061	·062	·063	·064	·065	·067	·068	1
2	·057	·058	·060	·061	·062	·063	·064	·066	2
3	·055	·056	·057	·059	·060	·061	·062	·063	3
4	·053	·054	·055	·056	·057	·058	·059	·061	4
5	·051	·052	·053	·054	·055	·056	·057	·058	5
6	·049	·050	·051	·052	·053	·054	·055	·056	6
7	·046	·047	·048	·049	·050	·051	·052	·053	7
8	·044	·045	·046	·047	·048	·049	·050	·051	8
9	·042	·043	·044	·045	·046	·046	·047	·048	9
10	·040	·041	·042	·042	·043	·044	·045	·046	10
11	·038	·039	·039	·040	·041	·042	·042	·043	11
12	·036	·036	·037	·038	·039	·039	·040	·041	12
13	·033	·034	·035	·036	·036	·037	·038	·038	13
14	·031	·032	·033	·033	·034	·035	·035	·036	14
15	·029	·030	·030	·031	·032	·032	·033	·033	15
16	·027	·028	·028	·029	·029	·030	·030	·031	16
17	·025	·025	·026	·026	·027	·027	·028	·028	17
18	·023	·023	·024	·024	·025	·025	·025	·026	18
19	·021	·021	·021	·022	·022	·023	·023	·024	19
20	·018	·019	·019	·020	·020	·020	·021	·021	20
21	·016	·017	·017	·017	·018	·018	·018	·019	21
22	·014	·014	·015	·015	·015	·016	·016	·016	22
23	·012	·012	·012	·013	·013	·013	·013	·014	23
24	·010	·010	·010	·010	·011	·011	·011	·011	24
25	·008	·008	·008	·008	·008	·008	·009	·009	25
26	·005	·006	·006	·006	·006	·006	·006	·006	26
27	·003	·003	·003	·003	·004	·004	·004	·004	27
28	·001	·001	·001	·001	·001	·001	·001	·001	28
	—	—	—	—	—	—	—	—	
29	·001	·001	·001	·001	·001	·001	·001	·001	29
30	·003	·003	·003	·004	·004	·004	·004	·004	30
31	·005	·006	·006	·006	·006	·006	·006	·006	31
32	·008	·008	·008	·008	·008	·008	·008	·009	32
33	·010	·010	·010	·010	·011	·011	·011	·011	33
34	·012	·012	·012	·013	·013	·013	·013	·014	34
35	·014	·014	·015	·015	·015	·015	·016	·016	35
36	·016	·017	·017	·017	·017	·018	·018	·019	36
37	·018	·019	·019	·019	·020	·020	·021	·021	37
38	·020	·021	·021	·022	·022	·023	·023	·023	38
39	·023	·023	·024	·024	·024	·025	·025	·026	39
40	·025	·025	·026	·026	·027	·027	·028	·028	40
41	·027	·027	·028	·029	·029	·030	·030	·031	41
42	·029	·030	·030	·031	·031	·032	·033	·033	42
43	·031	·032	·032	·033	·034	·034	·035	·036	43
44	·033	·034	·035	·035	·036	·037	·037	·038	44
45	·035	·036	·037	·038	·038	·039	·040	·041	45
46	·038	·038	·039	·040	·041	·042	·042	·043	46
47	·040	·041	·041	·042	·043	·044	·045	·046	47
48	·042	·043	·044	·045	·045	·046	·047	·048	48
49	·044	·045	·046	·047	·048	·049	·050	·050	49
50	·046	·047	·048	·049	·050	·051	·052	·053	50

TABLE II. (continued.)

Temp.	Inches.								Temp.
	24	24·5	25	25·5	26	26·5	27	27·5	
°	—	—	—	—	—	—	—	—	°
51	·048	·049	·050	·051	·052	·053	·054	·055	50
52	·050	·052	·053	·054	·055	·056	·057	·058	51
53	·053	·054	·055	·056	·057	·058	·059	·060	42
54	·055	·056	·057	·058	·059	·060	·062	·063	53
55	·057	·058	·059	·060	·062	·063	·064	·065	54
56	·059	·060	·061	·063	·064	·065	·066	·068	55
57	·061	·062	·064	·065	·066	·068	·069	·070	56
58	·063	·065	·066	·067	·069	·070	·071	·073	57
59	·065	·067	·068	·070	·071	·072	·074	·075	58
60	·068	·069	·070	·072	·073	·075	·076	·077	60
61	·070	·071	·073	·074	·075	·077	·078	·080	61
62	·072	·073	·075	·076	·078	·079	·081	·082	62
63	·074	·076	·077	·079	·080	·082	·083	·085	63
64	·076	·078	·079	·081	·082	·084	·086	·087	64
65	·078	·080	·082	·083	·085	·086	·088	·090	65
66	·080	·082	·084	·085	·087	·089	·090	·092	66
67	·083	·084	·086	·088	·089	·091	·093	·095	67
68	·085	·086	·088	·090	·092	·094	·095	·097	68
69	·087	·089	·090	·092	·094	·096	·098	·100	69
70	·089	·091	·093	·095	·096	·098	·100	·102	70
71	·091	·093	·095	·097	·099	·101	·102	·104	71
72	·093	·095	·097	·099	·101	·103	·105	·107	72
73	·095	·097	·099	·101	·103	·105	·107	·109	73
74	·097	·099	·102	·104	·106	·108	·110	·112	74
75	·100	·102	·104	·106	·108	·110	·112	·114	75
76	·102	·104	·106	·108	·110	·112	·114	·117	76
77	·104	·106	·108	·110	·112	·115	·117	·119	77
78	·106	·108	·110	·113	·115	·117	·119	·122	78
79	·108	·110	·113	·115	·117	·119	·122	·124	79
80	·110	·113	·115	·117	·119	·122	·124	·126	80
81	·112	·115	·117	·119	·122	·124	·126	·129	81
82	·114	·117	·119	·122	·124	·126	·129	·131	82
83	·117	·119	·121	·124	·126	·129	·131	·134	83
84	·119	·121	·124	·126	·129	·131	·134	·136	84
85	·121	·123	·126	·128	·131	·133	·136	·139	85
86	·123	·126	·128	·131	·133	·136	·138	·141	86
87	·125	·128	·130	·133	·136	·138	·141	·143	87
88	·127	·130	·133	·135	·138	·141	·143	·146	88
89	·129	·132	·135	·137	·140	·143	·146	·148	89
90	·131	·134	·137	·140	·142	·145	·148	·151	90
91	·134	·136	·139	·142	·145	·148	·150	·153	91
92	·136	·139	·141	·144	·147	·150	·153	·156	92
93	·138	·141	·144	·147	·149	·152	·155	·158	93
94	·140	·143	·146	·149	·152	·155	·157	·161	94
95	·142	·145	·148	·151	·154	·157	·160	·163	95
96	·144	·147	·150	·153	·156	·159	·162	·165	96
97	·146	·149	·152	·156	·159	·162	·165	·168	97
98	·148	·152	·155	·158	·161	·164	·167	·170	98
99	·151	·154	·157	·160	·163	·166	·169	·173	99
100	·153	·156	·159	·162	·165	·169	·172	·175	100

TABLE II. (continued.)

Temp.	Inches.							Temp.
	28	28·5	29	29·5	30	30·5	31	
°	+	+	+	+	+	+	+	°
0	·072	·073	·074	·076	·077	·078	·080	0
1	·069	·071	·072	·073	·074	·076	·077	1
2	·067	·068	·069	·070	·072	·073	·074	2
3	·064	·065	·067	·068	·069	·070	·071	3
4	·062	·063	·064	·065	·066	·067	·068	4
5	·059	·060	·061	·062	·063	·065	·066	5
6	·057	·058	·059	·060	·061	·062	·063	6
7	·054	·055	·056	·057	·058	·059	·060	7
8	·052	·053	·054	·054	·055	·056	·057	8
9	·049	·050	·051	·052	·053	·054	·054	9
10	·047	·047	·048	·049	·050	·051	·052	10
11	·044	·045	·046	·046	·047	·048	·049	11
12	·042	·042	·043	·044	·045	·045	·046	12
13	·039	·040	·040	·011	·042	·043	·043	13
14	·037	·037	·038	·038	·039	·040	·040	14
15	·034	·035	·035	·036	·036	·037	·038	15
16	·032	·032	·033	·033	·034	·034	·035	16
17	·029	·030	·030	·031	·031	·032	·032	17
18	·026	·027	·027	·028	·028	·029	·029	18
19	·024	·024	·025	·025	·026	·026	·027	19
20	·021	·022	·022	·023	·023	·023	·024	20
21	·019	·019	·020	·020	·020	·021	·021	21
22	·016	·017	·017	·017	·018	·018	·018	22
23	·014	·014	·014	·015	·015	·015	·015	23
24	·011	·012	·012	·012	·012	·012	·013	24
25	·009	·009	·009	·009	·009	·010	·010	25
26	·006	·006	·007	·007	·007	·007	·007	26
27	·004	·004	·004	·004	·004	·004	·004	27
28	·001	·001	·001	·001	·001	·001	·001	28
	—	—	—	—	—	—	—	
29	·001	·001	·001	·001	·001	·001	·001	29
30	·004	·004	·004	·004	·004	·004	·004	30
31	·006	·006	·007	·007	·007	·007	·007	31
32	·009	·009	·009	·009	·009	·010	·010	32
33	·011	·012	·012	·012	·012	·012	·012	33
34	·014	·014	·014	·015	·015	·015	·015	34
35	·016	·017	·017	·017	·018	·018	·018	35
36	·019	·019	·020	·020	·020	·021	·021	36
37	·021	·022	·022	·022	·023	·023	·024	37
38	·024	·024	·025	·025	·026	·026	·026	38
39	·026	·027	·027	·028	·028	·029	·029	39
40	·029	·029	·030	·030	·031	·031	·032	40
41	·031	·032	·033	·033	·034	·034	·035	41
42	·034	·034	·035	·036	·036	·037	·037	42
43	·036	·037	·038	·038	·039	·040	·040	43
44	·039	·040	·040	·041	·042	·042	·043	44
45	·041	·042	·043	·044	·044	·045	·046	45
46	·044	·045	·045	·046	·047	·048	·049	46
47	·046	·047	·048	·049	·050	·051	·051	47
48	·049	·050	·051	·052	·052	·053	·054	48
49	·051	·052	·053	·054	·055	·056	·057	49
50	·054	·055	·056	·057	·058	·059	·060	50

TABLE II. (continued.)

Temp.	Inches. 28	28·5	29	29 5	30	30·5	-	Temp.
°	—	—	—	—	—	—	—	°
51	·056	·057	·058	·059	·060	·061	·062	51
52	·059	·060	·061	·062	·063	·064	·065	52
53	·061	·063	·064	·065	·066	·067	·068	53
54	·064	·065	·066	·067	·068	·070	·071	54
55	·066	·068	·069	·070	·071	·072	·073	55
56	·069	·070	·071	·073	·074	·075	·076	56
57	·071	·073	·074	·075	·076	·078	·079	57
58	·074	·075	·077	·078	·079	·081	·082	58
59	·076	·078	·079	·080	·082	·083	·085	59
60	·079	·080	·082	·083	·085	·086	·087	60
61	·081	·083	·084	·086	·087	·089	·090	61
62	·084	·085	·087	·088	·090	·091	·093	62
63	·086	·088	·089	·091	·093	·094	·096	63
64	·089	·090	·092	·094	·095	·097	·098	64
65	·091	·093	·095	·096	·098	·100	·101	65
67	·094	·096	·097	·099	·101	·102	·104	66
66	·096	·098	·100	·102	·103	·105	·107	67
68	·099	·101	·102	·104	·106	·108	·109	68
69	·101	·103	·105	·107	·109	·110	·112	69
70	·104	·106	·108	·109	·111	·113	·115	70
71	·106	·108	·110	·112	·114	·116	·118	71
72	·109	·111	·113	·115	·117	·119	·120	72
73	·111	·113	·115	·117	·119	·121	·123	73
74	·114	·116	·118	·120	·122	·124	·126	74
75	·116	·118	·120	·122	·125	·127	·129	75
76	·119	·121	·123	·125	·127	·129	·131	76
77	·121	·123	·126	·128	·130	·132	·134	77
78	·124	·126	·128	·130	·133	·135	·137	78
79	·126	·128	·131	·133	·135	·137	·140	79
80	·129	·131	·133	·136	·138	·140	·143	80
81	·131	·134	·136	·138	·141	·143	·145	81
82	·134	·136	·138	·141	·143	·146	·148	82
83	·136	·139	·141	·143	·146	·148	·151	83
84	·139	·141	·144	·146	·149	·151	·154	84
85	·141	·144	·146	·149	·151	·154	·156	85
86	·144	·146	·149	·151	·154	·156	·159	86
87	·146	·149	·151	·154	·157	·159	·162	87
88	·149	·151	·154	·157	·159	·162	·165	88
89	·151	·154	·156	·159	·162	·165	·167	89
90	·153	·156	·159	·162	·164	·167	·170	90
91	·156	·159	·162	·165	·167	·170	·173	91
92	·158	·161	·164	·167	·170	·172	·175	92
93	·161	·164	·167	·170	·172	·175	·178	93
94	·163	·166	·169	·172	·175	·177	·180	94
95	·166	·169	·172	·175	·178	·180	·183	95
96	·168	·171	·174	·178	·181	·183	·186	96
97	·171	·174	·177	·180	·183	·186	·189	97
98	·173	·176	·179	·183	·186	·188	·191	98
99	·176	·179	·182	·185	·188	·191	·194	99
100	·178	·181	·184	·188	·191	·194	·197	100

TABLE III.

Correction to be applied to Barometers, the scales of which are engraven on *glass*, to reduce the observations to 32° Fahrenheit.

Temp.	Inches. 28·0	Inches. 28·5	Inches. 29·0	Inches. 29·5	Inches. 30·0	Inches. 30·5	Inches. 31·0	Inches. 31·5
25	+·017	+·017	+·017	+·018	+·018	+·018	+·019	+·019
30	+·005	+·005	+·005	+·005	+·005	+·005	+·005	+·005
35	—·007	—·007	—·007	—·008	—·008	—·008	—·008	—·008
40	—·019	—·020	—·020	—·020	—·021	—·021	—·021	—·022
45	—·031	—·032	—·032	—·033	—·033	—·034	—·035	—·036
50	—·043	—·044	—·045	—·046	—·046	—·047	—·048	—·049
55	—·055	—·056	—·057	—·058	—·059	—·060	—·061	—·062
60	—·067	—·068	—·069	—·071	—·072	—·074	—·075	—·076
65	—·079	—·081	—·082	—·083	—·085	—·086	—·088	—·089
70	—·091	—·093	—·094	—·096	—·098	—·100	—·101	—·103
75	—·103	—·105	—·106	—·109	—·111	—·114	—·116	—·118

TABLE IV.

Showing the Force of the Wind on a square foot for different heights of the Column of Water in Lind's Wind-gauge.

Height of the Column of Water.	Force of the Wind in Avoirdupois Pounds.	Common designation of such a Wind.
Inches.		
12	62·5	
11	57·29	
10	52·08	Most violent hurricane.
9	46·87	Most violent hurricane.
8	41·66	A very great hurricane.
7	36·55	A great hurricane.
6	31·75	A hurricane.
5	26·04	A very great storm.
4	20·83	A great storm.
3	15·62	A storm.
2	10·42	A very high wind.
1	5·21	A high wind.
0·5	2·60	A brisk gale.
0·1	0·52	A fresh breeze.
0·05	0·26	A pleasant wind.

In great degrees of cold, a saturated solution of sea salt may be used instead of water, the specific gravity of which is 1·244. If the force in the above Table for any height be multiplied by the specific gravity, the product will be the true force, as measured by the solution.

TABLE V.

Elastic Force of Aqueous Vapour for every degree of Temperature, from 0° to 34° Fahr.

Temp. Fahr.	Force. Inches of Mercury.	Temp. Fahr.	Force. Inches of Mercury.	Temp. Fahr.	Force. Inches of Mercury.	Temp. Fahr.	Force. Inches of Mercury.
°		°		°		°	
0	0·051	32	0·186	63	0·570	94	1·562
1	0·053	33	0·193	64	0·590	95	1·610
2	0·056	34	0·200	65	0·611	96	1·660
3	0·058	35	0 208	66	0·632	97	1·712
4	0·060	36	0·216	67	0·654	98	1·764
5	0·063	37	0·224	68	0·676	99	1·819
6	0·066	38	0·233	69	0 699	100	1·874
7	0·069	39	0·242	70	0 723	101	1·931
8	0·071	40	0·251	71	0·748	102	1·990
9	0 074	41	0·260	72	0·773	103	2 050
10	0·078	42	0·270	73	0·799	104	2·112
11	0·081	43	0·280	74	0·826	105	2·176
12	0 084	44	0·291	75	0·854	106	2·241
13	0·088	45	0·302	76	0·882	107	2·307
14	0·092	46	0·313	77	0·911	108	2·376
15	0·095	47	0·324	78	0·942	109	2·447
16	0·099	48	0·336	79	0·973	110	2·519
17	0·103	49	0·349	80	1·005	111	2·593
18	0·107	50	0·361	81	1·036	112	2·669
19	0·112	51	0·375	82	1·072	113	2·747
20	0·116	52	0·389	83	1·106	114	2·826
21	0·121	53	0·402	84	1·142	115	2·908
22	0·126	54	0 417	85	1·179	116	2·992
23	0·131	55	0·432	86	1·217	117	3·078
24	0·136	56	0·447	87	1·256	118	3·166
25	0·142	57	0·463	88	1·296	119	3·257
26	0·147	58	0·480	89	1·337	120	3·349
27	0·153	59	0·497	90	1·380	121	3·444
28	0·159	60	0·514	91	1·423	122	3·542
29	0·165	61	0·532	92	1·468	133	3·641
30	0·172	62	0·551	93	1·514	124	3·743
31	0·179						

METEOROLOGY.

The Sympiesometer is an instrument so generally employed, and found so valuable on ship-board, that a description of it by its inventor, Mr Adie, is subjoined : it is not recognised as an instrument of Meteorological Research in the East :—

My attention was first directed to the improvement of the Barometer, with the view of rendering it susceptible of indicating any of those minute changes in the weight of the atmosphere, which might be supposed to arise from the action of the Sun and Moon. A very sensible instrument was obviously necessary for such a purpose ; and I was therefore led to the idea of measuring the pressure of the atmosphere by its effect in compressing a column of common air. Upon constructing an instrument of this kind, however, I found that the air was absorbed by the fluid with which it was enclosed, and that a good and permanent barometer could not be made upon such a principle till this radical defect was removed. I therefore directed my attention particularly to this object, and succeeded beyond my most sanguine expectations, in freeing the Air Barometer from this great source of inaccuracy.

The name of *Sympiesometer*, which I have given to this improved instrument, is derived from the Greek words συμπιεζω, *to compress*, and μετρον, *a measure*, denoting the property it possesses of measuring the weight of the atmosphere by the compression of a gaseous column.

The principle of the Sympiesometer consists in employing an elastic fluid or gas, different from air, and any liquid, excepting quicksilver, which neither acts upon the gas which it confines, nor is perceptibly acted upon by the air, to the contact of which it is in some measure exposed. Hydrogen gas, azotic gas, or any of the gases not liable to be absorbed by the enclosing fluid, may be used; but I prefer hydrogen gas as superior to any other that I have tried.

The enclosed gas with which the bulb and part of the tube is filled, changes its bulk, or occupies more or less space, according to the pressure of the atmosphere upon the surface of the fluid. The scale for measuring the change in the bulk of the gas, occasioned by a change of pressure, is formed experimentally.

As the bulk of the gas is altered by any change that takes place in the temperature of the atmosphere, it is necessary to apply a correction on this account. For this purpose, the principal or barometric scale, is made to slide upon another scale, placed either below it, or on one side of it, which is divided into degrees and tenth parts, so as to represent the change of bulk in the gas produced by a change of temperature under the same pressure, and corresponding to the degrees of a common Thermometer attached to the instrument, the scale of which is also divided into degrees and tenth parts of a degree.

When the Sympiesometer is hung up for observation, the cistern must be opened by pushing up the small slider at its mouth, having previously unturned the nut at the bottom, which is placed there to keep it down in carriage, and prevent the escape of the fluid from the cistern. If any of the fluid at the top of the column should be separated, which sometimes happens in carriage, hang it up for a few minutes to drain, then turn it into a horizontal position, so that the fluid may run quickly up, until the separated portion of it disappear, when it must be turned slowly upright. This operation may be repeated, if found to be necessary, till the column of fluid be joined.

In cases where the fluid has been very much separated from bad usage in carriage, or from placing the box with the top of the Sympiesometer down, it is to be corrected by holding the Sympiesometer with the top up, and having the stopper of the cistern close, shake the instrument by jerking it downwards, then hang it up to drain, when the column of fluid will be got to join.

MANNER OF USING THE INSTRUMENT.

Observe the temperature by the thermometer, and set the pointer above the top of the sliding scale, opposite to the degree of temperature upon the fixed scale ; and then the height of the fluid, as indicated on the sliding scale, will be the pressure of the air required.

Suppose the temperature observed by the mercurial thermometer to be 52.°4, then slide the Sympiesometer scale until the pointer is at 52·4 on the fixed scale, at the right hand side under the sliding scale ; it is to be observed, that the numbers on this scale, and also on the thermometer, read downwards, and the top of the column of red fluid stands opposite to the second division above the third tenth higher than the number 30. The height of the barometer is then 30 inches 3 tenths and 4 hundredths of an inch, or 30·34 inches. The tenths are easily distinguished from the hundredth parts, by the lines being drawn longer. As it is convenient to know what change has taken place since the last observation, the circular register at the bottom of the frame should be set, by turning the division on it corresponding to that indicated by the Sympiesometer to the fleur-de-luce or index. When the column of fluid descends, bad weather may be expected; and when it rises, the weather will in general be fine.

Previous to laying the Sympiesometer before the public, I wished to have it submitted to a fair trial, by comparing it with observations made in the same ship with the Marine Barometer. For this purpose Quintin Leitch, Esq. of Greenock, the proprietor of the ship "Buckinghamshire," obligingly sent one of the first which I had made with this ship on her voyage from the Clyde to the East Indies, in the year 1816; and the following is the report given of the instrument by the late Captain Christian, the commander, on his return:—

"I am glad to say, that I consider your Barometer a valuable instrument at sea, having given it a fair trial on the outward passage to India, by keeping a correct register of it, as well as of the common Marine Barometer, taken every third hour, night and day, during the passage: and I not only found that it was fully as sensible of the changes of the atmosphere as the other barometer, but that it had a great advantage over all barometers I have ever seen used at sea, namely, that of not being in the smallest degree affected by the motion of the ship, which will often make the quicksilver in the common tube plunge, or rise and fall, in such a degree as to make it very difficult to come within at least one or two tenths of an inch of the truth, even in the largest ships. On the passage home, I also found it very correct in the indication of the winds and weather."

An opportunity of trying the Sympiesometer in a very different climate, occurred in the year 1818, when the Expedition under Capt. Ross sailed to the Arctic regions. Lieutenant Robertson of the "Isabella" kindly undertook the charge of this instrument, and regular observations were made every four hours with the Sympiesometer and Marine Barometer, the results of which were highly satisfactory. The observations commenced on the 24th of April, in North Latitude 51° 39′, and Longitude 1° 7′ E.; and were continued to the latitude of 76° 50′ N., and during the return of the Expedition to Deptford, till the 13th of November. These observations, in the form of a graphical representation of the progress of the Sympiesometer and Marine Barometer, have been published in Captain Ross's Account of the Expedition, and will enable navigators to form a correct estimate of the relative value of the two instruments.

The following is Captain Ross's Official Report upon the Sympiesometer:—

"This instrument acts as a Marine Barometer, and is certainly not inferior in its powers. It has also the advantages of not being affected by the ship's motion, and of taking up very little room in the cabin. I am of opinion that the instrument will supersede the Marine Barometer when it is better known."

Lieutenant Robertson, in a letter to Lord Napier, has spoken of it in the following manner:—

"The Sympiesometer is a most excellent instrument, and shews the weather far better than the Marine Barometer. In short, the barometer is of no use compared to it. If it has any fault, it is that of being too sensible of small changes, which might frighten a reef in, when there was no occasion for it; but, take it altogether, in my opinion it surpasses the mercurial barometer, as much as the barometer is superior to having none at all."

In a letter to the inventor, he farther states:—"From my own observations, I found that the Sympiesometer was, almost without exception, sooner affected by a change of weather than the common Marine Barometer, the latter frequently giving no intimation, and only beginning to rise or fall when the change has taken place for some time.

"A sudden fall of the Sympiesometer generally indicated a breeze of wind, which came to blow from two to four hours after the fall. When the breeze came to its height, the Sympiesometer rose again, though it might continue to blow for some hours after. At the approach of snow, fog, or rain, without wind, its fall was more gradual, and while amongst ice, where we had little wind, its rising and falling was a certain indication of clear or thick weather. Having attentively compared the changes of the weather with the rising and falling of the weather-glasses, I decidedly give the preference to the Sympiesometer; its convenience for a ship is obvious, as it can be placed any where, without risk of breaking."

I have also had it in my power to make trial of the Sympiesometer on coasting voyages, through the favour of my friend Mr Stevenson, Engineer to the Scotch Lighthouse Board, who placed one of them in the cabin of the Lighthouse Yacht, beside a good Marine Barometer. Along with a register of both instruments, extracted from the ship's log-book, he has favoured me with a communication, which states, that, "after an experience of two years, the Sympiesometer affords the most delicate and correct indications of the weather;" and that "it is a great favourite on board, being commodious even for the smallest cabin, and at the same time easily read off."

"The master, mate, and steward, of the Lighthouse Yacht (Mr Stevenson adds), give such accounts of the utility and convenience of the Sympiesometer, as are well calculated to recommend it to the attention of those sailing in vessels of the smallest burden. It is now in use in the service of the Commissioners of the Northern Lights, on board the Lighthouse Yacht, of 80 tons register, and the Pharos or Bell Rock Tender, of 45 tons."

The following extract of a letter from Captain Dalling, of His Majesty's ship "Nimrod," on the Leith station, to Sir Henry Jardine, Edinburgh, contains an additional testimony to the utility of the Sympiesometer, and its superiority over the Mercurial Barometer: "During Sunday the 15th (November 1818), we had fine clear weather, wind from the north and west; Sympiesometer on the rise, and at midnight it stood at 29·72. The wind soon after hauled to the southward, the weather became unsettled, and at 8 A. M. on the 18th I found the instrument 29·42. The weather not threatening much, sent a boat on shore. At noon, it fell 29·24, being nearly ·20 in four hours. The wind freshened up; we got the boat off with difficulty; ten minutes more and she must have staid on the beach: by half-past 12 it was a perfect gale of wind at west. At 8 in the afternoon, the Sympiesometer began gradually to rise, being 29·29; the Barometer perfectly stationary: at midnight it (the Sympiesometer) was 29·40: at 4 in the morning of the 17th, 29·50. The Barometer did not begin to rise till midnight; the Sympiesometer had therefore four hours' start. The gale abated at 2 in the morning, and at 8 in the morning we had most beautiful weather; Sympiesometer 29·62.

"This, I think, a very pleasing and satisfactory example of the quickness and truth of the instrument. It began to rise upwards of six hours before the gale abated, and had four hours' start of my Barometer."

The following letter is from the Honourable Captain Duncan:—

"*H. M. S. Liffey, Spithead, August 27*, 1820.

"Having repeatedly tried your Sympiesometer since I purchased it when the "Liffey" was at Leith in September last, I think it fair to let you know that it is impossible anything could have answered better. It is, in my opinion, much superior to the Barometer, and is decidedly much quicker in denoting the changes of weather. I had one very striking instance of this fact last month, when beating from the Downs to Spithead. We were off the Ower's Light-vessel at 8 P. M.; the weather was fine, and every appearance of continuing so. About half-past 8, the Sympiesometer fell, and soon after the night became cloudy; we double-reefed our topsails, and at 11 it blew very fresh, and continued so with squalls and rain. The Barometer did not fall till past two in the morning."

THE ANEROID.—Subjoined is an account of the Aneroid, a newly invented instrument, so convenient in point of size, and portable, that it were very desirable indeed that it should succeed—though I have but little hope of its ever becoming entitled to take a place amongst our Meteorological instruments in India. It seems to suit well for Marine purposes, and its agreement with the Barometer for the first 1000 feet, or the fluctuation of an inch, is quite remarkable. It does not, however, seem at all to be depended on, and is, I should think, worthless for the stricter purposes of Meteorology.

Aneroid Barometer.* Since writing the preceding paragraph, the author has inspected† this new and beautiful instrument, invented by M. Vidi. It was described by Professor Lloyd to the British Association,‡ and reported to have stood the test of being placed under the receiver of an air-pump, when the indications corresponded with those of the mercurial gauge to less than 0·01 inch. The principle upon which the instrument depends, is the pressure of the atmosphere upon a metallic chamber partially exhausted, and so constructed, that by a system of levers a motion is given to an index-hand which moves upon a dial.

The principle of the vacuum-case was formerly applied by M. Conte§ in Egypt, but from the faulty mode of constructing his instrument, it was rejected and neglected.

Upon comparison of indications made with the Aneroid Barometer—not corrected for the particular temperature—and a very perfect mercurial barometer, given by Mr Dent, we find that from forty-nine observations made between the 6th January and 23rd February 1848, the mean difference was 0.037 inch, the *aneroid* being in excess; and from sixty similar observations made with a standard barometer, during December 1848, and between the 3rd and 31st January 1849, the mean difference amounted to 0.026 inch, the *mercurial* being, in this case, in excess over the aneroid barometer. Combining these observations (109 in number) a mean difference amounting to 0.0025 inch is found to exist, the indication of the aneroid being in excess.‖ For general use, the instrument is thus shewn to be well suited; for the measurement of heights it is peculiarly adapted, from its portability and comparative strength; and for nautical purposes we know of no better instrument.

Fig. 1. represents the external appearance of the Aneroid Barometer; Fig. 2. its internal arrangement, where the dial is supposed to be removed and the index-hand retained; and Fig. 3. a perspective view of the same.¶

In Fig. 2. *a* is the metallic chamber or vacuum-vase, which receives the atmospheric impressions; it is corrugated in concentric circles, which increases its elasticity, and renders it more susceptible of atmospheric impressions; *b* is the tube, hermetically sealed, through which the air in *a* is exhausted. At the centre of *a* there is a solid cylindrical projection *x*, to the top of which the chief lever *c d e* is attached—this lever, which is of the second order, rests upon fixed pins, or fulcra, placed vertically, and upon a spiral spring under *d*, but it is perfectly mobile. The extremity *e* of this lever is attached by a vertical rod and bow-shaped spring *f*, with another lever to which a watch-chain *g* is fastened and extended to *h*, where it works upon a drum fixed to the axis of the index-hand, connected with a delicate spring at *h*,—the vertical motion is thus changed to a horizontal one, and the hand, which is attached to the metallic plate *i*, is thereby moved upon the dial. The movement originating in the vacuum-chamber is multiplied by these levers, so that a change in the corrugated surfaces, amounting to 1-220th of an inch, carries the point of the index-hand through a space of three inches on the dial.

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* α privative, νηρος, and ἐιδος—a form without moisture. See Dent on the Aneroid Barom.; Mech. Mag. No. 1307.

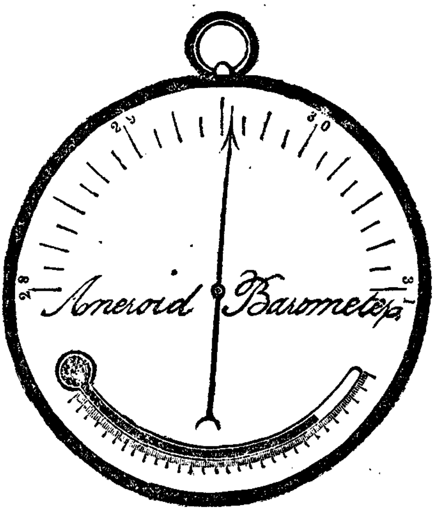
† At Mr Abraham's, Lord Street, Liverpool. The price is £3. It is 4¾ inches in diameter, and 1¾ inches thick. The scale is divided to 0.025 inch.

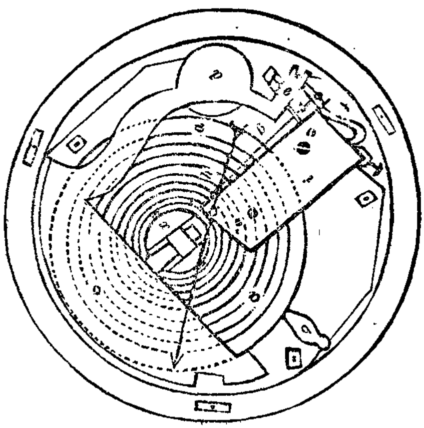
‡ At Swansea, in 1848.

§ Bulletin des Sciences. Floreal An. 6 p. 106.

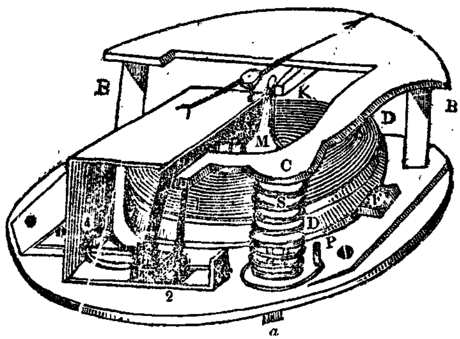
‖ The sum of all these observations gave 2139.722 inches for the aneroid, and 3239·4 inches for the mercurial barometer, the difference being 0·272 inch, which, divided by 109, = 0.00249.

¶ We beg to acknowledge the kindness of Mr Dent, in permitting casts to be taken of Figs. 3, 4, and 5,—Aneroid Barometer.



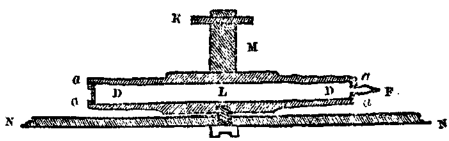


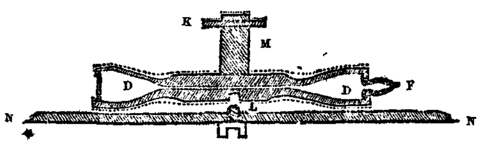
In Fig. 3. the vacuum-chamber is represented by D ; the large lever by C, resting upon the fulcra B B and spiral spring S, and supporting the box D by the pin K. At the extremity of C is seen the vertical rod (1) connecting it with the levers (2 and 3) by the bow-shaped spring (4). The square-headed screws *b e*, by screwing or unscrewing, admit an alteration in the distance of leverage, and thereby enable the index-hand to move over a space corresponding with the scale of a mercurial barometer. To the lever (3) is attached a light rod terminating with the watch-chain, which is attached to the drum fastened to the axis. The handle is kept firmly fixed, when not in motion, by a delicate flat spiral spring attached to the axis, acting against the force of the levers, and always in a state of tension.



F is the exhausting tube; and A, at the back of the instrument, is a screw, which upon being turned, alters the position of the index-hand, and thus enables the observer to adjust the aneroid to any mercurial barometer. The atmospheric pressure increasing on D. will cause a slight depression of the corrugated surface to which K is attached, and a corresponding inclination of the lever C; but as this lever is resting upon unmoveable fulcra at BB, the motion will take place chiefly over the spiral spring S, the increased distance of the lever being as six to one. The metallic chamber being 2·5 inches in diameter, the pressure of the atmosphere should be about 73 lbs. upon the corrugated diaphragms, but owing to various causes it is not more than 44 pounds.

Figs. 4. and 5. represent the vacuum-case, separated from the levers. The former shews the case before exhaustion; the latter after the air has been withdrawn. *a a a a* indicate the lapping over of the thin corrugated metallic diaphragms, where they are soldered to the rim; D is the vacuum-chamber, with F the exhausting tube; and L the





screw part fixing D to the metallic plate N below. In Fig. 5, the vacuum case is in a state of compression after being exhausted, and M represents the socket, which being pulled by the pin K, places D in a state of tension. The dotted line marks the position of the diaphragms after the introduction of the gas, which effects compensation for changes in the capacity of the case by alterations of temperature. Without this gas the capacity of the case would be diminished by heat, and increased by cold, but the changes in the elasticity of the gaseous fluid by varying temperatures, effect compensation.

In using the Aneroid Barometer for scientific purposes, a certain thermometrical correction is required. This is made by carefully noticing the indication of the instrument in the external atmosphere, then placing it before a fire till the thermometer indicates 100° F., and watching the change which has taken place. The variation of the hand, divided by the degrees of the thermometer, gives the quantity for each degree. The amount will be sometimes in excess, occasionally in defect.—*Dr. D. P. Thomson's Introduction to Meteorology*, pp. 447-452.

The above includes all the Thermometrical and Barometrical Instruments that I have deemed it requisite to describe. The fluctuations of pressure in India are so minute, and at the same time so exquisitely symmetrical, that instrumental observations are valueless unless the instruments themselves are of the best quality, and the readings exact and accurate to a degree. A general account of the state of the weather by an observant intelligent person, is always acceptable, and occasions no delusion. The wheel, and other varieties of the Barometer general at home, have not been so much as adverted to: they are all but unknown amongst us, and they are altogether useless.

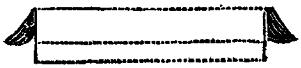
HYGROMETRY.

After Temperature and Pressure, the next condition of the air that comes under consideration is its moistness; but the determination of the quantity of water dissolved in a given bulk of air, though by itself an interesting problem, bears on the whole but lightly, unless when combined with other things, on the general phenomena of Meteorology.

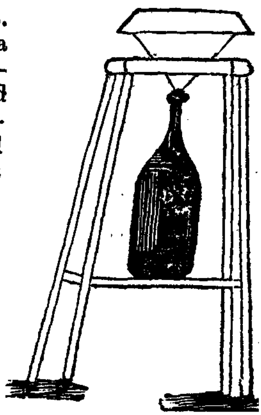
One of the first facts on this point to be determined, mixed up, as it is, with the other, is, not how much water the air contains, but how much it carries away; and unhappily our means of ascertaining the exact amount of evaporation from any given surface under any assumed class of circumstances, such as the temperature, the moistness, and the velocity of the wind, are in the last degree imperfect and unsatisfactory. Evaporation is not only dependant on the various conditions of the air just referred to, but on a variety of peculiarities of the surface from which it arises. It differs in degree over every variety of country, or variable surface, according to its hue, texture, temperature, and humidity,—and the confusion arising from this is so extremely great, that very rude approximations indeed must for the present content us. But not only does the condition of the surface of the earth present us with endless varieties of adaptations for evaporation, the surface of water under different circumstances is affected in many different ways by the impact of moving masses of air. The great body of the Ocean, or of the waters of deep Lakes, afford a considerable degree of uniformity as to temperature; but when raised in waves or spray, or agitated by the winds, the evaporating surface presented by them is infinitely greater than when they are at rest: and it is, besides, in a condition much more open to be acted on by an evaporating agent. Estuaries, Bays, Rivers, and still shallow Pools, again, are apt to get warmed by the influence of the sun much beyond the temperature of the adjoining waters,—as, on the other hand, they get cooled beneath them by the radiation of a clear sky. To meet these various conditions of things, the most simple and serviceable contrivance we possess is the evaporating dish, an instrument for which, like the rain-gauge, we have no equivalent,—which, instead of being made the most of until something better can be found, has been treated with almost total disregard, so that, poor as it is naturally, its natural poverty has been aggravated by neglect.

The first condition of an evaporation dish is that the form of its surface shall be such that its area may be determined with perfect accuracy—a state of things, as already mentioned, with which a circle alone is compatible (vide p. 20, article Rain-gauge); —the second, that its sides shall be parallel to its axis, and its area perfectly uniform to the depth that evaporation may chance to extend betwixt any two observations—that is, for an inch or so at least. The third condition is, that we shall be able to observe the precise amount of water evaporated within a given time—say twelve or twenty-four hours. Rain-gauges such as have been elsewhere described, fulfilling all these conditions, may be used as evaporating dishes—the ordinary evaporating dish, the contents of which are poured out into a glass measure, I consider all but useless. When a cylinder, or funnel with a cylindrical mouth, is used—the limit to which the water ascends may be determined as follows:—place a light bar of wood or metal across its mouth: through this thrust two pins, the one protruding say $\frac{1}{100}$th of an inch or so—the smaller the quantity the better—further than the other. Fill up the dish with water till the pin most prominent just dips into it—the less prominent pin not quite touching the surface. The two ought to be as far apart as to preclude the second from being affected by the little mass of water raised by the capillarity of the first above the general level. The arrangement may be very conveniently reversed by placing a stick athwart the dish, and pointing the pins upwards—or a combination of the two may be resorted to. An evaporating dish of this sort is carefully filled at starting: next day as much water is poured into it as brings it up to the original position, from a measure, previously accurately divided into so many grains and so many inches and decimals, for both ought to be indicated on the measure—the latter only to be read:—the water required for this will indicate the amount carried off in vapour. These observations can only be made when the air is perfectly still, and as the evaporating dish ought to be exposed to the breeze, so a moveable screen must be provided to secure shelter while observing, and permit the breeze to exercise its full force when the dish is in use.

I have found the following contrivance very convenient indeed for the purpose of determining evaporation. Procure a dish edged and turned the same as the rain-gauge funnel already described (page 28). In this case the mouth of the funnel must be provided with a stop-cock—or, where this is not procurable, with a plug or cork. The funnel ought to be made to hold



a quart exactly, quite up to the brim, and this it will do if made two inches deep, the conical portion one, and the cylindrical portion one; and six and a half inches wide—the extra half inch being allowed for the insertion of the turned rim which will bring it down to six inches. The funnel being put in its place, a quart bottle, carefully filled with water exactly to the neck, is now emptied into it, and the bottle itself placed under it, on a stand like that represented in the accompanying diagram. On first filling the evaporating dish, the bottle-full should be poured in and emptied out several times to see how much exactly is kept back on the sides of the funnel after some minutes have been allowed for it to drip—the plug being thoroughly soaked at the same time. All these precautions having been duly attended to, the dish is filled—the deficiency next day in the bottle will indicate the amount of evaporation.



The marks of the measuring tubes are made to read both ways by figures both above and below the lines. The best way is to fill the tube up to the top of the scale exactly: then open the stop-cock and let the water flow into the measure, taking great care that none is allowed to run over or spill. Note the number of grains run out, and divide this by the number of grains corresponding to the area of the evaporating dish as found in the table, adding ciphers—the quotient will give the amount of evaporation.

Example.—The area of the evaporating dish is 6 inches :—a stratum of water of this area one inch in thickness weighs 7158·5974152 grains—the decimal may be dismissed. Supposing that it loses 941 grains, as indicated by the scale on the tube, to supply the amonnt of one day's evaporation : then

```
7158)941·0000(0·1314
     715 8
     -----
     225 20
     214 74
     ------
      10 460
       7 158
      ------
       3 3020
       2 8632
      -------
         4388
```

So that the evaporation amounts to no inches—·1314 merely : it is seldom necessary to go beyond the place of thousandths of an inch.

The graduations marked on a bottle, which suffice for rain-gauge purposes, are scarcely delicate enough for those of evaporation—for the form of evaporating dish first described, they are unserviceable altogether. The following is the method of graduation and measure I have resorted to to secure a standard. For an unit of measure I have found the bulb, if spindle-shaped, and part of the stem of a broken thermometer, well suited. It must first be carefully emptied and dried—then weighed—then filled with water up to the neck of the stem and weighed again—as much more should now be added as gives one or two grains more, according as the length of the stem allows : from these fill up the bulb to where the bore becomes uniform. In a fine bored thermometer a grain will occupy an inch in the stem, and may be subdivided by measurement into tenths or twentieths—the bulb will hold from ten to fifteen or twenty grains. All these operations are performed before an aperture is secured in the lower part of the bulb—

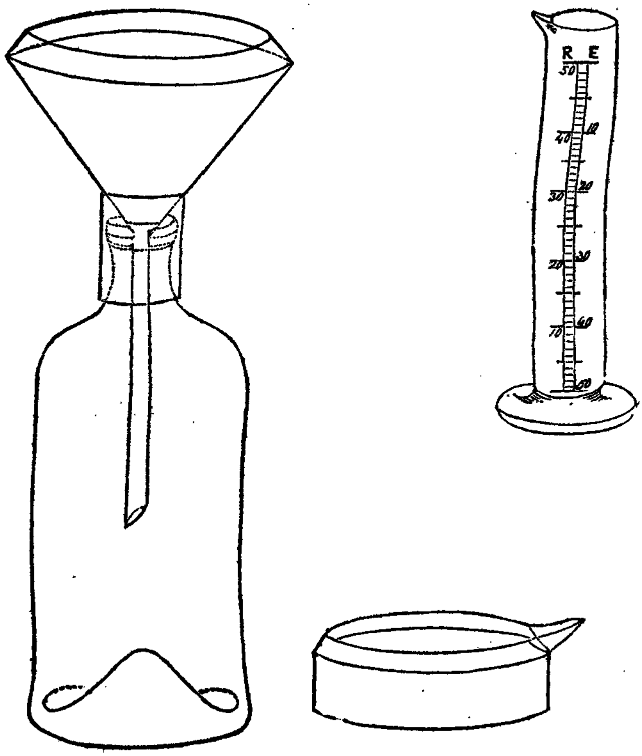
and marks should be made for say ten, fifteen, or twenty, grains of water at different temperatures from 80° to 90°—those we have most commonly to deal with in India. If these experiments have been accurately performed, the unit measure may now be carefully heated—the point of it being approached to a lamp, and drawn out, so as to secure a capillary aperture below. If this be well managed, the error occasioned by the bore now opened will rarely amount to the tenth of a grain. This measure does not often require to be resorted to. The most convenient for an unit of larger size is what is called a quill tube,—that is, a tube of glass, about the thickness of a crow-quill, as thin in the walls as can be made: a piece a foot long at least should be taken, and one end of it sealed up. It should now be gauged in the manner formerly described—if not uniform in diameter, it is useless for the present purpose. The tube is now suspended from a fine beam, and counterpoised; fifty grains are next added and marked, and a second fifty may be poured in to make sure—this being marked also by a slight scratch on the tube. The spaces between the marks are now taken off by a pair of compasses and a paper scale the length of the tube laid down on a drawing board, and very carefully ruled and divided. This is then gummed or pasted on, the fifty grain marks on the scale and tube being placed together: the point of the tube may now be heated by a lamp, and drawn out so as to secure a capillary aperture as before. The fundamental measure once made, should be placed in a box for reference, as it is very apt otherwise to get broken, and much dexterity, time, and care, are required for its construction. Tubes of greater bore for similar purposes are graduated from this—after being gauged and prepared as before.

Those required for measuring purposes are fitted up with a stop-cock—grains are marked in black on one side of the scale, decimals of an inch on the other,—the tube being filled by sucking the water up into it, and any excess that may exist being allowed to drop through the stop-cock, until the graduated portion of the scale be attained. The figures ought to read from the upper end downwards, so that the tube may always be filled full, and as much water drawn off as is required to fill up the gauge to the pin points, or the bottle to the mouth. The expansion of water betwixt 70° and

90°, our usual temperatures, is so insignificant, that no account of it need be taken. The following is the description given of his evaporating dishes by Mr Luke Howard in his "Climate of London," Vol. I., pp. xvi. to xxii.

OF THE GAUGES FOR RAIN AND EVAPORATION.

These are treated of together, as being connected in the most essential part,—the graduated measure for the water.



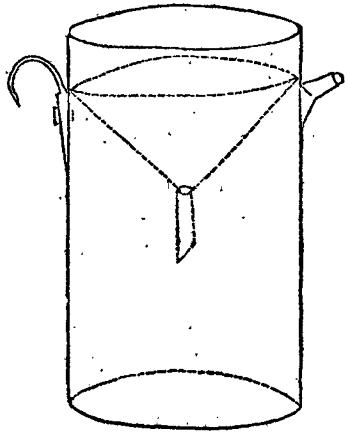
The *rain gauge* consists of three pieces—a funnel, a bottle, and the measure. The *Funnel* is most conveniently made of five inches opening, and of the form represented in the figure: the mouth piece of brass, turned in a lathe, the remainder of tinned copper. It has two necks: the inner and longer one widening a little downward, enters deep into the Bottle, and conveys the rain: the outer neck is soldered on the cone of the Funnel, having no opening into the latter: it serves the necessary purpose of preventing the entrance of water from the outside, and by resting on the shoulder of the bottle, it gives steadiness to the funnel.

As to the *Bottle,* a common winequart will contain from two to two and a half inches of rain on this funnel, but it is better to use a three-pint bottle (technically termed a *Winchester quart*), which has the proportions given in the figure. For an unusual fall of Rain may happen, when a previous quantity has not been measured out: and it is on such occasions that we would wish, more especially, to be certain of the amount.

A cylindrical Glass of the depth of eight inches, exclusive of its foot, and an inch and a third in diameter, serves to make the *Measure.* It is graduated in parts, each of which is equal in capacity to the depth of a hundredth part of an inch on the area of the mouth of the funnel. A Glass of the above size will measure out fifty such parts, or half an inch, at once. The graduation is conducted on the principle (which is a medium between calculation and experiment) that a Cylinder of water at a mean Temperature, an inch deep, and five inches in diameter, weighs ten ounces *Troy.* The hundredth part of this, or forty-eight grains, is accordingly taken for the graduating quantity, and the Scale is formed by successive additions, at each of which the surface is marked. Considering the nature of this operation, which scarcely admits of our going to fractions of a grain, I suppose the above standard to be sufficiently correct. *I have been accustomed to *etch* the scale on the glass with fluoric acid, but it is more conspicuous when engraved at the glass cutter's wheel. Previously to sending it for this purpose, the whole scale should be traced, either on a strip of paper pasted on before it is divided, or in oil paint on the glass itself. A diamond, or steel point, may be used in default of other means, for engraving the scale.

Although I recommend these dimensions as convenient, and have had them executed in different instances for others, I have hitherto used a Gauge, the funnel of which has eight inches aperture, and the Measure is graduated by the quantity of a hundred and twenty-four grains, the bottle being large in proportion.

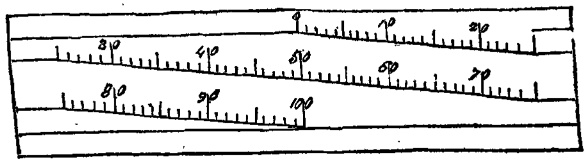
For Tropical climates, and in cases where a large bottle is found inconvenient, the whole recipient part may be of tinned copper, the *rim* excepted, which is still to be of turned brass. On this construction, a moveable funnel may be let in, so as to rest below the rim and prevent evaporation: a spout,



with a small aperture, should also be provided at the side, both for the convenience of emptying the water into the measure, and to permit the air, on occasion, to pass out freely. (See the figure above.)

The *Position* which, since the year 1811, I have preferred for the Rain-gauge, is to sink it into the ground, bringing the mouth of the Funnel nearly to the level of the turf, which should be kept cut, so as to leave a clear space of an inch or two around. In winter, when snow may be expected, it is proper to raise it a few inches. A thick sheet of snow is apt to have a large depression above the Funnel, the surface of which, slightly thawed and frozen again, has, more than once, collected and sent into my gauge a redundancy of water. On the subject of different products from different situations of the gauge, the reader may consult the appendix to Table LXIV.

The graduated measure for the Rain being numbered on the opposite side of the scale downward, serves also to ascertain the *Evaporation*. For this purpose, a cylindrical tinned copper vessel is employed, of five inches diameter within, furnished with a rim to prevent spilling, in which is a lip, set on clear of the cylinder. Two measures, or an inch, of water being poured in, fills two thirds of the Cylinder: the vessel is then placed near the ground in a situation where it may be sheltered from rain, and have the sun's rays, without reflexion. At the end of twenty-four hours, or a longer period, extending to a week if desirable, but regulated by the season of the year, the water being returned into the measure, the quantity which is evaporated may be read off, and the vessel replenished. For warmer Climates, or longer periods of observation, the depth of the vessel may be increased, and a greater number of measures put in.



Where the *Evaporation* alone is in question, and the observer wishes to ascertain it daily, without trouble, the following contrivance may be used. On a plate of glass, six inches long, and an inch and a half wide, a line is to be drawn near and parallel to one side, to serve for a base. From this a diagonal Scale, etched with floric acid, is to be carried up, ascending at the rate of one inch in *ten*; so that the tenths of an inch into which it is ultimately divided shall rise in progression just one hundredth part of an inch above each other. The glass being now fixed perpendicularly on its edge, in a vessel of the proper capacity and depth, (if this be square it may be set in diagonally and supported by the angles,) a little Water is first to be put in, the surface of which is to be brought, by adjusting the position of the vessel, to range with the horizontal line at the bottom of the scale. This adjustment made, more water is to be added, up to the line which cuts the division at *Zero*. Then, in proportion as the surface is lowered by evaporation, it will cut the several divisions in succession, indicating at sight the effect to the hundredth part of an inch.

[I have varied the position of the Scale in this instrument, and made it *an inclined plane.* A piece of plate glass about eleven inches long, by an inch wide, is graduated in the manner of a measuring rule, in divisions one tenth of an inch apart, which are numbered at every ten, from 0 to 100. The dividing lines being half an inch in length, the water (when the Scale has been so placed as to make just an inch difference in the perpendicular between the two extremes) makes a bend, or half round, against the lower surface. This is to be brought to touch the upper division at 0, after which it will descend, forming a tangent to each division as the Evaporation proceeds, and indicating very neatly, by simple inspection, the results.]

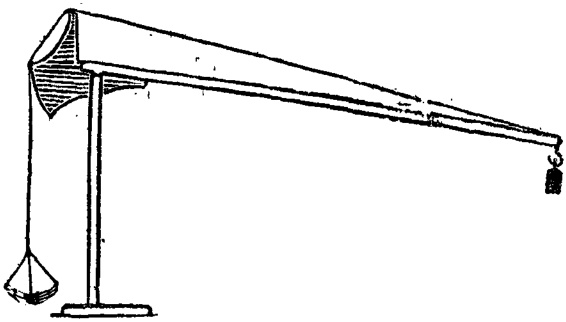
Lastly, for delicate occasional observation on *Rain, Dew,* and *Evaporation*, I have an Instrument which will indicate either to the thousandth part of an inch, and which I likewise find useful in graduating other gauges. This Instrument, a figure of which is given on the succeeding page, I shall now describe.

A funnel like that of the Rain-gauge, but with an upright cylindrical rim, five inches in diameter, terminates in a glass tube twenty inches long, and of half an inch calibre, having at bottom a good stop-cock. The tube is graduated on the principle of the glass measure above described: but the

divisions are here wide enough to admit of decimal subdivisions. When the Instrument is used for *Evaporation*, the tube is first to be filled to the *Zero at top*; a full bottle of water is then to be added, so that the surface may stand at a proper height in the Cylinder during the experiment, at the close of which, the same quantity of water being returned into the bottle, the deficiency will appear in the Tube. When for *dew*, or for *rain*, in minute quantities, or at short intervals, water is to be introduced up to the *Zero at bottom*, and the inside of the Funnel moistened with a sponge at the outset; the difference in volume caused by change of temperature, must, in these delicate experiments, be obviated or allowed for. This instrument requires, likewise, a support to keep it upright and steady in use.

In India, the Evaporating Dish ought never to be exposed to the sun, unless the difference of evaporation at different temperatures with the same breeze is meant to be ascertained. The water in an evaporating dish in the sun will often rise to a temperature of 120°, while that of the atmosphere around is no higher than 80°: this only occurs with small masses of water—so as to have nothing analogous to it amongst the phenomena of nature desired to be investigated; the surface of the ocean seldom differing more than a few degrees from the air around—the mean temperature of the two approximating closely to each other. A shaded dish, fully exposed to the breeze, though not correct in its indications, will be found infinitely so than one exposed to the sun.

Actual weighing of the evaporating dish, contents and all, is the most accurate method of determining evaporation, but it is so troublesome and tedious that it is not likely often to be made use of. Where the evaporation from damp earth, or other similar surface, is to be determined on, the weighing must on almost all occasions be resorted to. I have found a steel-yard of the following fashion to afford very interesting results for short periods of time, say at the change from the land to the sea breeze. It is made up of straight pieces of deal wood, tied with a thread to keep it stiff. As the water evaporates, the dish, suspended from the shorter end of the lever, becomes lighter, and the larger descends,—the amount of its descent, which indicates the amount of evaporation, being read off by a graduated scale. The whole, with the exception of the dish, must be under glass, to escape the disturbances occasion by the wind.



The following experiments on an evaporation at sea by Mr Laidley, are taken from the Transactions of the Bengal Asiatic Society —Leslie's instrument has the disadvantage of being only exposed fairly to the wind on one side—on the opposite side we most certainly have an atmosphere of damp, partially stagnant, greatly interfering with evaporation.

[*From the Bengal Asiatic Transactions,* Part I. Vol. XIV., 1845.]

Observations on the rate of Evaporation on the Open Sea: with a description of an Instrument used for indicating its amount. By T. W. LAIDLEY, *Esq.*

It has often occurred to me, that a simple and convenient instrument for ascertaining the actual amount of exhalation from a humid surface, could not fail of being essentially serviceable to meteorological science, as well as to the arts. An instrument for this purpose was indeed contrived by the late Professor Leslie, to which he gave the name Atmometer : but though very ingenious, and fulfilling tolerably well the intentions of the inventor, it fails in a very important qualification of scientific instruments, simplicity of construction and use ; and is consequently less frequently employed in observing the condition of the atmosphere in reference to dryness and humidity than is desirable. The instrument is thus described by its inventor : "The Atmometer consists of a thin ball of porous earthenware, two or three inches in diameter, with a small neck, to which is firmly cemented a long and rather wide glass tube, bearing divisions, each of them corresponding to an internal annular section, equal to a film of liquid that would cover the outer surface of the ball to the thickness of the thousandth part of an inch. The divisions are marked by portions of quicksilver introduced, ascertained by a simple calculation, and they are numbered downwards to the extent of 100 to 200 : to the top of the tube is fitted a brass cap, having a collar of leather, and which after the cavity has been filled with distilled water, is screwed tight. The outside of the ball being now wiped dry, the instrument is suspended out of doors, exposed to the free access of the air. In this state of action the humidity transudes through the porous substance just as fast as it evaporates from the external surface; and this waste is measured by the corresponding descent of water in the stem. If the Atmometer had its ball perfectly screened from the agitation of the wind, its indications would be proportional to the dryness of the air at the lowered temperature of the humid surface; and the quantity of evaporation every hour as expressed in thousandth parts of an inch, would when multiplied by 20 give the hygrometric measure. The Atmometer is an instrument evidently of extensive application, and of great utility in practice. To ascertain with accuracy and readiness the quantity of evaporation from any surface in a given time, is an important acquisition, not only in meteorology, but in agriculture and in the various arts and manufactures. The rate of exhalation from the surface of the ground is scarcely of less consequence than the fall of rain, and a knowledge of it might often direct the farmer advantageously in his operations. On the rapid dispersion of moisture depends the efficacy of drying houses, which are often constructed most unskilfully, or on very mistaken principles."

The instrument which I have found to answer extremely well, consists of a glass tube the bore of which must be equable, and may vary from one or two-tenths of an inch in diameter to a much larger size, according to the pleasure of the constructor. If the bore be not quite equable, its varying capacity must be ascertained and allowed for on the scale to which it is to be attached. One end of this tube, after being ground quite flat and smooth, is to be closed with a porous substance, which space permits the free transudation of water, but yet not so freely as to accumulate in drops or to fall. I find that common cedar wood possesses the requisite quality, and forms a plug which swells so as to become water-tight; and by its porous structure permits the fluid to permeate as rapidly as the atmosphere removes it from the exposed surface. The tube thus prepared, and filled with distilled water, is to be attached to a scale divided into fiftieths or hundredths of an inch, upon which as the evaporation proceeds and the column of fluid descends, the daily amount of evaporation may be conveniently observed. No other precaution seems necessary in using this Atmometer than to supply it with very pure rain or distilled water; for any saline matter it might contain would be deposited upon the evaporating surface, and would interfere very materially with the result. To prevent error from this source, the entire tube should be very frequently (say every time that it is filled,) washed in a quantity of clean water to remove accidental impurities; and the cedar plug occasionally renewed.

The following observations made with this instrument on board of the ship "Southampton," on her recent voyage from England to Calcutta, showing the rate of evaporation on the open sea in tropical latitudes, may not be altogether uninteresting to such as are curious in oceanic meteorology. The instrument was suspended in a shaded part of the vessel, exposed freely to the action of the wind.

	Latitude.	Longitude.	Barometer.	Thermometer.	Evaporation in inches.
	° ′	° ′		°	
October 3	37 15 S	40 31 E	29.90	62	0.40
4	37 13	44 05	30.13	63	0.38
5	37 19	47 50	30.10	64	0.51
6	37 09	51 51	30.06	66	0.33
7	36 38	56 14	30.08	56	0.40
8	35 58	59 50	30 12	58	0.45
9	35 39	62 21	30.16	61	0.40
10	34 46	67 19	30 14	62	0.40
11	33 24	71 47	30.02	63	0.41
12	31 51	76 04	29.94	63	0.35
13	30 27	79 05	30.09	66	0.38
14	28 54	82 37	30.16	69.5	0.37
15	26 14	84 25	30.18	71	0.39
16	24 25	86 10	30.19	71.5	0.60
17	23 02	86 14	30.24	72	0.62
18	21 06	86 18	30.10	73	0.72
19	18 25	86 34	30.11	76	0.68
20	16 39	86 36	30.10	77.5	0 70
21	14 42	86 54	30.11	81	0.70
22	11 07	86 54	30.00	82	0.78
23	7 39	86 34	30.09	84	0.80
24	3 57	87 10	30.05	84.5	0.82
25	2 08	87 19	30.04	83.5	0.75
26	1 09 N	87 57	29.97	84	0.86
27	4 19	89 32	30.00	82.5	0.98
28	6 41	90 16	30.00	84	1.00
29	7 58	90 40	30.00	84.5	1.06
30	8 50	90 52	30.02	81.5	0.88
31	9 35	90 40	30.00	84	0.72
November 1	10 55	90 15	30.00	84	0.93
2	13 10	89 56	30.03	81	0.82
3	14 15	90 00	30.05	86	0.40
4	15 20	89 30	30.05	84	0.70
5	17 25	88 49	30.00	83	0.67
6	18 34	88 24	30.00	83	0.72
7	18 52	88 45	30.02	83	0.63
8	19 23	88 53	30.10	83	0.88
9	19 18	89 37	30.00	82	1.15
10	19 56	89 43	30.00	82	1.25
11	20 37	89 00	30.00	81	1.24
12	20 54	89 12	29.95	80	1.32
13	Sandheads.		29.98	80	1.04

The reader will perhaps be surprised at this high rate of evaporation on the open sea, differing as it does so widely from that deduced by M. Von Humboldt from his own observations with the hair hygrometer. That accomplished observer gives the following results, calculated from a formula of M. d' Aubuisson, which does not however appear to meet all the circumstances of the case.

Latitude N.	Thermometer, (Cent. grade.)	Hygrometer.	Quantity of water evaporated per hour in millimetres.
° ′		°	
39 10	14.5	82	0.13
30 36	20.0	85.7	0.14
29 18	20.0	83.8	0.16
18 53	21.2	81.5	0.20
16 19	22.5	88	0.13
12 34	24.0	89	0.13
10 46	25.4	90	0.12
11 1	25.0	92	0.09

"It follows from these researches," says M. Von Humboldt, "that if the quantity of vapour which the air commonly contains in our middle latitudes, amounts to about three-quarters of the quantity necessary for its saturation, in the torrid zone this quantity is raised to nine-tenths. The exact ratio is from 0.78 to 0.88. It is this great humidity of the air under the tropics, which is the cause that the evaporation is less than we should have supposed it to be from the elevation of the temperature."

These inferences seem scarcely compatible with the actual indications of my instrument. But it must be observed, that besides being imperfect as a hygroscope, De Luc's instrument takes no cognizance of the important agency of the wind in promoting evaporation. So far from diminishing, the exhalation from the surface of the sea would appear to augment very rapidly as we approach the torrid zone; my observations exhibiting a daily average of 0.398 in. from latitude 37° 15′ S. to latitude 24° 25′, and of 0.309 in. through the tropics.

[*From the Bengal Asiatic Transactions,* Part I. Vol. XVII., 1848.]

DAILY RATE OF EVAPORATION IN CALCUTTA.

On the chance of its proving serviceable to some speculator in meteorology, we place on record the subjoined statement of the daily rate of evaporation in Calcutta for the year 1845. The instrument employed was that described in

Volume XIV. page 213; it was freely exposed in an open verandah to the influence of the atmosphere, sheltered, however, from the direct rays of the sun.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	0.49	0.22	0.75	0.71	0.60	0.76	0.29	0.32	0.15	0.74	0.50	0.55
2	.65	.42	.78	.62	.62	.62	.43	.33	.49	.82	.58	.56
3	.66	.50	.74	.46	.54	.43	.42	.38	.55	.81	.54	.60
4	.61	.54	.90	.43	.62	.53	.37	.36	.63	.73	.56	.54
5	.61	.55	.90	.31	.67	.46	.43	.35	.40	.62	.62	.50
6	.50	.84	.83	.43	.77	.54	.42	.36	.31	.43	.63	.43
7	.52	.93	.77	.53	.98	.63	.51	.22	.45	.52	.66	.51
8	.55	.90	.78	.56	.69	.55	.61	.20	.34	.54	.61	.23
9	.55	.84	.76	.66	.96	.47	.39	.26	.32	.68	.61	.76
10	.66	.82	.80	.30	.87	.51	.23	.21	.44	.77	.64	.53
11	.65	.74	.63	.51	.78	.34	.25	.21	50	.75	.55	.50
12	.66	.76	.73	.60	.74	.48	.37	.30	.55	.45	.56	.58
13	.59	.83	.97	.60	.66	.49	.26	.17	.40	.42	.65	.62
14	.64	.84	1.00	.61	.81	.44	.23	.28	.23	.61	.64	.67
15	.51	.83	1.00	.56	.65	.54	.28	.19	.46	.58	.64	.53
16	.55	.86	1.05	.56	.64	.78	.34	.20	.42	.39	.56	.42
17	.37	.77	.73	.76	.64	.77	.40	.29	.54	.20	.57	.20
18	.43	.61	.72	.77	.66	.70	.37	.31	.39	.19	.56	.12
19	.43	.28	.85	.69	.93	.65	.29	.44	.47	.17	.64	.28
20	.55	.44	.96	.61	.94	.59	.35	.36	.52	.15	.52	.39
21	.62	.70	.96	.63	.77	.58	.38	.42	.47	.25	.50	.46
22	.45	.57	1.02	.85	.76	.46	.37	.35	.31	.46	.57	.40
23	.46	.76	.87	.77	.67	.48	.29	.38	.53	.30	.57	.38
24	.56	.70	.86	.78	.17	.46	.34	.43	.58	.46	.50	.52
25	.51	.71	.89	.82	.36	.21	.54	.43	.58	.47	.50	.51
26	.48	.81	.84	.45	.65	.21	.55	.44	.61	.30	.50	.46
27	.61	.80	.75	.48	.54	.40	.38	.44	.51	.58	.55	.44
28	.58	.89	.86	.77	.47	.31	.30	.28	.78	.52	.50	.40
29	.52	...	.88	.57	.38	.26	.24	.29	.63	.55	.42	.35
30	.31	...	.82	.66	.45	.19	.24	.33	.65	.68	.51	.59
31	.39	...	.85	..	.50	...	.24	.36	..	.52	..	.52
Average.	.537	.695	.714	.602	.650	.494	.358	.315	.373	.515	.565	.468

I have found a wine glass with a piece of wood or earthenware or clay, suit very well for an evaporating dish at sea. The dampness of the atmosphere is commonly determined without any direct relation to the quantity of moisture it contains, this being a result compounded of dryness and velocity. The Hygrometers chiefly employed in Meteorology are the wet and dry bulb, and Daniel's Hygrometer: Leslie's instruments have been long out of use. The following account of the wet bulb and its uses is from a pamphlet by Mr Glaisher, of the Greenwich Observatory:—

1. *Precautions necessary before using the Instrument.*

The thermometers should be essentially good; and, if possible, when under the same circumstances with both bulbs uncovered, their readings should be identical. The obtaining of two thermometers strictly comparable, is difficult, but not impossible. Out of twenty-five thermometers made by Watkins and Hill for me at one time in 1843, twenty of them agreed within one-tenth of a degree at every part of the scale; the extreme difference between the readings of the remainder was half a degree.

If there be a difference between their readings, the amount of it must be ascertained at different parts of the scale, and *particularly* at *and below* 32°: in doing this it is well to let the instrument be out of doors some days, and the readings should be frequently taken; the true difference at one part of the scale will thus be well determined. For other parts of the scale a liquid must be used; water must be heated a little higher than the desired temperature; if the water be too hot, cold water may be added, and well-mixed with the hot. The thermometers should be placed in the water, so that the same quantity of their stems should be covered by it, and thus they should be allowed to remain for half an hour, and the readings then should be taken quickly.

If their readings or that of the dry bulb could be compared with a standard thermometer, it would be well.

A quantity of rain-water should be provided.

2. *Position of the Instrument, and Precautions necessary in using it.*

The instrument should be in the shade, and should therefore have a North aspect.

It should be placed with the bulbs about four feet from the ground, and as far from walls, &c. as possible; especial care should be taken that it is not affected by the radiation of any heated bodies.

The wet bulb should be covered with thin muslin (I have used book-muslin), the conducting thread should be of floss-silk or cotton lamp-wick; the latter I always use, having found it to act better than the former; both the muslin and the conducting thread should be renewed about once a month. The reading of the wet bulb appears to be uninfluenced by currents of air; I have frequently during windy days screened the bulb from the wind, and the reading has been unaffected: it would seem that the air in quick motion communicates to the bulb as much heat as compensates for the increased rapidity of evaporation.

The water-vessel should never be allowed to be free from water; a supply of rain-water should always be kept.

In frosty weather the instrument is as effective as at other times. Water evaporates at all temperatures; even ice sends off vapour.

Between December 3rd and 14th, 1844, during which the temperature of the air varied from 20° to 37°, the temperature of several of the days being below 32° all the day, water to the depth of half an inch, placed in a proper evaporating dish fully exposed to the sky (ice immediately forming after exposure,) produced less than 0·4 inch of water when examined at the same time on the following day; the same result was obtained from experiments made between December 21st and 27th, the temperature in the meantime ranging from 27° to 35°.

The wet bulb in frosty weather should have a thin coating of ice over it, which when once formed will last a considerable time; if the bulb be not enveloped with its thin coating of ice, water must be poured over it, and it then must be left for a period of one hour at least. I have known an hour and a half to elapse after pouring water over the bulb before its readings have descended below those of the dry bulb, although, from the continuous preceding readings, I had reason to expect that such should be the case, and which was subsequently confirmed; it is indeed the safest course, if continuous readings be not taken, to pour the water over the bulb at least two hours before the time of observation.

The eye must be at the time of reading at the same distance from the ground as the top of the mercury is in the stem of the thermometer: this requires care: for if the eye be too high, the reading will be too low, and *vice versa.*

The reading of the dry bulb should first be taken, and then that of the wet bulb.

Promptitude of observation is necessary, so that the heat of the body should not pass to the instrument.

In observation, the breath should be held: I have known untaught observers, who have been a long time reading, and who did not hold their breath, cause the readings to rise several degrees; of course the observation was quite vitiated.

The cotton lamp-wick or floss-silk should be of such extent that the water conveyed should be sufficient in quantity to keep the wet bulb as wet as it would be were the air quite saturated; if too much water be conveyed, this may be lessened by taking a division or more from the thread.

At times the reading of the wet bulb may be higher than that of the dry bulb, which indicates that the air is completely saturated with moisture: it is well at those times, after the observation is taken, to examine the state of the dry bulb as to the degree of moisture on it compared with that on the wet bulb. The finger may be passed over the bulbs, noticing the quantities of moisture left on the finger; if more be left from the wet bulb than from the dry, it would indicate that the former was too wet.

In wet fogs a globule of water may hang from the dry bulb; this should be removed, and the bulb wiped dry about a quarter of an hour before the time of observation.

The dry bulb should be examined after rain has fallen, to see that it is really dry. If rain should be falling at the time of the observation, the bulb should be examined as to its dryness; and if the rain should have fallen on it, it had better be wiped, and the reading should be taken a few minutes afterwards: examination a few minutes before the observation is better.

Careful observers should annually verify the point 32° of their thermometers by plunging them into melting snow or ice, so that, should this point be displaced, the correction may be known.

For meteorological purposes the instrument should be constantly out of doors; it is then at all times ready for use. It should be fixed firmly so that the wind cannot move it: so ought also the water-vessel to be fixed.

3. *Temperature of the Air.*

The simple reading of the dry bulb thermometer gives this at once.

4. *Evaporation.*

Is the conversion of liquids into elastic fluids by the influence of heat: expose, for instance, water to that influence; bubbles at first appear, which by degrees ascend to the surface and burst. These bubbles rise the more rapidly in proportion to the heat.

Water evaporates in the open air at very low temperatures, and the vapour rising into the air mixes with it in an invisible form, until it is condensed, and assumes that of clouds, fog, mist, or falls in the shape of rain.

The amount of water thus changed into vapour is very large indeed. From experiments I have made during the years 1844, 1845 and 1846, it appears to be nearly 50 inches annually. It is probable that this quantity is much above the average; but all experiments that I have seen justify us in assuming that the average evaporation is more than 30 inches annually (that is, that the vapour in the atmosphere in one year, if reconverted into water, would cover the surface from which the evaporation took place to a height of 30 inches.) Assuming that this is about the annual quantity, and that the surface of all the waters on the earth is 130,000,000 of miles, then, water to the amount of 62,000 solid miles would be annually changed into vapour. To this large amount must be added the evaporation from moist earth, and from the watery parts of the animal and vegetable kingdoms.

To all persons engaged in meteorological researches, the knowledge of the distribution of this mass of water with the air is necessary, as we may readily infer, that the most important changes in our atmosphere are occasioned by it.

5. *Temperature of Evaporation.*

The bulb *d* being covered with muslin, and moistened by means of the water passing by capillary action up the cotton lamp-wick leading from the water-vessel to the covered bulb, and keeping the muslin on it constantly wet, will take a temperature depending on the following circumstances:—The air in contact with the wet bulb gives enough of heat to vaporise the water, which being converted into vapour sufficient in quantity to saturate the space which the air occupies, the reduction of temperature will be according to the quantity of heat which has been combined in order to change its state from water to vapour. The principle holds equally well when the temperature is below freezing, only in this case the air in contact with the bulb covered with ice has to liquefy as well as to vaporise the water: and owing to this, the difference between the reading of the dry and wet bulb thermometers, at temperatures below 32°, is always small, and the readings must be taken with great care.

If the air were completely saturated, it could not take up any additional vapour; no heat would therefore be lost in vaporising the water, and the readings of the dry bulb thermometer and of the wet bulb thermometer would be alike; but if the atmosphere be not saturated it will take up additional vapour, and if it be very dry it will take up much vapour, but that vapour must have been combined with a large quantity of heat, and the temperature of the air in the now saturated space will be lowered accordingly. There is another circumstance which affects the temperature of evaporation: if the barometer be very low, the air would yield less heat, and the temperature of evaporation would be lowered in consequence, but to so small an amount, that, except at great heights, it is inappreciable. By observing the reading of a wet bulb thermometer the temperature of evaporation is found. The difference between the readings of the dry bulb and the wet bulb in this country, between the months of April and September, will frequently be from 9° to 12°, less frequently 12° to 15°, and occasionally it will amount to 18°; and during the other months of the year it will frequently be between 4° and 9°.

6. *Temperature of the Dew-Point.*

If a mass of air be gradually cooled, it will descend to a degree of temperature at which it will be saturated by the quantity of vapour contained in it. This temperature is called the dew-point. The temperature of the air, together with this temperature, which is called the dew-point, being known, nearly all hygrometrical problems can be solved. In order to find the dew-point, a Daniell's hygrometer may be used: it consists of a glass tube bent at right angles, with a very thin glass bulb at each end; one of the bulbs contains æther, and the bulb of a delicate thermometer whose stem and scale are included in the upright arm of the instrument. All air is excluded from the tube, and consequently the enclosed space and the other bulb which is covered with a piece of muslin are filled with the vapour of æther. In using the instrument a few drops of the best æther are dropped upon the covered bulb; quick evaporation follows, cools and condenses the vapour within it; but the place of the condensed vapour is supplied by a fresh portion arising from the æther in the other bulb, whose temperature is reduced by the act of evaporation: the difference between the reading of the enclosed thermometer and that of the dry thermometer shows the amount of reduction; this reduction goes on until the bulb is at that temperature which cools the air in contact to that degree at which the vapour contained in it is deposited upon the bulb, and thus the dew-point is found. In this country it is sometimes 30° below the temperature of the air; this occurs between April and September; during which time the difference frequently amounts to 20°. During the other part of the year the difference often amounts to quantities between 6° and 15°.

7. *Relation existing between the Temperatures of the Air, Evaporation, and Dew-Point.*

The Greenwich Magnetical and Meteorological Observations for 1843 contain a complete discussion of the relation existing between the three preceding temperatures. The discussion embraces all the simultaneous observations of the dry, wet, and dew-point thermometers taken in the years 1841 to 1845, at all temperatures of the air below 35°, and all those taken in the years 1841, 1842 and 1843, for all temperatures above 35°. During these years the observations of the dry and wet thermometers have been taken every two hours, and of the dew-point every six hours, day and night; with the exception of Sundays.

The following are the factors deduced from these observations:—

When the temperature of the air is	Below 24°,	The difference between the temperature of evaporation, and the temperature of the air multiplied by	8.5	Gives the difference between the temperature of the air and the temperature of the dew-point.
Between	24° and 25°	...	7·3	...
...	25 and 26	...	6·4	...
...	26 and 27	...	6·1	...
...	27 and 28	...	5·9	...
...	28 and 29	...	5·7	...
...	29 and 30	...	5·0	...
...	30 and 31	...	4·6	...
...	31 and 32	..	3·6	...
...	32 and 33	..	3·1	...
...	33 and 34	..	2·8	...
...	34 and 35	...	2·6	..
...	35 and 40	...	2·5	...
...	40 and 45	...	2·3	...
...	45 and 50	...	2·1	...
...	50 and 55	...	2·0	...
...	55 and 60	...	1·8	...
...	60 and 65	...	1·8	...
...	65 and 70	...	1·7	...
...	above 70	..	1·5	...

The factors corresponding to all temperatures above 35° differ very little from those contained in the volume for 1842, and as the whole of the tables were originally formed from the factors in this volume, it was not thought necessary to disturb so much work for such small differences. I have also reduced and discussed all the similar observations taken at the Observatory at Toronto in Upper Canada during the years 1840, 1841 and 1842, and the factors deduced from these, for all temperatures above 30°, were found to be nearly identical with those used in calculating the tables: the factors for temperatures below 30° were all smaller than those deduced from the Greenwich Observations; the individual observation, however, differed very much among themselves at these temperatures; but they are sufficiently good to confirm the Greenwich numbers, and to prove that these factors are as applicable at Toronto as at Greenwich.

8. *Calculating the Dew-Point from Observations of the Dry and Wet Bulb Thermometers.*

The product of the difference between the readings of the two thermometers into the factors contained in section 6, according to the temperature of the dry bulb, taken from the reading of the dry bulb, gives the temperature of the dew-point as it would have been given by Daniell's hygrometer, and in this way the dew-points contained in the tables have been computed.

The knowledge of the dew-point merely indicates to us the temperature at which aqueous vapour begins to be condensed, and the quantity of it at the time of the observation mixed with the air, which quantity is quite independent of the temperature of the air; all that is necessary is, to seek in a properly constructed table of the force of aqueous vapour for the quantity corresponding to the dew-point; such a table is published in the Greenwich Magnetical and Meteorological Observations for 1842; it is calculated from Dalton's experiments on the expansive powers of steam (Manchester Memoirs, vol. v.) and Ure's experiments (Philosophical Transactions for 1818): great care was bestowed in examining other tables before adopting this, and for that reason I have used it in constructing the following tables.

9. *Elastic Force of Vapour.*

This expression is equivalent to saying, that the pressure of the acqueous vapour mixed with the air is capable of supporting a certain weight or a column of mercury of a certain height: in this latter form it is represented in the tables. To know this force, all that is necessary is to find the temperature of the dew-point, and to seek for that temperature in the following tables, and the quantity of vapour which corresponds to it is immediately seen.

For instance, suppose the dew-point to be 50°; then the extreme force of vapour at that temperature is by the tables 0·373 inch of mercury; or it is about $\frac{1}{80}$th part of an atmosphere whose whole pressure is 30 inches of mercury.

As in an atmosphere of pure steam the force of it at the earth's surface would be its weight; so in a mixture of atmospheres, the elastic force of each at the earth's surface is the weight of the whole atmosphere of each kind. Therefore, the elastic force of vapour representing the weight of the entire mass of aqueous vapour diffused throughout the atmosphere expresses the pressure on the surface in the cistern of the barometer produced by the vapour present in the air at the time of observation, and it therefore becomes a correction to be applied subtractively to all readings of the barometer, to obtain from them the pressure of the atmosphere of dry air.

As the pressure of the whole atmosphere is about 15lbs. on the square inch when the reading of the barometer is about 30 inches; and as the weight of the vapour in the atmosphere when the temperature of the dew-point is 50° is about $\frac{1}{80}$th part of the whole pressure; it follows that the actual weight of the vapour is about $\frac{3}{16}$lbs., or 1300 grains nearly. The weight of a cubic inch of water is 253 grains, therefore the quantity of water is $\frac{1300}{253}$, or 5 inches nearly; that is, if a perpendicular column of air to the top of the atmosphere had the whole of its vapour precipitated to the bottom, the depth of the water so precipitated would be about 5 inches. It will be found, if a similar calculation be performed for different temperatures of the dew-point, that the number representing the weight in grains of the vapour in a cubic foot of air very nearly represents the depth of water in inches that the vapour then existing in the atmosphere would produce if all were condensed, leaving the atmosphere of dry air only.*

An examination of this part of the table at different temperatures shows that the increased capacity of heat for aqueous vapour at a higher temperature does not follow the same ratio as the temperature of the air increases. The capacity for aqueous vapour at 70° is less than the mean between the capacities at 60° and 80°: for example, aqueous vapour at 60° has an elastic force of 0·523 inch, and at 80° a force of 1·001 inch; if therefore two masses of air, the one at 60° and the other at 80° (being both saturated with moisture), are mixed together, the compound will take a mean temperature of 70°; but the elastic force of vapour at 70° is 0·727 inch, while the mean of the forces at 60° and 80° is 0·762 inch. The tension of vapour is therefore greater than the air can contend with, and the difference between the quantities becomes condensed and falls in the form of rain.

10. *Weight of Vapour in a Cubic Foot of Air, and Additional Weight required for Complete Saturation of a Cubic Foot of Air.*

These sufficiently explain themselves; all that is necessary is to state the values used in their calculation. A thousand cubic inches of dry air, or of air deprived of all aqueous vapour, under the pressure of 30 inches of mercury, and at the temperature of 60°, weigh 305 grains, as given by Sir George Shuckburgh: and according to Biot and Thenard under the same circumstances the weight is 311 grains (Penny Cyclopædia, article AIR). The mean of these two values is 308 grains, and, consequently, the weight of a cubic foot of dry air at the temperature of 32°, and under the pressure of 30 inches of mercury, was found to be 563·2154 grains: 563 was the number actually used in calculating the tables.

A cubic inch of vapour under the pressure of 29·92196 inches of mercury, and at the temperature of 212°, weighs 0·147176 grains (Edinburgh Cyclopædia, article HYGROMETRY). The expansion of dry air has been considered to be $\frac{1}{480}$th part for every addition of 1° of heat of Fahrenheit's scale: aqueous vapour has been considered to expand precisely as permanently elastic fluids, and that it suffers changes of volume proportional to the changes of pressure. (Annales de Chimie, vol. xliii.)

In article 7 it is stated that the knowledge of the dew-point only indicates the quantity of aqueous vapour; it is, therefore, not sufficient to characterise the hygrometrical conditions of the air; for instance, in summer, when it is hot, the air may be very dry, whilst in winter, when it is cold, it may be saturated with moisture, and yet the absolute quantity of vapour contained in the air may be the same at both times. If we have in addition to the temperature of the dew-point that of the air, then with the constant values mentioned in the beginning of this article, the hygrometrical conditions of the air can be calculated at any time, but the calculations are troublesome; the same results are obtained with but little trouble by means of the following tables. (Vide Appendix A.)

By examining the column of the table representing the absolute quantity of vapour in a cubic foot of air, it will be found that the greater the difference between the temperature of the air and that of the dew-point, the drier is the air; and by examining the column showing the additional quantity required for complete saturation of a cubic foot of air, the quantities become larger and larger, so that the air may then dissolve vapour in still greater quantities without any probability of being saturated. By examining the quantities with any varying temperatures, it will at once be seen whether the numbers become larger or smaller, and consequently whether the state of the air is removing from or approaching to that of saturation.

11. *Degree of Humidity.*

In the preceding section the absolute quantities of each element have been treated of. In order readily to determine these conditions on a natural scale, complete saturation has been assumed as represented by unity; and air absolutely deprived of moisture as represented by zero. The numbers are obtained by dividing the quantity of vapour which the air contained at the time of observation, by the quantity which it would contain if it were saturated, and these numbers are printed in the tables; if this number be multiplied by 100, it will tell us how much per cent. of complete saturation is contained in the air: for example, if the temperature of the air be 50°, that of the dew-point 30°, then the degree of humidity is 0·507 in the tables; if this be multiplied by 100, it will be 51. So that the air contains, at the moment of the observation, about 51 per cent. of the quantity of aqueous vapour which it would contain if it were in a state of saturation.

12. *Weight of a Cubic Foot of Air.*

This title needs no explanation. If in addition to the readings of the dry and wet thermometers that of the barometer be also taken, then the actual weight of a cubic foot of air expressed in grains, under the varying circumstances of heat, of humidity, and of pressure of the air, can be taken out from the tables very nearly at sight. The difference between these numbers, as well as between the numbers in the other parts of the table, in every division of it, from degree to degree is small, and therefore, if the readings of the thermometers be not whole degrees, the interpolation for the parts of degrees is easily made.

By examining this table at different temperatures, the effect of the expansion of the air from heat is shown; as under the pressure of 30 inches, the weight of a cubic foot of air at 10° is 589·4 grains, and at 90° it is 494·3 grains. By examining the numbers in any division on the same line the effect of pressure is shown; as at the temperature of 32° the weight of a cubic foot of air at 28 inches' pressure is 524·2 grains, and at 31 inches' pressure it is 580·3 grains. And on examination of the numbers in any division, on different lines, at the same reading of the barometer, the effect of humidity is seen; as under the pressure of 30 inches, and at the reading of the dry bulb of 50°, the weight of a cubic foot of air at the reading of the wet bulb of 50° is 540.2 grains, and at 40° it is 541·5 grains.

13. *Manner of using the Tables.*

This will be best understood by an example. The temperature of the atmosphere in the shade, and of evaporation being given, to find the corresponding temperature of the dewpoint and the quantities treated of in the tables.

If the temperatures be alike, then the numbers on the same line will be those required: in this case the air is completely saturated with moisture, as shown by the number in the sixth column being 0·00, and that in the seventh column being unity.

If the temperatures be different, as that of the dry bulb 70°, and that of the wet bulb 55°, then in the division of the table of 70° of dry thermometer and opposite 55° of the wet, the temperature of the dew-point is immediately found to be 47°·5; in the next column is 0·343 inch, showing that the force of aqueous vapour is equivalent to keep in equilibrium a column of mercury of that height: the weight of vapour in a cubic foot of air is found in the next column to be 3·76 grains; the additional weight of vapour required to completely saturate a cubic foot of air is 4·24 grains: the degree of humidity is 0·470, that of complete saturation being represented by unity. If in addition, the reading of the barometer be taken, then the weight of a cubic foot of air at the time of the observation is found in the line and under its own reading.

The state of the atmosphere in the assumed state of the example is such as would constitute very fine weather; and one of two things or a modification of both must happen, before any of the moisture in the air can be precipitated. First, either the temperature of the air must fall from 70° to below 47°·5, and in this case the precipitation would most probably be only slight, as mist, fog, or small rain; or the temperature of the dewpoint must rise to 70°; or the quantity of aqueous vapour in a cubic foot of air must increase from 3·76 grains to 8·00 grains, that being the greatest quantity of moisture that can be held in solution at 70°; and in this case the precipitation would probably assume the form of heavy rains or storms. Secondly, the temperature of the dew-point may rise, and the temperature of the dry bulb may fall at the same time, and in this case some conjecture may be formed of the probable duration and kind of precipitation according as one or the other of the causes prevailed.

Should a reading of the wet bulb be met with, lower than the lowest inserted in the tables, the several quantities may be found by finding the differences between those at the lowest reading, and those at a reading as much higher as the reading is below it, and applying those differences to the former numbers. The numbers thus deduced will not be strictly true, but they will be quite near enough for such extreme cases.

16. *Vertical Distribution of Aqueous Vapour in the Atmosphere.*

Now that we have a simple means of ascertaining the distribution of vapour in the atmosphere, we may hope to know more than we yet do respecting its distribution. Some persons residing in elevated districts may have the means of taking simultaneous observations with others resident at a less elevation.

At any one place two or more pairs of thermometers may be placed at different distances from the ground, and simultaneous readings taken of them; for it is yet a question as to whether the higher strata of the atmosphere be more moist than the lower. I do not here speak of absolute quantities of vapour, but of the relative humidity; the determining this is of high importance toward giving us a knowledge of atmospheric changes. This instrument simply indicates the conditions of the air of the place where it is situated. At a hundred feet above it, the conditions may be very different, and this may account for the phænomena that I have frequently seen, viz. that at times when the sky has been quite cloudy, and at times during the fall of rain, a great difference has existed between the readings of the two thermometers: supposing that the quantity of vapour diminished regularly with the height, and that it should meet with an unusually cold stratum of air, then the vapour would be condensed, and assume either the form of clouds, or it would fall in the shape of rain. At other times the two thermometers have read alike, and at the same times the weather has been fine, and the sky clear of cloud: it is probable that in this case there may be an unusually hot stratum of air above, which dissipates the vapour and leaves a clear sky; however, these apparent anomalies should all be noted; they will cease to be such when our knowledge is increased.

17. *Lateral Distribution of Aqueous Vapour.*

The quantity of vapour existing at the same time in different places, particularly on large continents, is known to be very different, and it is so even on our small island.

In the open sea the air appears to be generally saturated with moisture; on coasts, therefore, the quantity of vapour must be great, and it probably diminishes as the distance from the sea increases. For many purposes, the knowledge of the amount of vapour at different places is important. The life of plants and animals depends on humidity as much as on temperature. It is probable that localities which appear to be similar in every respect may differ in this, if they be at unequal distances from the sea. The influence of different winds on the lateral distribution of vapour, may be great. In a series of observations for determining this element, the direction and estimated strength of the wind should be noted; all that is necessary is the ordinary observations of the instrument in its ordinary place; the elevation of the place of observation should be ascertained or approximately stated. Travellers could give much information by carrying the instrument with them, and observing it with this view, whilst at the same time the instrument would give them much information as to the weather to be expected.

18. *Value of the Instrument to the Public, and Uses to which it is applicable.*

In addition to its value to the meteorologist, there are many cases in ordinary life to which this class of observations may be applied. The simple inspection of the two thermometers will often afford a better criterion of the weather and of the probability of rain than the barometer itself; regard, however, must be had to the time of the day and the time of the year at which the observation is made.

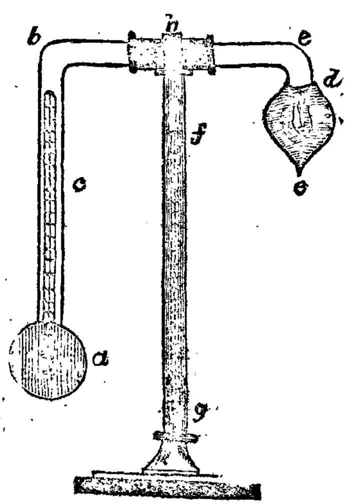
During the day, in summer-time, the rise of the temperature of the air is great: if in the morning the difference between the air temperature and the dew-point temperature be small, the accession of heat during the day being great, it is probable that the difference will therefore increase. If the temperature of the dew-point at the same time fall, it is an indication of very fine weather. If, on the contrary, the temperature of both should increase with the day in nearly equal proportion, rain will almost certainly follow as the temperature of the air falls with the declining sun.

In winter, when the diurnal range of temperature is small, the indicationof the weather must be taken more from the increase or decrease in the temperature of the dew-point than from the difference between the temperatures of the air and of the dewpoint. In showery weather the indications vary rapidly, and a person making observations at short intervals may predict the approach of a storm, particularly if they be combined with simultaneous observations of the barometer. Prediction based on observations of the wet and dry bulb thermometers alone, may at times be at fault : see concluding remarks on the "Vertical Distribution of Vapour in the Atmosphere," on apparently anomalous readings of the wet and dry thermometers, article 16.

The following account of Daniell s Hygrometer is given by the author: abundance of these instruments are generally to be had from the Government stores, but they are troublesome to observe, and the æther required for them is expensive :—

Daniell's, or the Dew-Point Hygrometer.—This instrument consists of a tube twice bent, having a bulb at each extremity. This tube is supported by the middle on an upright stem, so that it assumes somewhat the form of a T, as seen in the figure.

The ball *a* is of black glass about one and a quarter inch in diameter, and is connected with a ball *d* of the same size, by a bent tube 1-eighth of an inch in diameter. A portion of sulphuric æther, sufficient to fill 3-fourths of the ball *a* is introduced ; a small mercurial thermometer, with a pyriform bulb, is fixed in the limb *a*, *b*, the atmospheric air is expelled as completely as possible, and the whole is sealed at *e*. The ball *d* is covered with muslim ; the whole is supported on a brass stand *f*, *g*, on which is another delicate mercurial thermometer. The tube can be removed from the spring tube *h* ; and the whole together with a phial of æther, packed neatly in a box, that goes easily into the pocket.



The following directions for the use of the Hygrometer are given by Daniell himself:—

Place the Hygrometer at an open window, or out of doors, with the uncovered ball nearly upon a level with the eye. A few drops of ether are then to be poured upon the covered ball; evaporation immediately takes place, which, producing cold, causes a rapid and continuous condensation of the ethereal vapour in the interior of the instrument. The consequent evaporation of the included ether produces cold in the uncovered ball, the degree of which is measured by the interior thermometer. A condensation of the atmospheric vapour ensues, which first makes its appearance upon the naked ball, in a thin ring of dew, coincident with the surface of the ether: the degree at which this takes place is to be carefully noted. A little practice may be necessary to seize the exact moment of the first deposition, but certainty is very soon acquired. If the instrument be one of those formed with a transparent ball, it is advisable to have some dark object behind it, such as a house or a tree, as the cloud is not so soon perceived against an open horizon; but, for general purposes, a black ball is preferable, which shews the ring of dew, by reflected light. In very damp or windy weather, the ether should be slowly dropped, otherwise the descent of the thermometer is so rapid, as to render it difficult to be certain of the temperature. When this however, happens, the observation may be corrected by watching the degree at which the ring of dew disappears again: the mean of the two will give the correct point of precipitation. In dry weather, on the contrary, the covered ball requires to be well wetted more than once, to produce the requisite degree of cold. It is almost superfluous to observe, that care should be taken not to permit the breath to affect the glass.

When the included ether has passed from the naked ball into the covered, it may easily be driven back to its proper situation, by reversing the hygrometer, and holding the covered ball for a few seconds in the hand; and, in general, this will be a proper precaution to take before commencing an observation.

The following extract from a paper by Colonel Sykes, published in the *Philosophical Transactions* for 1850, goes far to shake our faith in the observations of the Wet-Bulb Thermometer. I entertain no doubt whatever of the soundness of the views of Mr. Orlebar on the subject; and to me it appears indispensible that if a current of air from a fan, a pair of bellows, or a thermantidote, be directed against the wet bulb thermometer immediately before being read, until it will fall no further: it seems impossible to prescribe any definite amount of breeze short of this,—and without something of this sort its readings seem altogether untrustworthy.

The mean monthly and annual results at the several stations have no doubt a certain relation to truth, as it is seen that the per-centages of moisture or fractions of saturation in the atmosphere in the different months of the year have an increasing or diminishing amount as the several months approximate to, or recede from, the monsoon month of the year; this is sufficiently shown at Madras, whether the monsoon months are the dry months at Bombay and in the Deccan. Nevertheless the amount of moisture in the atmosphere, deduced from the observations of the wet bulb, is so very great, compared with the amount determined by the direct method by Daniell's hygrometer (itself an imperfect instrument) in the Deccan, and at some of the stations is so little in accord with personal recollections and experience, that I cannot refrain from suspecting some error of observation, some mismanagement in the manipulations, or a fallacy in the formula by which the dew-point is deduced from the temperature of the wet bulb. The first cause of error that struck me was that arising from the proximity of the dry to the wet bulb, as noticed by Professor Orlebar in his Report of Meteorological Observations taken at the Bombay Observatory in 1846. He had a stand erected out of doors, 6 feet high, and with a thatched roof, and every precaution was taken to guard off radiation by layers of cotton and tow upon a board under the roof upon which the meteorologic instruments were placed; there was lateral access for the air all round. He soon found that the dry bulb, in the neighbourhood of the wet bulb, was almost always depressed below the neighbouring *standard* thermometer, and that the depression of the *dry* bulb was greater as the depression of the wet bulb below the standard was greater. Professor Orlebar explains this in the following words:—"This seems accountable only on the supposition that heat is extracted from the air to form the shell of moisture round the wet bulb at a distance as far off as the dry bulb." These discrepancies amounted on the 3rd and 4th of November, at the 19th hour, Göt. mean time.

Standard.......82·4	Dry.......76·5	Wet bulb.......71·8	Diff.......5·9
Standard.......82·4	Dry.......75·4	Wet bulb.......69·3	Diff.......7·0

Professor Orlebar therefore abandoned observing with the attached dry bulb. But supposing this cause of error to have been overlooked by other observers, the tension of vapour and the per-centage humidity would have been recorded by them greatly higher than the truth; and if we apply this source of error to the mean monthly and annual results in the comparative table I have given;—for instance, to the annual mean for Dodabetta, the 90 per cent. is reduced for the first difference, to 64 per cent., and if the correction be made for 7°, by depression of the dry bulb below a standard owing to its proximity to the wet bulb, the 90 per cent. of moisture at Dodabetta is reduced to 60 per cent. Professor Orlebar says the dry bulb *always* stood below the standard (and he had determined that it was not owing to error in graduation of the thermometers), often to the extent of 2°, and even in the monsoon month of September I observe that on the 2nd it was 3°·4 minus. Any amount of error in depression would necessarily affect the numerical determinations of the tension of vapour and degree of humidity; but supposing it not to exceed 2°, even this small depression would reduce the 90 per cent. of moisture in the air at Dodabetta to 80 per cent. Supposing therefore that the same error was not discovered at the other places of observation as was discovered in Bombay, there is necessarily some ground for the expression of my doubts, whether the air really did hold at the different stations the quantity of moisture represented by the figures I have elaborated. But Professor Orlebar observed another source of error, contingent upon the *locality* of the wet bulb apparatus, whether placed within doors or out of doors. To determine the amount of error he placed a wet bulb *within* the observatory, observing simultaneously with the wet bulb *out* of doors upon the meteorologic stand. This was done hourly for March, April, and to the 10th of May. The reading was almost always plus with the wet bulb inside; on the 22nd of March, at 19th hour, to the extent of 3°·2, while at 18th hour it had been only 0·2 plus; but there were great irregularities in the readings, being plus or minus dependent apparently upon drafts of air within the observatory, which would depress the wet bulb or raise it. Also the 'atmosphere within the room would tend to keep up a reading at any time to whatever it had been at a time preceding,' and the latter, Professor Orlebar says was the principal cause of the plus readings in-doors. Supposing this error of 3° to be applied as a correction of the reading of the annual means of the wet bulb at Bombay for 1843, the percentage of moisture in the atmosphere would only be 65 instead of 76. The distinguished experimental philosopher Regnault has pointed out the same sources of error. He placed the dry and wet bulb in the open air in the court of the College of France in a closed room in the College, and in the theatre of the College, opening the windows. In the open air, with a temperature ranging from 7°·16 to 17°·88 Centigrade, and a depression ranging from 1°·86 to 9°·60, the results, by observation and by M. Regnault's tentative formula*, were sufficiently satisfactory; but in the closed chamber he says, 'Les fractions de saturation calculées avec la formule†, sont ici beaucoup plus fortes que celles que l'on deduit des pesées directes de l'eau renfermée dans l'air; en d'autres termes la température t' marquée par la thermomèter mouillé n'es pas assez abaissée par la vaporisation de l'eau que se fait à sa surface pour donner dans la formule la véritable force élastique x de la vapeur. Cette circonstance tient évidemment à ce que l'air se trouve beaucoup moins agité qu'à l'extérieur.'—Page 219. At page 220 M. Regnault adds, 'Ces expériences démontrent de la manière la plus evidente que la formule ne peut pas rester la même pour les divers états d'agitations de l'air.'

Here then is a second source of error: and it is somewhat curious that Professor Orlebar, in guarding against another grave source of error, which will be adverted to, himself contributes to an error of observation. He had observed the effect of wind blowing upon the wet bulb in unduly depressing the temperature, and to guard against this he says, 'As it was equally essential that the bulb of this thermometer should not be exposed to the wind, and that it should be in the same body of air as the air-thermometer when the latter was exposed to the wind, a small mirror, about an inch square, was put on a little stand, and this being placed upon the tin board could be moved about by the observer into such a position that it might always *cut off the wind from the bulb of the wet thermometer* only' (page lxiii). Now the wet bulb being thus screened, would be buried in its own vapour and the reading would necessarily be too high. When the air is perfectly calm the same would be the result without the screen, for there would be a shell or coat of saturated air around the bulb. I had occasion to notice this local character of aqueous vapour in my Meteorology of the Deccan, where I constantly witnessed it, as regulated in its distribution by nature. Speaking of dew, I said in the year 1828, 'At Marheh in the Pergunnah of Mohol, garden produce (which is usually irrigated during the day-time) was covered with a copious dew every morning; the lands bordering the gardens for forty or fifty yards around were slightly sprinkled with it, *but there was not a vestige of it* in the fields constituting the rising ground north and south of the tract of garden land.' Hence I inferred that 'aqueous vapour had been taken up by the action of the sun during the day, *suspended over the spot*, and deposited by the lower temperature at night as dew upon the land in proportion to the supply obtained by day." My tents were within 200 yards of the fields where I observed these phenomena, but from the 11th to the 30th of January 1828, there was not any deposition of dew about them, ex-

* Annales de Chimie, tom. xv. p. 218.

† $x = f' - \frac{0{\cdot}420(t - t')}{610 - t'} H.$

cepting on the 13th of January. In consequence of these observations I was induced to remark particularly the localities of dew at Poona and in its neighbourhood. In September and October I found that when there was not a trace of dew in the cantonment, there would be a deposition on the fields of standing grain half a mile distant, and when there was not any dew either in the cantonment or in the fields, it would yet be found on the banks of running rivulets and on the banks of the Mota Mola River; but with respect to the rivulets, "*fifteen or twenty feet from the water were the limits of the deposition.*" I gave numerous other instances of the local deposition of dew proximate to irrigated lands, or in the neighbourhood of water, indicating the suspension of vapours over the localities, in complete analogy with what occurs to the wet bulb thermometer when the air is calm. That agitation of the air is necessary to disperse the vapour surrounding a wet bulb, has been noticed by British chemists. BRAND says (page 111, last edition), "It is now established that the pressure of air is really an obstacle to evaporation, and that *a current* is useful, not by supplying new quantities of air, but *by removing the vapour* according as it is formed and leaving fresh spaces into which the vapours may expand." He elsewhere says (page 82), "Evaporation is proportional to the surface exposed; it is also accelerated by agitating the superincumbent air, as in the case of a brisk wind, or by artificial means. When the *are is tranquil the vapour rests upon the surface of the water, and it is the pressure of its own vapour on the surface of a liquid, and not that of the gaseous* atmosphere, which stops the process." M. REGNAULT has demonstrated the truth of this in an elaborate manner. Accounting for the different results of observations in a closed and open chamber, he says the wet bulb was not sufficiently depressed in the closed chamber. "Cette circonstance tient évidemment à ce que l'air se trouve beaucoup moins agité qu'à l'extèrieur."* After experimenting in a room with two windows open, he adds, as before stated, "Ces expériences démontrent de la maniére la plus évidente que la formule ne peut pas rester la même pour divers états d'agitation de l'air." (P. 220.) The vapour therefore resting upon the wet bulb is a source of error, but the removal of it leads to one much more grave. M. REGNAULT, in reference to M. AUGUST's formula, says (p. 207), "La formule, ne tient aucun compte de la vitesse du courant d'air; d'après cette formule, la différence de température devrait être la même, quelle que soit cette vitesse. Ce résultat parait impossible *ā priori.* J'ai cherché à déterminer *par des expériences directes,* l'influence de cette vitesse et à reconnaitre si, à partir d'une certaine valeur de la vitesse, les différences de temperature des thermomètres sec et mouillé deviendraient indépendentes de la vitesse absolue du courant d'air, conséquence à laquelle onse trouve noturellement conduit par le raisonnement que M. AUGUST applique au calcul de la formule du psychromètre." M. REGNAULT then describes his apparatus and mode of making his experiments. He gives two series of experiments; in the second experiment the air being made to blow upon the wet bulb with a greater velocity than in the first.

* Annales de Chimie, tom. xv., page 219.

BAROMETRIC MEASUREMENTS.

In a vast, varied, and little known country like India, the altitudes of the great bulk of our more notable eminences, and the levels of the higher portions of the country, must necessarily for a long time remain unknown to us, and must, for the present at all events, until trigonometry comes to our aid, be determined by the Barometer or Thermometer—by some reference to apparent pressure. It but rarely happens that a traveller amongst us can command the services or assistance of a second observer, or the aid of a reference barometer, and he must suffer himself to be guided in his researches by referring to the known pressure of some given locality, as near as possible to the place of observation; and with a due amount of precautions, it will rarely happen by this means that he will go greatly astray. We have had repeated occasion to notice in the paper and elsewhere the remarkable regularity with which the barometer fluctuates. Subjoined are tables of the Pressure for Bombay, Lat. 18°52′35″, Long. 72°49′5″; for Calcutta, Lat. 22°34′40″, Long. 88°28′15″; Aden, Lat. 12°46′26″, Long. 45°15′; Madras, Lat. 13°4′10″, Long. 80°21′58″; Trevandrum, Lat. 8°30′, Long. 76°59′; Dodabetta, Lat. 11°23′22″, Long. 76°47′; Lucknow, Lat. 26°51′, Long. 80°55′; St. Helena, Lat. 15°56′41·2″ South, Long. 5°40′31·5″ West; &c. &c. We are unfortunately unable to give these exactly in the same form, or for the same number of years, but the changes are so small and so regular that the average of one year without storm periods, for which no rule can be given, come close on those of a series of years. A hundredth part of an inch may be assumed as corresponding to ten feet, where the altitude does not exceed 300 feet in all. In measuring, the traveller should be careful to refer to the pressure tables of the place next to him, and to be exact, not only as to the month of the year, but also to the hour of the day. The observations here given, it must be remembered, have all been corrected for temperature,—they are not corrected, however, for level:—

[The fluctuations of the Barometer are so regular throughout India, as far north, at all events, as Calcutta and Kurrachee, that the following tables may serve the Traveller who wishes to determine altitudes by means of pressure, in place of a reference Barometer. The first set are meant to exhibit in abstract form the atmospheric fluctuations at Bombay for the years 1843-44-45-46, to show how very little corresponding portions of different years vary from each other, unless during periods of actual disturbance. The other tables afford the hourly, daily, and monthly means, with the hourly fluctuations. In using them the traveller should select the observations of the place nearest to that he is traversing, and the month of the year, and hour of the day, corresponding to those of observation. If this be carefully attended to, the greatest possible error will certainly fall short of half a tenth of an inch—that corresponding to 50 feet of elevation, unless during periods of atmospheric disturbance, during which accuracy is not to be looked for whatever be the precautions resorted to, and observation for the purposes of measurement is almost in vain. The barometer has been corrected in all the tables for temperature for 32° Fahr. These tables may also prove eminently serviceable to the navigator in rating his barometers, and in watching the approach of a storm. No better test of the accuracy of a barometer, short of actual comparison, can be had in these latitudes than that of its daily fluctuations: if they differ widely from those in the tables, the instrument may be set down as untrustworthy. The marine barometer does not admit of an exact correction for temperature, so that absolute coincidence even in the case of the best of instruments, is not to be looked for: a table of approximate corrections has been given. The change of temperature betwixt any two turning-points is seldom such as to occasion any great amount of error where the correction is omitted altogether, and it is the range as much as the position of the mercury that indicates the quality of the instrument.]

Range of the Barometer—Bombay, given for each month, with the interval in space and n time betwixt the Daily Maximum and Minimum on the means of the month—1843 and 1844.

Months.	Morning Maximum.		Afternoon Minimum.				Night Maximum.				Morning Minimum.				Morning Maximum Repeated from Columns first.				
	Morning Max.	Hour of Morning Max.	Afternoon Min.	Hour of After. Min.	Interval in Time.	Range.	Night. Max.	Hour of Night Max.	Interval from aft Min.	Range from aft Min.	Morning Min.	Hour of Morn. Min.	Interval from N. Min.	Range from N. Min.	Morning Max.	Hour of Morn. Min.	Interval from Morn. Min.	Range from M. Min.	Means.
1843.	in.		in.			in.	in.			in.	in.			in.	in.			in.	in.
January.	29·995	10	29·873	4	6	·112	29·950	10	6	·077	29·896	4	6	·054	29·985	10	6	·089	·923
February	·954	10	·840	4	6	·114	·913	10	6	·073	·863	3	5	·045	·954	10	7	·086	29·889
March.	·899	9	·786	4	7	·113	·853	10	6	·057	·816	3	5	·037	·899	9	6	·083	·839
April	·871	10	·752	4	6	·119	·834	10	6	·032	·799	4	6	·035	·871	10	6	·072	·813
May.	·713	9	·612	4	7	·110	·679	10	6	·037	·636	3	5	·043	·713	9	6	·077	·662
June.	·691	10	·617	5	7	·074	·673	10	5	·056	·626	3	5	·047	·691	10	7	·065	·654
July.	·687	9	·634	4	7	·054	·689	10	6	·055	·629	4	6	·030	·687	9	5	·058	·661
August	·767	10	·692	4	6	·087	·758	10	6	·065	·695	4	6	·062	·767	10	6	·071	730
September.	·836	9	·740	3	6	·086	·803	9	6	·053	·747	4	7	·056	·826	9	5	·079	779
October.	·903	9	·794	3	6	·108	·865	9	6	·071	·829	3	6	·036	·902	9	6	·073	845
November.	·955	9	·836	4	7	·119	·910	10	6	·074	·855	4	6	·055	·955	9	5	·100	·887
December	30·026	9	·910	4	7	·116	·987	9	5	·077	·929	4	7	·058	30·026	9	5	·097	·961
Means	29·856	9·4	29·757	3·9	6·5	·100	29·826	9·8	5·8	·070	29·777	3·6	5·8	·049	29·856	9·4	5·8	·079	29·804
1844.																			
January	30·019	10	29·899	4	6	·120	29·960	10	6	·031	29·918	3	5	·012	30·019	10	7	·101	29·947
February	29·993	10	·832	3	6	·110	·954	10	6	·073	·900	3	5	·054	29·993	10	7	·093	·928
March.	·993	10	·812	4	6	·184	·836	10	6	·074	·844	3	5	·042	·996	10	7	·152	·869
April	·870	9	·752	4	7	·118	·820	10	6	·063	·774	3	5	·046	·870	9	6	·096	·804
May.	·802	9	·704	4	7	·098	·761	10	6	·060	·726	4	6	·039	·802	9	5	·076	·750
June.	·665	9	·594	4	7	·071	·649	10	6	·055	·600	3	5	·049	·655	9	6	·065	·638
July.	·682	10	·619	4	6	·063	·675	10	6	·036	·617	4	6	·058	·632	10	6	·065	·648
August	·741	10	·671	4	6	·070	·721	10	6	·055	·670	3	5	·054	·741	10	7	·071	·701
September	·849	10	·752	4	6	·097	·824	10	6	·070	·767	3	5	·055	·819	10	7	·082	·795
October.	·893	9	·771	4	7	·122	·848	9	5	·077	·799	3	6	·049	·893	9	6	·094	·825
November	·995	9	·868	4	7	·127	·915	9	5	·077	·899	3	6	·046	·995	9	6	·096	·924
December.	·963	9	·841	4	7	·122	·919	9	5	·073	·866	3	6	·053	·963	9	6	·097	·893
Means	29·872	9·30	29·762	3·50	6·30	·110	29·330	9·45	5·45	·063	29·781	3·10	5·35	·019	29·872	9.30	6·40	·091	29·800

Range of the Barometer—Bombay, given for each month, with the interval in space and in time betwixt the daily Maximum and Minimum on the means of the month—1845 and 1846.

Months.	Morning Maximum.		Afternoon Minimum with Interval from the Preceding.				Night Maximum with Interval from the Preceding.				Morning Minimum with Interval from the Preceding.				Morning Maximum with Interval from the Preceding.				
	Morning Max.	Hour of Morng. Max.	Afternoon Min.	Hour of After. Min.	Interval in Time.	Range from M. Max.	Night Max.	Hour of Noon Max.	Interval from A. Min.	Range from A. Min.	Morning Min.	Hour of Morng. Min.	Interval from N. Max.	Range from N. Max.	Morning Max.	Hour of Morng. Max.	Interval from Morng. Min.	Range from M. Min.	Means.
1845.	in.		in.			in.	in.			in.	in.			in.	in.			in.	in.
January.... ...	29·966	9	29.842	3	6	·124	29·967	9	6	·125	29·871	4	7	·095	29·966	9	5	·095	29·923
February......	30·015	9	·865	4	7	·150	·932	10	6	·067	·882	3	5	·050	30·015	9	6	·133	·930
March.	29·976	10	·826	4	6	·150	·904	10	6	·078	·853	3	5	·051	29·976	10	7	·123	·894
April.........	·952	9	·762	4	7	·190	·830	10	6	·068	·785	3	5	·045	·952	9	6	·167	·848
May.	·878	9	·711	4	7	·167	·775	10	6	·064	·736	3	5	·039	·878	9	6	·142	·787
June.	·816	9	·606	4	7	·210	·672	10	6	·066	·626	3	5	·046	·816	9	6	·190	·708
July.	·686	10	·618	3	5	·068	·693	10	7	·075	·628	4	6	·065	·686	10	6	·058	·660
August.........	·701	10	·651	3	5	·050	·729	10	7	·078	·639	4	6	·090	·701	10	6	·062	·686
September. ...	·739	10	·686	3	5	·053	·860	9	6	·174	·675	4	7	·185	·739	10	6	·064	·770
October......	·895	9	·765	4	7	·130	·837	9	5	·072	·790	3	6	·047	·895	9	6	·105	·829
November. ..	·887	9	·766	3	6	·121	·960	9	6	·194	·794	4	7	·166	·887	9	5	·093	·879
December. ..	30·007	9	·863	4	7	·144	·937	10	6	·074	·887	3	5	·050	30·007	9	6	·120	·937
Means......	29·876	9·20	29·747	3·35	6·15	·129	29·841	9·40	6·5	·094	29·764	3·25	5·45	·077	29·876	9·20	5·55	·112	29·820
1846.																			
January.	29·980	9	29·866	3	6	·114	30·015	10	7	·149	29·889	4	6	·126	29·980	9	5	·091	29·953
February......	30·059	9	·895	4	7	·164	29·972	10	6	·077	·919	3	5	·053	30·059	9	6	·140	·968
March.	·017	10	·830	4	6	·187	·895	10	6	·065	·844	3	5	·051	·017	10	7	·173	·911
April......	29·938	9	·756	4	7	·182	·826	10	6	·070	·779	3	5	·047	29·938	9	6	·159	·840
May.	·869	9	·695	5	8	·174	·764	10	5	·069	·720	3	5	·044	·869	9	6	·149	·776
June.	·799	9	·587	4	7	·212	·653	10	6	·066	·599	3	5	·054	·799	9	6	·200	·690
July.	·661	10	·594	3	5	·067	·670	10	7	·076	·598	4	6	·072	·661	10	6	·063	·636
August..	·681	10	·631	3	5	·050	·745	10	7	·114	·622	4	6	·123	·681	10	6	·059	·694
September. ...	·762	10	·707	3	5	·055	·783	10	7	·076	·692	4	6	·091	·762	10	6	·070	·742
October.	·811	10	·731	3	5	·080	·807	9	6	·075	·736	4	7	·075	·811	10	6	·075	·775
November. ..	·860	9	·740	3	6	·120	·911	10	7	·171	·773	4	6	·138	·860	9	5	·087	·844
December. ...	·973	9	·844	3	6	·129	·935	10	7	·091	·873	4	6	·062	·973	9	5	·100	·907
Means......	29·867	9·25	29·740	3·30	6·5	·127	29·831	9·55	6·25	·091	29·754	3·35	5·40	·077	29·867	9·25	5·50	·113	29·810

Range of the Barometer—Madras, given for each month, with the interval in space and in time betwixt the daily Maximum and Minimum on the means of the month—1844 and 1845.

Months.	Morning Maximum.		Afternoon Minimum with Interval from the Preceding.				Night Maximum with Interval from the Preceding.				Morning Minimum with Interval from the Preceding.				Morning Maximum with Interval from the Preceding.				Means.
	Morning Max.	Hour of Morng. Max.	Afternoon Min.	Hour of After. Min.	Interval in Time.	Range from M. Min.	Night Max.	Hour of Noon Max.	Interval from A. Min.	Range from A. Min.	Morning Min.	Hour of Morng. Min.	Interval from N. Max.	Range from N. Max.	Morning Max.	Hour of Morng. Max.	Interval from Morng. Min.	Range from M. Min.	
1844.	in.	h.	in.	h.	h.	in.	in.	h.	h.	in.	in.	h.	h.	in.	in.	h.	h.	in.	in.
January	30·059	10	29·949	4	6	·110	30·028	10	6	·076	29·965	3	5	·060	30·059	10	7	·094	29·999
February	·061	10	·931	5	7	·130	·001	10	5	·070	·953	3	5	·048	·061	10	7	·107	·906
March	·047	10	·852	5	7	·195	29·936	10	5	·084	·881	3	5	·055	·047	10	7	·174	·936
April	29·972	10	·736	5	7	·136	·839	11	6	·103	·798	3	4	·041	29·972	10	7	·174	·813
May	·870	10	·636	5	7	·234	·741	11	6	·105	·682	3	4	·059	·870	10	7	·188	·732
June	·752	9	·603	5	8	·149	·693	11	6	·090	·655	3	4	·038	·752	9	6	·097	·676
July	·721	10	·606	4	6	·115	·759	11	7	·053	·657	4	5	·092	·721	10	6	·064	·686
August	·779	10	·656	4	6	·123	·766	11	7	·110	·708	4	5	·058	·779	10	6	·061	·725
September	·788	10	·663	4	6	·125	·826	10	6	·163	·718	4	6	·108	·788	10	6	·070	·799
October	·853	9	·723	4	7	·130	·903	10	6	·180	·778	4	6	·125	·853	9	5	·075	·864
November	·929	10	·806	4	6	·129	·993	10	6	·187	·846	4	6	·147	·929	10	6	·083	·893
December	30·021	10	·882	5	7	·139	·963	10	5	·081	·896	3	5	·067	30·021	10	7	·125	·940
Means	29·904	9·50	29·753	4·30	6·40	·142	·870	10·25	5·65	·117	29·795	3·25	5	·075	29·904	9·50	6·25	·109	·837
1845.																	h.		
January	29·980	10	29·872	4	6	·108	30·044	10	6	·172	29·893	4	6	·151	29·980	10	6	·087	29·945
February	30·076	10	·913	5	7	·153	29·994	10	5	·081	·938	3	5	·056	30·076	10	7	·118	·980
March	·031	10	·911	5	7	·120	·960	10	5	·049	·895	3	5	·065	·031	10	7	·136	·947
April	29·988	10	·738	5	7	·250	·854	11	6	·116	·808	3	4	·046	29·988	10	7	·180	·848
May	·883	9	·649	5	8	·234	·745	11	6	·096	·692	3	4	·053	·883	9	6	·191	·742
June	·765	9	·634	5	8	·131	·739	11	6	·105	·693	4	5	·046	·765	9	5	·172	·708
July	·754	9	·644	4	7	·110	·758	11	7	·114	·696	4	5	·062	·754	9	5	·058	·704
August	·776	9	·658	4	7	·118	·769	11	7	·111	·720	4	5	·049	·776	9	5	·056	·731
September	·802	9	·670	4	7	·132	·864	10	6	·194	·736	4	6	·128	·802	9	5	·066	·763
October	·887	9	·759	4	7	·128	·881	10	6	·122	·821	4	6	·060	·887	9	5	·066	·837
November	·910	10	·788	4	6	·122	30·026	10	6	·238	·832	4	6	·194	·910	10	6	·078	·889
December	30·034	9	·918	5	8	·116	·000	10	5	·082	·935	3	5	·065	30·034	9	6	·099	·972
Means	29·907	9.25	29·763	4·30	7·05	·144	29·886	10·25	5·55	·123	29·805	3·35	5·10	·081	·907	92·5	5·50	·102	29·838

TABLE showing the Mean Hourly Rise and Fall of the Barometer, during each month of the year 1844, *at Bombay, Lat.* 18° 52′ 35″ *N., Long.* 72° 49′ 5″ *E. The yearly mean pressure of the Atmosphere, reduced to* 32° *Fah., being inches* 29·809.

Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Mid-* night.	in. 29·948	in. 29·939	in. 29·873	in. 29·803	in. 29·763	in. 29·639	in. 29·654	in. 29·706	in. 29·798	in. 29·829	in. 29·928	in. 29·894
1	—·023	—·017	—·014	—·010	—·012	—·015	—·017	—·015	—·013	—·014	—·013	—·011
2	·010	·013	·013	·011	·010	·014	·013	·012	·012	·011	·011	·010
3	·007	·009	·007	·008	·005	·010	·005	·008	·006	·003	·005	·007
4	+·004	+·002	+·010	+·003	+·006	+·003	·001	+·001	+·003	+·004	+·004	+·003
5	·008	·006	·003	·013	·008	·011	+·006	·008	·009	·011	·013	·007
6	·018	·017	·022	·019	·017	·015	·015	·015	·014	·025	·019	·016
7	·026	·025	·024	·027	·022	·014	·016	·016	·029	·022	·026	·028
8	·026	·023	·014	·021	·014	·013	·016	·016	·013	·020	·022	·024
9	·019	·018	·018	·013	·009	·009	·010	·012	·012	·012	·012	·019
10	—·005	·002	—·004	—·003	—·003	·000	·002	·001	—·000	—·005	—·007	—·001
11	·029	—·016	·013	·009	·011	—·006	—·003	—·006	·009	·022	·023	·020
Noon.	·033	·027	·016	·019	·014	·011	·011	·012	·020	·028	·029	·032
1	·034	·025	·028	·029	·020	·014	·010	·014	·006	·028	·035	·035
2	·017	·024	·025	·028	·020	·015	·013	·015	·023	·024	·020	·021
3	·010	·018	·020	·021	·019	·015	·014	·013	·016	·014	·012	·019
4	·000	·002	·007	·009	·010	·010	·012	·011	·003	·001	·001	·000
5	+·008	+·008	+·005	+·000	+·001	+·003	+·003	+·014	+·014	+·011	+·009	+·011
6	·010	·009	·013	·012	·008	·006	·009	·009	·010	·013	·013	·013
7	·019	·016	·018	·026	·014	·010	·012	·009	·013	·021	·015	·023
8	·019	·022	·020	·017	·016	·014	·014	·013	·016	·020	·017	·016
9	·004	·014	·015	·016	·005	·012	·010	·013	·014	·012	·013	·015
10	·009	·004	·003	·007	·007	·010	·008	·006	·003	—·001	·000	·000
11	—·006	—·009	·003	—·003	—·005	—·001	—·004	—·004	—·012	—·005	·008	—·010
Mean Range.	·125	·114	·123	·118	·098	·071	·063	·071	·097	·122	·127	·122
Monthly Means.	29·947	29·928	29·869	29·804	29·750	29·628	29·648	29·701	29·795	29·835	29·925	29·890

Extreme Annual Range, ·401.—The Barometer is 36 feet above the level of the sea.

* The upper line of figures gives the elevation of the mercury at midnight : the figures below indicate the amount to be added to, or subtracted from, the line preceding, for the fluctuation due to a single hour.

TABLE showing the Mean Rise and Fall of the Barrometer at stated intervals during the Day, for the year 1844. *—At Calcutta, Lat.* 22° 34′ 40″ *N., Long.* 88° 28′ 15″ *E.—The yearly mean pressure of the Atmosphere, reduced to* 32° *Fahr., being* 29·749. *in.—There is no register of hourly observations at Calcutta.*

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
At Sun Rise......	29·934	29·907	29·791	29·651	29·566	29.457	29·524	29·523	29·696	29.827	29·957	29·971
At 9h. 50m. A. M......	+·062	+·066	+·058	+·062	+·044	+·050	+·044	+·049	+·051	+·044	+·051	+·058
Apparent Noon.........	—·034	—·025	—·018	—·018	—·010	—·020	—·024	—·023	—·024	—·038	—·041	—·042
At 2h. 40m. P. M......	—·048	—·057	—·056	—·059	—·049	—·053	—·046	—·057	—·063	—·058	—·063	—·063
At 4 P. M.............	—·007	—·012	—·013	—·020	—·027	—·011	—·017	—·013	—·015	—·005	—·002	—·005
At Sun Set............	+·002	+·008	—·009	+·005	+·008	+·010	+·009	+·008	+·010	+·004	+·004	+·003
Mean Monthly Range...	·089	·094	·096	·099	·008	.092	·087	·093	·102	·101	.106	·110
Monthly Means........	29·937	29·914	29·793	29·656	29.564	29·484	29.517	29·516	29.687	29·817	29·940	29·958

Yearly Extreme Range, ·719.—The Barometer is 18 feet above the level of the sea.

TABLE showing the Mean Hourly Rise and fall of the Barometer, during each month of the year 1847, at Aden, in East Long. 45° 15′, Lat. 12° 46′ 26″ North. The yearly mean pressure of the Atmosphere, reduced to 32° Fah., being inches 29·708.

Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	in	in	in	in	in	in	in	in	in	in	in	in
Noon.	29·735	29·799	29·774	29·752	29·608	29·587	29·500	29·580	29·585	29·783	29·904	29·893
1	—·002	—·023	—·003	—·014	—·014	—·047	—·016	—·021	—·013	—·012	—·026	·027
2	·012	·035	·011	·046	·014	·044	·041	·035	·009	·026	·019	·018
3	·015	·010	·020	·002	·034	·010	·022	·016	·007	·003	·014	·019
4	+·003	+·020	+·020	·001	+·011	+·002	·004	+·003	+·002	+·009	·002	+·022
5	·018	·009	·026	+·023	·006	·010	+·010	·009	·008	·014	+·016	·020
6	·022	·018	·025	·011	·013	·015	—·005	·011	·022	·022	·024	·017
7	·012	·032	·006	·015	·015	·022	+·012	·023	·024	·017	·023	·019
8	·011	·015	·016	·009	·013	·006	·017	·008	·020	·019	·012	·010
9	—·001	·002	·009	·001	·021	·002	·023	·005	·018	·011	·015	·012
10	·002	·020	·000	·019	·013	·004	·019	·014	·013	·000	·014	·010
11	·012	—·030	—·007	—·007	—·015	—·009	—·005	—·018	—·015	—·024	—·019	—·029
12	·013	·013	·014	·005	·014	·006	·021	·007	·016	·012	·007	·000
13	·014	·014	·020	·014	·015	·007	·012	·006	·008	·015	·016	·024
14	·022	·008	·018	·014	·019	·009	·020	·008	·014	·008	·014	·021
15	·006	·012	·019	·009	·009	·010	·021	·007	·008	·007	·012	·015
16	+·009	+·006	·000	·004	+·011	+·014	+·024	·006	+·015	+·013	+·016	+·012
17	·015	·002	+·009	+·010	·027	·024	·027	+·012	·023	·015	·018	·014
18	·014	·015	·013	·009	·023	·018	·020	·017	·014	·015	·015	·017
19	·025	·022	·022	·026	·021	·012	·018	·019	·026	·023	·011	·020
20	·016	·025	·019	·033	·014	·018	·011	·015	·023	·010	·025	·011
21	·010	·027	·021	·002	·011	·010	·006	·006	·009	·019	·006	·004
22	—·002	—·003	·004	·009	·011	·015	·012	·024	—·011	—·008	·005	·026
23	·024	·049	—·016	—·013	—·044	—·027	—·013	—·034	·024	·037	—·041	—·035
Monthly Mean Range.	·066	·150	·100	·124	·138	·133	·115	·138	·156	·121	·132	·099
Monthly Means	29·747	29·807	29·788	29·743	29·607	29·541	29·466	29·571	29·626	29·799	29·909	29·896

Extreme Annual Range, ·558.—The Barometer is 187 feet above the level of the sea.

***TABLE** showing the Mean Hourly Rise and fall of the Barometer during each month of the year* 1844, *at Madras, Lat.* 30° 4′ 10″ *N., Long.* 80° 21′ 38″ *E. The yearly mean pressure of the Atmosphere, reduced to* 32° *Fah., being* 29·842.

Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
4	in 29·970	in 29·966	in 29·950	in 29·882	in 29·798	in 29·632	in 29·657	in 29·708	in 29·718	in 29·778	in 29·846	in 29·934
5	+·007	+·008	+·004	+·006	+·007	+·003	+·008	+·007	+·006	+·010	+·006	+·009
6	·015	·015	·014	·016	·013	·016	·015	·018	·014	·016	·023	·018
7	·022	·023	·023	·027	·019	·024	·020	·016	·018	·017	·021	·021
8	·025	·025	·023	·017	·021	·013	·012	·014	·017	·020	·016	·022
9	·021	·022	·022	·019	·012	·015	·009	·014	·014	·012	·012	·016
10	·003	·002	·009	·005	·000	—·003	·000	·002	·000	—·002	·005	·001
11	—·011	—·011	—·009	—·020	—·013	·010	—·012	—·012	—·011	·012	—·018	—·014
NOON	·025	·027	023	·025	·022	·020	·017	·018	·019	·025	·023	·025
P. M. 1	·030	·030	·027	·031	·030	·026	·024	0 25	·030	·029	·024	·029
2	·025	·030	·030	·027	·034	·030	·025	·027	·027	·029	·025	·026
3	·017	·016	·024	·024	020	·019	·022	·023	·023	.021	·019	·010
4	·003	·000	·005	·011	·015	·013	·017	·018	·015	·012	·004	·007
5	+·003	·016	·077	·008	·000	·028	+·049	+·003	+·059	+·089	+·114	·028
6	·012	+·012	+·009	+·011	+·014	+·011	·014	·012	·019	·018	·014	+·017
7	·013	·016	·006	·026	·024	·020	·022	·020	·021	·018	·015	·017
8	·023	·017	·023	·023	·024	·020	·020	·024	·024	·024	·024	·023
9	·016	·017	·022	·020	·022	·019	·023	·027	·027	·024	·016	·019
10	·003	·018	·014	·019	·018	·015	·017	·017	·013	·007	·004	·005
11	—·006	—·001	·000	·004	·003	·005	·010	·007	—·003	—·008	—·007	—·008
12	·010	·006	—·008	—·010	—·013	—·008	—·012	—·006	·010	·012	·012	·012
A. M. 1	·005	·010	·016	·011	·021	·010	·017	·017	·017	·014	·013	·012
2	·017	·018	·018	·014	·013	·013	.014	·016	·014	·017	·015	·017
3	·012	·013	·012	·006	·012	·007	·010	·009	·003	·007	·012	·019
Mean Range.	·094	·129	·195	·236	·141	·146	·153	·123	·146	·130	·187	·139
Monthly Means.	29·998	29·988	29·947	29·861	29·761	29·682	29·694	29·727	29·760	29·829	29·912	29·948

Extreme Annual Range, ·458.—The Barometer is 27 feet above the level of the sea.

TABLE showing the Mean Hourly Rise and Fall of the Barometer during the year 1850, *at Trevandrum, Lat.* 8° 30′; *Long.* 76° 59′.—*The Mean pressure of the* 11 *months, reduced to* 32° *Fahr., being* 29·738.

Gottingen Maen Time.	Trevandrum Mean Time.	January.	February.	March.	May.	June.	July.	August.	September.	October.	November.	December.
	h. m.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Noon.	4·49	29·675	29·735	29·729	29·648	29.669	29·661	29·67[illegible]	29·709	29.685	29·698	29·732
1	5·49	+·017	+·016	+·017	+·015	+·015	+·014	+·016	+·017	+·016	+·017	+·016
2	6·49	·019	·017	·019	·019	·017	·017	·017	·019	·019	·021	·021
3	7·49	·019	·019	·013	·018	·016	·014	·015	·016	·019	·018	·019
4	8·49	·017	·014	·018	·017	·014	·016	·01[illegible]	·018	·016	·018	·019
5	9·49	·015	·015	·016	·011	·013	·012	·015	·011	·013	·016	·015
6	10·49	·004	·004	·002	·002	·000	·000	.001	—·002	—·002	—·001	—·001
7	11·49	—·010	—·010	—·008	—·009	—·011	—·009	—·009	·010	·009	·012	·012
8	12·49	·022	·011	·012	·012	·015	·010	.014	·013	·015	·011	·014
9	13·49	·012	·013	·014	·015	·014	·012	·014	·014	·013	·014	.017
10	14·49	·015	·015	·014	·013	0·14	·013	·013	·013	·011	·014	·016
11	15·49	.013	·014	·014	·012	0·13	·016	·016	·016	·014	·014	·015
12	16·49	+·005	+·011	+·009	+·010	+·010	+·012	+·008	+·007	+·009	+·006	+·013
13	17·49	·001	·012	·016	·013	·015	·013	·013	·016	·014	·015	.018
14	18·49	·017	·017	·017	·013	·015	·012	·014	·016	·020	·016	·016
15	19·49	·025	·020	·019	·014	·017	·014	·014	·014	·018	·017	·018
16	20·49	·019	·019	·016	·014	·010	·004	·016	·017	·015	·017	·018
17	21·49	·005	.015	·014	·010	·005	·007	·008	·012	·010	·012	·013
18	22·49	—·009	—·012	—·006	—·009	—·007	—·008	—·010	—·011	—·010	—·015	—·015
19	23·49	·024	·020	·025	·019	·017	·016	·016	·018	·020	·026	·024
20	0·49	·024	·028	·030	·019	·015	·018	·019	·022	·026	·028	·027
21	1·49	·025	·026	·029	·023	·019	·018	·021	·024	·024	·021	·015
22	2·49	·023	·024	·022	·021	·020	·018	·029	·022	·020	·019	·021
23	3·49	·015	·016	·011	0·15	·011	·014	0·14	·014	·019	·011	·013
Mean Range.		·110	·128	·123	·106	·089	.092	·099	·111	·119	.120	·125
Monthly Means.		29·731	29·787	29·780	29·697	29·709	29·704	29.724	29.724	29.735	29·749	29·783

Elevation above the level of the sea, 130 feet.

TABLE showing the Mean Hourly Rise and Fall of the Barometer from Feb. 1847 to January 1848, at Dodabetta, Lat. 11° 23′ 22″ N.; Long. 76° 47′ E. The yearly mean pressure of the Atmosphere, reduced to 32° Fahr., being 22·058.

Mean Time.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.
A. M. 10	in 22·124	in 22·310	in 22·130	in 22·010	in 21·962	in 22·026	in 22·080	in 22·066	in 22·128	in 22·110	in 22·120	in 22·106
11	—·002	—·004	—·006	—·004	—·012	—·006	+·002	—·008	—·022	—·008	—·008	—·026
Noon	·002	·016	·008	·004	·000	·008	—·020	·018	·013	·011	·022	·014
1	·016	·006	·006	·010	·031	·016	·010	·007	·023	·015	·017	·009
2	·020	·015	·018	·018	·005	·010	·014	·009	·015	·007	·020	·021
3	·002	·019	·012	·014	·006	·014	·004	·014	·017	·009	·011	·017
4	·008	+·019	·002	·007	·036	·012	·010	·002	+·007	·001	·004	·001
5	·000	—·009	+·006	+·017	·002	+·002	+·008	+·000	·009	·003	·008	·003
6	·002	+ 012	·000	—·006	+·010	·006	·008	·012	·010	+·002	+·024	+·003
7	+·018	·003	·002	+·010	·034	·010	·004	·026	·018	·016	·004	·008
8	·008	·023	·008	·018	·012	—·002	·016	·004	·012	·012	·016	·021
9	·010	·000	·024	0 20	·000	+·034	·010	·000	.020	·008	·002	·011
10	·000	·001	·000	·006	·006	·005	·005	·000	·002	·006	—·008	·000
11	—·008	·022	—·008	—·002	—·014	—·003	—·013	·002	—·006	—·008	·002	—·002
Mid-night.	·008	—·032	·029	·026	·006	·030	·000	—·012	·022	·008	·008	·018
1 A. M.	·020	·020	·011	·018	·008	·014	·018	·019	·016	·009	·008	·004
2	·020	·030	·016	·014	·014	+·002	·012	·002	·018	·009	·012	·020
3	+·002	+·006	·004	·008	·020	—·010	·000	·002	·010	·008	·008	·006
4	·000	—·016	·002	+·006	·002	·010	·000	+·012	+·006	·008	·000	·000
5	·004	+·010	+·002	·008	·004	+·018	+·008	·008	·004	+·004	+·006	·008
6	·012	—·012	·014	·012	·004	·004	·018	·002	·028	·016	·014	+·014
7	·032	+·024	·020	·000	·012	·003	·020	·022	·014	·014	·012	·024
8	·022	·014	·012	·020	·022	.011	·004	·018	·018	·026	·018	·024
9	·027	·022	·023	·006	·004	·010	·004	·017	·008	·011	·012	·024
Mean Range.	·099	·094	·082	·065	·082	·076	·062	·084	·100	·077	·086	·086
Monthly Means.	22·071	22·272	22·089	21·986	21·915	27·984	22·053	22·026	22·077	22·082	22·070	22·063

Extreme Annual Range, ·418.—The Barometer is 8640 feet above the level of the sea.

TABLE showing the Mean Hourly Rise and Fall of the Barometer, during the year 1847, *at Lucknow, in Lat.* 26° 51′ ; *Long* 80° 55.′ *The yearly mean pressure of the Atmosphere, reduced to* 32° *Fahr., being inches* 29·388.

Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	in	in	in	in	in	in	in	in	in	in	in	in
Mid-night.	29·604	29·594	29·487	29·326	29·203	29·103	29·134	29·190	29·273	29·489	29·584	29·619
1 A.M.	—·004	—·010	—·010	—·010	—·005	—·005	—·010	—·011	—·006	—·010	—·007	—·007
2	·013	·011	·005	·008	·007	·008	·004	·009	·007	·006	·007	·006
3	·007	·004	·006	·001	+·004	+·002	·004	·004	+·003	·002	·005	·006
4	·002	+·004	+·005	+·011	·001	·009	+·004	+·004	·006	+·006	+·006	·000
5	+·014	·015	·015	·016	·017	·011	·006	·011	·011	·014	·013	+·011
6	·016	·014	·018	·026	·025	·021	·017	·017	·016	·022	·020	·021
7	·023	·023	·026	·020	·016	·009	·015	·017	·017	·020	·021	·025
8	·025	·026	·018	·017	·015	·010	·005	·01[illegible]	·011	·015	·025	·028
9	·014	·013	·012	·004	·002	—·001	·006	·00[illegible]	·010	·010	·012	·010
10	—·009	—·001	—·005	—·005	—·003	·002	—·005	·001	—·004	—·007	—·010	—·004
11	·026	·017	·019	·017	·012	·009	·008	—·010	·014	·022	·022	·025
Noon	·034	·028	·028	·022	·021	·018	·012	·01[illegible]	·018	·023	·008	·034
1	·019	·025	·031	·028	·028	·025	·021	·016	·032	·020	·028	·027
2	·033	·025	·029	·030	·036	·029	·021	·02[illegible]	·028	·019	·016	·017
3	·009	·012	·014	·022	·018	·028	·019	·010	·012	·005	·004	·006
4	+·003	·001	·008	·008	·009	·017	·006	·00[illegible]	·004	·001	+·007	·000
5	·008	+·010	+·011	+·005	·002	+·005	+·005	·00[illegible]	+·010	+·007	·008	+·008
6	·021	·017	·017	·016	+·016	·024	·021	+·024	·017	·021	·020	·018
7	·013	·011	·014	·016	·012	·020	·018	·021	·021	·012	·010	·013
8	·004	·012	·016	·021	·013	·017	·012	·016	·016	·011	·006	·010
9	·004	·005	·018	·009	·017	·018	·010	·013	·006	·005	·003	·008
10	—·000	—·003	—·005	·000	·005	·003	·001	—·001	—·002	—·001	—·005	—·005
11	·009	·006	·000	—·002	—·006	·001	—·009	·006	·007	·004	·010	·008
Monthly Mean Range.	·100	·109	·131	·132	·129	·128	·092	·097	·114	·105	·098	·116
Monthly Means	29·609	29·601	29·488	29·331	29·213	29·099	29·128	29·188	29·277	29·497	29·600	29·625

Extreme Annual Range, ·672.

TABLE showing the Mean Hourly Rise and Fall of the Barometer, during each month of the year 1844, *at St. Helena, Lat.* 15° 56′ 41·2″ *South ; Long.* 5° 40′ 31·5″ *West.—The yearly Mean pressure of the Atmosphere, reduced to* 32° *Fahr., being* 28·278.

Mean Time.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Noon.	28·256	28·247	28·244	28·256	28·292	28·344	28·372	28·364	28·324	28·290	28·268	28·268
1	—·012	—·017	—·021	—·018	—·019	—·018	—·016	—·020	—·015	—·017	—·014	—·014
2	·016	·015	·016	·016	·017	·003	·016	·014	·015	·014	·015	·014
3	·009	·014	·013	·013	·009	·018	·006	·009	·010	·010	·012	·015
4	·009	·008	·005	·001	·001	+·000	+·002	·001	·000	·003	·006	·009
5	+·003	·000	+·003	+·004	+·006	·004	·008	+·006	+·007	+·005	+·001	+·002
6	·009	+·008	·008	·006	·007	·009	·007	·006	·008	·011	·009	·010
7	·012	·011	·013	·012	·010	·009	·008	·012	·014	·012	·013	·013
8	·015	·016	·015	·013	·014	·010	·010	·012	·014	·014	·016	·015
9	·013	·012	·015	·012	·010	·008	·007	·008	·011	·011	·011	·011
10	·008	·009	·009	·005	·003	·004	·004	·005	·002	·006	·008	·009
11	—·004	·000	—·004	—·001	—·002	—·004	—·003	—·002	—·002	—·007	—·007	—·006
12	·005	—·012	·010	·005	·008	·009	·005	·008	·010	·014	·014	·014
13	·017	·015	·013	·011	·010	·006	·010	·013	·017	·017	·019	·019
14	·012	·015	·014	·015	·009	·011	·012	·013	·014	·014	·013	·012
15	·001	·009	·011	·012	·010	·011	·011	·009	·010	·011	·005	·017
16	+·003	+·003	·002	·002	·001	·001	·004	·004	·004	+·002	+·003	+·001
17	·008	·004	+·007	+·004	+·004	+·002	+·002	+·001	+·006	·007	·007	·011
18	·019	·014	·011	·015	·010	·009	·008	·013	·012	·014	·018	·020
19	·017	·018	·017	·015	·016	·014	·013	·012	·015	·018	·017	·017
20	·011	·014	·017	·016	·016	·017	·017	·016	·014	·015	·014	·010
21	·006	·010	·011	·011	·013	·015	·016	·015	·011	·009	·008	·006
22	·000	·001	·002	·006	·003	·003	·004	·006	·004	—·001	·000	—·001
23	—·007	—·007	·007	—·011	—·009	—·008	—·009	—·007	—·005	·003	—·007	·005
Mean Range.	·068	·070	·075	·076	·072	·062	·061	·064	·062	·065	·067	·070
Monthly Means.	28·238	28·226	28·225	28·242	28·277	28·331	28·360	28·350	28·313	28·275	28·252	28·280

Extreme Annual Range, ·206.

Elevation of Barometer above the level of the sea, 1746 feet.

The following instructions for computing Barometrical Altitudes, drawn up by Professor Patton, of the Bombay Elphinstone College, are amongst the simplest to be met with :—

If the earth were surrounded by an atmosphere of uniform temperature, and the intensity of gravity were constant, the density of the air in ascending from the surface would decrease in a geometric ratio, on account of the diminished pressure; and it can be easily shown that under these circumstances the distance of any place from the superior limit of the atmosphere is proportional to the logarithm of the height of the barometric column by which the weight is measured, and consequently the distance between any two places in the same vertical is proportional to the differences between the logarithms of the heights of the barometer at the two places. This uniform temperature is assumed at 32°F., and when the temperature is greater than this, the same difference of barometric pressure must correspond to a greater distance; because the increase of temperature has expanded the column of air, the weight remaining the same. The law of diminution of temperature being unknown, the temperature of the column of air is assumed equal to the mean of the two temperatures at its extremities. If the hygrometric state of the atmosphere were accurately known, some correction should be also introduced on this account; but as the calculation is complicated, and the foundation on which it rests is not established with certainty, in the following rules, it has been neglected.

Before the calculation is made, the height of the mercurial column at the upper station ought to be corrected on account of the contraction of the mercury. Since the expansion of mercury is very nearly the ten thousandth part of its height for every degree of Fahrenheit, the correction to be added at the upper station will be found by changing the decimal point four places to the left and multiplying by the difference of the degrees on the attached Thermometers at the two stations. The formula given by Poisson in the second volume of his *Traitè de Mechanique,* when changed into English feet and degrees of Fahrenheit, becomes

$$Z = 60346\left(\frac{418+\frac{t+t'}{2}}{450}\right)\text{Log}\,\frac{h}{h_{\prime}}$$

Where Z is the height in feet t and t' the temperature of the air in degrees of Fahrenheit, and h and h' the Barometric heights, the latter corrected in the manner beforementioned.

$$\text{Log.}\,\frac{h}{h'} = 2\text{ M.}\left\{\frac{h-h'}{h+h'} + \frac{1}{3}\left(\frac{h-h'}{h+h'}\right)^{3} \times \&c\right\}$$

in which M is the modulus of the common system of logarithms, and is equal to ·43429450, and when $\frac{h-h'}{h+h'}$ is a small fraction, the third and higher powers may be neglected, and the formula becomes

$$Z = 52416\left(\frac{418+\frac{t+t_{\prime}}{2}}{450}\right)\frac{h-h_{\prime}}{h+h'}$$

To facilitate calculation, the following table of the values of $52416\left(\frac{418+\frac{t+t'}{2}}{450}\right)$ has been constructed for every value of $\frac{t+t_{\prime}}{2}$ from 32° to 91°, which includes, I presume, almost every possible case.

32°	52416	47°	54163	62°	55911	77°	57658
33°	52532	48°	54280	63°	56027	78°	57774
34°	52649	49°	54396	64°	56143	79°	57890
35°	52765	50°	54512	65°	56260	80°	58007
36°	52882	51°	54629	66°	56376	81°	58124
37°	52998	52°	54745	67°	56493	82°	58240
38°	53115	53°	54862	68°	56609	83°	58356
39°	53231	54°	54979	69°	56726	84°	58472
40°	53348	55°	55095	70°	56842	85°	58589
41°	53464	56°	55211	71°	56959	86°	58706
42°	53581	57°	55328	72°	57075	87°	58823
43°	53697	58°	55444	73°	57192	88°	58939
44°	53814	59°	55561	74°	57308	89°	59055
45°	53930	60°	55677	75°	57424	90°	59172
46°	54046	61°	55794	76°	57541	91°	59288

Rule.—Multiply the number in the table opposite to the mean of the temperatures of the two places by the difference, and divide by the sum of the Barometric heights, and the quotient is the altitude in feet.

Example.—M. Humboldt made the following observation on the mountain of Guanamato in Mexico.

	Upper Station.	Lower Station.
Thermometer in air...	70·4	77·6
Attached Do...	70·4	77·6
Barometer.....	23·66	30·05

What was the difference in height of the two stations.

Here the correction to be applied to the barometer at the Upper Station is ·002366×7·2=·017; and the height should be taken 23.66+·017=23·677. The mean of the two temperatures is 74°, opposite to which in the table is found 57308, which multiplied by 6.373 (30·05—23·677) and divided by 53·727 (30·05+23·677) gives 6800 feet.

This example has been taken from Bailley's Tables, page 263, where he obtains the result 6843 without correcting for the temperature of the mercury. The above rule without this correction gives 6817, differing only 26 feet from Bailey's result. When the height is very great, say above 7000 feet, the principle on which the above approximation depends, that $\frac{h-h'}{h+h'}$ is a very small fraction, no longer applies, and a correction must be added. There are two ways in which this may be done,—either by subdividing the interval into portions, as Leslie recommends, or by multiplying the result found as above directed by one third of $\frac{h-h'}{h+h'}$ squared, which gives the correction to be added with considerable accuracy.

Example.—Humboldt observed on the summit of the Andes the

Barometer 14·850 Att. Ther. 50° Det. 29.°2

And on the shore of the Pacific,

Barometer 30. Att. Ther. 77.°5 Det. 77°5

This example calculated as above, gives as an approximation

$$\text{Altitude}=54901\,\frac{15{\cdot}11}{44{\cdot}89}=18479, \text{ and since } \frac{15{\cdot}11}{44{\cdot}89}={\cdot}34 \text{ nearly,}$$

the correction is $18479\times\frac{1}{3}(.34)^2=711$ feet, and the total altitude is 19190 feet, only differing by 142 feet from the result found by logarithms. When the height does not much exceed 10000 feet, this correction will give the result within a few feet; for example, if applied to the case above given from Bailey, the correction is $6817\times\frac{1}{3}({\cdot}119)^2=32$ feet.

The following remarks by Captain Shortrede, and by an anonymous writer in the Transactions of the Bengal Society, are well worthy of attention :—

If I remember rightly, your correspondent D has given a formula for computing Barometric heights, which to me appears to be neither so simple nor easy of recollection as that given by Professor Leslie, at the end of his Geometry ; which is " As the sum of the mercurial columns is to their difference, so is the constant number 52,000 to the approximate height in feet." This rule is easily remembered, and is not far from the truth ; but a more correct result may be obtained by using 52,200 as the third term. At the height of a mile the height thus found differs only nine feet in defect from that obtained by a logarithmic calculation, whereas by Leslie's rule the defect is twenty-nine feet. When the height does not exceed 4,000 feet, 52,200 gives within two feet of the logarithmic calculation. At elevations above a mile, the difference increases rapidly : it then becomes necessary, as Leslie recommends, to subdivide the interval into smaller portions.

The following Table shews the results of the several Rules.

	Approximate Height by		
Barometers.	Logarithms.	52,200	52,000.
30 and 29.5	438.0	438.7	437.0
... „ 29.0	883.4	884.7	881.3
... „ 28.5	1336.6	1338.0	1333.3
... „ 28.0	1798.0	1800.0	1793.1
... „ 27.5	2267.3	2269.1	2260.4
... „ 27.0	2745.4	2747.4	2736.8
... „ 26.5	3232.5	3233.6	3221.2
... „ 26.0	3728.9	3728.6	3714.3
... „ 25.5	4234.9	4232.4	4216.2
... „ 25.0	4750.9	4745.5	4727.3
... „ 24.0	5814.6	5800.0	5777.8
... „ 23.0	6923.6	6894.3	6867.9
... „ 22.0	8081.9	8030.8	8000.0
... „ 21.0	9294.1	9211.8	9176.5
... „ 20.0	10565.5	10440.0	10400.0

At 3700 feet by using 52,200 we get exactly the same result as by logarithms.

Leslies's rule is then in defect about 15 feet.

This rule may be thus expressed in words : " The sum of the barometric columns at the two stations is to their difference as 52,200 to the approximate height in feet," and algebraically (B and b being the barometers at the two stations) $\left(\frac{B-b}{B+b}\right)52{,}200=$ Approximate height (A).

On the reduction of mean temperature by elevation, Professor Leslie has given the following formula as the result of his experiments on the cold produced by diminution of barometric pressure. If B and b denote the barometric pressure at the lower and upper stations, then will $\left(\frac{B}{b}-\frac{b}{B}\right)25$ express on the Centigrade scale, the diminution of heat in ascent (B). This formula cannot be universally true, though it is known to give results agreeing very well with observation in moderate elevations. For if we suppose three stations A, B, C, in the same vertical line at which the Barometer stands respectively at 30, 20, and 10 inches, it is obvious that the reduction of temperature between A and B together with that between B and C must be the same as the whole reduction from A to C. The formula gives $\left(\frac{30}{20}-\frac{20}{30}\right)25 = 20.83$ as the diminution from A to B; and $\left(\frac{20}{10}-\frac{10}{20}\right)25 =$ 37.5 as that from B to C: the sum of which is 58.33. But we have also $\left(\frac{30}{10}-\frac{10}{30}\right)25 =$ 66.67 as the reduction from A to C. This differs so much from the former result, that we may without any hesitation conclude that the formula cannot be strictly true. In order that the diminution from A to C may be equal to the sum of the diminutions from A to B and from B to C, it seems necessary to make it proportional to the ratio of the densities, or as the logarithm of $\frac{B}{b}$; that is, as the difference of the logarithms of the barometers at the two stations; and if we assume that Leslie's formula gives results not sensibly differing from the truth, at first, we shall have $115 \log.\frac{B}{b}$ to be marked (C) as the expression for the diminution of temperature on the Centigrade scale, or $207 \log.\frac{B}{b}$ to be marked (D) on Fahrenheit, which will give *consistent* results in all cases.* The diminution of temperature is thus proportional to the approximate height in barometric calculations, and if we calculate the approximate height corresponding to a reduction of 1 degree in temperature, we shall have 521.738 feet for 1° cent. and 289.86 feet for 1° Fahr., or in round numbers 522 for 1° cent., and 290 for 1° Fahr. at the temperature of freezing. The numbers 522 and 290 will require a correction for mean temperature, as in barometric measurements: This may be done very simply. The expansion on a column of air of 522 feet for 1° cent. is just about 2 feet, and on 290 feet for 1° Fahr. the expansion is 6 feet very nearly. Hence the corrected numbers may be found as follows: To 522 add twice the number expressing the mean temperature in degrees cent., and we have the correct height corresponding to a difference of 1° cent., and on Fahr. multiply the mean temperature above 32 by 0.6 and add it to 290, the sum is the correct height giving a difference of 1° Fahr.

* If necessary, the co-efficient may be corrected so as to agree with observation.

The following Table may be convenient for reference.

Mean Temp. Cent.	Height for 1°	Mean Temp. Fahr.	Height for 1°
0	522	30	289
5	532	32	290
10	542	40	295
15	552	50	301
20	562	60	307
25	572	70	313
30	582	80	319

I may perhaps have occasion to refer again to this subject.

There is a formula for finding the approximate height in barometric operations of the same general form as that of Leslie, for diminution of temperature. The *formula* is $\left(\frac{B}{b}-\frac{b}{B}\right)13050$ = Approximate Height.* (E). The co-efficient in this formula is *half* the height of the equiponderant column. The co-efficient of formula (A) before given is 52,200, being *double* the height of the equiponderant column, or just 4 times the co-efficient of formula (E). Now as in Leslie's formula the co-efficient is 25 cent. or just ¼ of the interval from freezing to boiling, we may therefore transform it into another of the form (A) and it becomes $\left(\frac{B-b}{B+b}\right)100$ = diminution in degree cent. or $\left(\frac{B-b}{B+b}\right)180$ = diminution in deg. Fahr. which may be thus expressed: "The sum of the barometers at the two stations is to their differences, as the number of degrees in the interval from boiling to freezing is to the diminution of mean temperature by ascent." This rule will give results not sensibly differing from those of the logarithmic formula (C and D) at intervals of 4000 feet, or even at a mile.

The following rule is given by Sir John Leslie in reference to accurate Barometric Measurements, in the *Encyclopædia Britannica*. The use of detached Thermometers may be dispensed with, by permitting the Barometer to remain freely exposed to the air, but shaded from the sun for half an hour or so, till the mercury within approaches the temperature of the air without. The attached ther-

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* The formula, $\left(\frac{B}{b}-\frac{b}{B}\right)$ 13,000 and $\left(\frac{B-b}{B+b}\right)$52,200, for the approximate height, are only close approximations to the truth, and are not absolutely identical: the former errs in excess, and the latter a little in defect. If they were absolutely identical, we should have $\frac{B}{b}-\frac{b}{B} = 4\,\frac{B-b}{B+b}$, or $\frac{B-b}{B+b} = \frac{B^2-b^2}{4Bb} = \frac{(B+b)\,(B-b)}{4Bb}$, from which by transposition and division we get $4Bb = (B+b)^2 = B^2+2Bb+b^2$ hence $2Bb = B^2+b^2$, which however do not differ much from the truth when B and b are nearly equal.

mometer in this case takes the place of the detached thermometer—that is, it is treated as if it were a case in which the two agreed. The correction of the mercury for expansion is most expeditiously performed by the tables, Appendix A.

In the actual state of physical science, it is preposterous, therefore, to affect any high refinement in the formula for computing barometrical measurements. The whole operation may be reduced to a very short and easy process. But the simplicity of the calculation would be still greater, if the centesimal thermometer were generally adopted. It will be sufficiently accurate, till better data are obtained, to assume the expansion of mercury by heat as equal to the 5000th part of its bulk for every centesimal degree, while that of air is twenty times greater, being an expansion for each degree of the 250th part of the bulk of this fluid. 1. *Correct the length of the mercurial column at the upper station, adding to it the product of its multiplication into twice the difference between the degrees on the attached thermometers, the decimal point being shifted four places to the left.* 2. *Subtract the logarithm of this corrected length from that of the lower column, multiply by six, and move the decimal point four places to the right; the result is the approximate elevation expressed in English feet.* 3. *Correct this approximate elevation, by shifting the decimal point three places back to the right, and multiplying by twice the sum of the degrees on the detached thermometers; this product being now added, will give the true elevation.*

If it were judged worth while to make any allowance for the effect of centrifugal force, this will be easily done, before the last multiplication takes place, by adding to twice the degrees on the detached thermometers, the fifth part of the mean temperature corresponding to the latitude. The mean temperature itself is formed by multiplying the square of the cosine of the latitude by 29.

In illustration of these rules, we shall subjoin some real examples. General Roy, in the month of August, 1775, observed the barometer on Caernarvon Quay, at 30.091 inches, the attached centesimal thermometer indicating 15.7, and the detached 15.6; while, on the peak of Snowdon, the barometer fell to 26.409 inches, and the attached and detached thermometers marked respectively 10°.0 and 8°.8. Here twice the difference of the attached thermometers is 11°.4, and twice the sum of the detached thermometer is 48°.8, which becomes 50°.8, when augmented by the fifth part of the mean temperature on that parallel. Now, omitting the lower decimals, the first correction is .00264 × 11.4 = .030, to be added to 26.409. Wherefore,

Log. 30.091 =	1.4784866
Log. 26.439 =	1.4223450
Difference =	.0561416
Constant multiplier =	60000
Approximate height =	3368.496

And, for the true height, the correction is 3.37 × 50.8 = 171.2, which gives 3340 for the final result.

We shall take another example from the observations made by Sir George Shuckburgh Evelyn, at the same period, among the mountains of Savoy. This accurate philosopher found the barometer, placed in a cabin near the base of the Mole, and only 672 feet above the surface of the lake of Geneva, to stand at 28.152 inches, while the attached and detached thermometers indicated 16°.3 and 17°.4 ; but, in another barometer carried to the summit of that lofty insulated mountain, the mercury sunk to 24.176 inches, the attached and detached thermometers marking 14°.4 and 13°.4. Wherefore, twice the difference of the degrees on the attached was 3°.8, and twice the sum of the degrees on the detached thermometers was 61°.6. Consequently, the correction to be applied to the higher column was .0024 × 3.8 = .009, which makes it 4.185. Now,

Log. 28.152 =	1.4495092
Log. 24.185 =	1.3835461
Difference =	.0659631
Constant multiplier =	60000
Approximate elevation =	3957.786

To correct this approximate elevation, remove the decimal point three places back, and multiply it by 61°.6, increased by 2°.9, the fifth part of the mean temperature, corresponding to the latitude ; but 3.96 × 64.5 = 255.4, and 3957.8 + 255.4 = 4213. Hence the summit of the Mole is 4885 feet above the lake of Geneva, or 6083 feet above the level of the Mediterranean Sea.

The last example we shall give is drawn from the observation which Baron Humboldt made among the Andes, near the summit of Chimboraço, the highest spot ever approached by man. This celebrated traveller found there, that the barometer fell to 14.850 English inches ; the attached thermometer in the tent being at 10°, and the detached in open air being 1°.6 under zero. But the same barometer, carried down to the shore of the Pacific Ocean, rose exactly to 30 inches, while both the attached and detached thermometer stood at 25°.3. Consequently, the correction to be applied to the upper column is = .0015 × 30·6, equal .045. Wherefore,

Log. 30.000 =	1.4771213
Log. 14.895 =	1.1730405
Difference =	.3040808
Constant multiplier =	60000
Approximate elevation =	18244.848

Now, the difference of the detached thermometers or 26°.9 being doubled and further increased by 5.8°, the fifth part of the mean temperature at the equator, makes 59°·6 ; and the final correction to be applied is therefore = 18·24 + 59·6 = 1087, which gives 19,332 feet for the true elevation observed, or 2140 feet below the summit of Chimboraco.

These calculations are performed by the help of logarithms. It is desirable, however, to approximate at least to barometrical measurements without such aid. A very simple rule for this object has been given by Professor Leslie in his *Elements of Geometry*. Since

$$\text{Log. } \frac{a}{b} = 2\,M\left(\left(\frac{a-b}{a+b}\right) + \frac{1}{3}\left(\frac{a-b}{a+b}\right)^3 + \frac{1}{5}\left(\frac{a-b}{a+b}\right)^5 \&c.\right),$$

where M denotes the modulus of the logarithmic system. When a approaches to b, the lower terms may be rejected without sensible error, or

$$\text{Log. } \frac{a}{b} = 2\,M\left(\frac{a-b}{a+b}\right),$$

very nearly. Wherefore, in reference to our atmosphere, the modulus is expressed by the equiponderent column of homogeneous fluid, or 60,000 × .4342945 = 26,058 feet, or only 26,000 in round numbers ; whence, *as the sum of the mercurial columns is to their difference, so is the constant number* 52,000 *feet to the approximate height.* Let General Roy's observation on Snowdon be resumed as an example: The analogy is 30.091 + 26.439 : 30.091—26.439, or 56.530 : 3.652 : : 52000 : 3,359, the approximate elevation, differing very little from the logarithmic result.

This mode of calculation may be deemed sufficiently accurate for determining any altitude that exceeds not 5000 feet. But it will extend to greater elevations, if the second term of the series be likewise taken, which is done by striking off three figures, and cubing the half of this number. Thus, resuming the mensuration of Chimboraço, 44.895 : 15.105 : : 52,000 : 17,496, and $(8.75)^3$ = 670, making together 18,166 for a nearer approximation.

The action of the Mountain Thermometer is dependant as much as that of the Barometer, on the pressure of the air, and the tables given for barometric reference must equally in this case be consulted as in the other. The following are the results given by Colonel Sykes, as quoted by Jackson in his "What to Observe":—

Thermometrically.—The next method of measuring the heights of places, we shall mention, is by means of the boiling point of water. It has been found that water boils at diminished temperatures according as the atmospheric pressure is less, and thus the boiling point of water, at different heights, is made to measure these heights. The thermometer used for this particular purpose has been described Section INSTRUMENTS. Its great portability is its chief recommendation, for it is subject to many errors; nevertheless, when we consider the little time which travellers often have for making any thing like strictly satisfactory barometrical observations, and that the errors in their results may sometimes be considered, particularly when the temperature and pressure at the level of the sea are *assumed*, we can the more readily reconcile ourselves to the use of the thermometer, especially as Col. Sykes assures us (and he has had long practice with this instrument) that sufficient accuracy may be obtained with it for all the practical purposes of physical geography.

The mode of operating is simple. Before starting, the boiling points of the thermometers must be ascertained at the level of the sea, in order afterwards to add or deduct from the temperatures observed, the quantities above or below 212 of Fahrenheit (or 100 of the Centigrade), marked by the instruments as the boiling points of water at the sea. Where an observation is to be made, it should be conducted in the following manner practised by Col. Sykes "From four to five inches of pure water were put into the tin pot. The thermometer was fitted into the aperture in the lid of the sliding tube by means of a collar of cork; the tin tube was then pushed up or down to admit of the bulb of the thermometer being about two inches above the bottom of the pot. Violent ebullition was continued for ten minutes or a quarter of an hour, and the height of the mercury was repeatedly ascertained during that time, and the temperature of the air was noticed. Similar operations were repeated with a second thermometer, for it is never safe to rely upon one instrument."

Having obtained the boiling points, it remains to determine the value of the indications of diminished pressure, when the observations are taken above the level of the sea. For this purpose tables are used which, as they are short, we shall here insert; observing, that as the degrees in the tables are those of Fahrenheit, it will be necessary, if centigrade thermometer are used, to turn these indications into the corresponding ones of Fahrenheit, for which the formula is

$$F = \frac{9\,c}{5} + 32$$

whenever the degrees are above the freezing point of water.*

TABLE I.

To find the Barometric Pressure and Elevation corresponding to any observed Temperature of Boiling Water between 214° and 180°.

Boiling Point of Water.	Barometer Modified from Tredgold's Formula.	Logarithmic Differences or Fathoms.	Total Altitude from 30.00 in. or the Level o the Sea.	Value of each Degree in Feet of Altitude.	Proportional part for One tenth of a Degree.
°			Feet.	Feet.	Feet.
214	31.19	00.84.3	—1013	—505	...
213	30.59	84.5	507	—507	...
212	30.00	84.9	0	+ 509	...
211	29.42	84.2	+509	511	51
210	28.85	85.5	1021	513	...
209	28.29	85.8	1534	515	...
208	27.73	86.2	2049	517	...
207	27.18	86.6	2566	519	52
206	26.64	87.1	3085	522	...
205	26.11	87.5	3607	524	...
204	25.59	87.8	4131	526	...
203	25.08	88.1	4657	528	...
202	24.58	88.5	5185	531	53
201	24.08	88.9	5716	533	...
200	23.59	89.3	6250	536	...
199	23.11	89.7	6786	538	...
198	22.64	90.1	7324	541	54
197	22.17	90.5	7864	543	...
196	21.71	91.0	8407	546	...
195	21.26	91.4	8953	548	..
194	20.82	91.8	9502	551	55
193	20.39	92.2	10053	553	...
192	19.96	92.6	10606	556	...
191	19.54	93.0	11161	558	...
190	19.13	93.4	11719	560	56
189	18.72	93.8	12280	563	...
188	18.32	94.2	12843	565	...
187	17.93	94.8	13408	569	57
186	17.54	95.3	13977	572	...
185	17.16	95.9	14548	575	58
184	16.79	96.4	15124	578	...
183	16.42	96.9	15702	581	...
182	16.06	97.4	16284	584	...
181	15.70	97.9	16868	587	...
180	15.35		17445		59

The fourth Column gives the Height in Feet.

* If Fahrenheit's thermometers are used, and it be desired to convert its indications into those of the centigrade, the formula is

$$C = \frac{(F-32)\times 5}{9}$$

TABLE II.

Table of Multipliers to correct the Approximate Height for the Temperature of the Air.

Temperature of the Air.	Multiplier.	Temperature of the Air.	Multiplier.	Temperature of the Air.	Multiplier.
°		°		°	
32	1.000	52	1.042	72	1.083
33	1.002	53	1.044	73	1.085
34	1.004	54	1.046	74	1.087
35	1.006	55	1.048	75	1.089
36	1.008	56	1.050	76	1.091
37	1.010	57	1.052	77	1.094
38	1.012	58	1.054	78	1.096
39	1.015	59	1.056	79	1.098
40	1.017	60	1.058	80	1.100
41	1.019	61	1.060	81	1.102
42	1.021	62	1.062	82	1.104
43	1.023	63	1.064	83	1.106
44	1.025	64	1.066	84	1.108
45	1.027	65	1.069	85	1.110
46	1.029	66	1.071	86	1.112
47	1.031	67	1.073	87	1.114
48	1.033	68	1.075	88	1.116
49	1.035	69	1.077	89	1.118
50	1.037	70	1.079	90	1.121
51	1.039	71	1.081	91	1.123

Enter with the mean temperature of the stratum of air traversed, and multiply the approximate height by the number opposite, for the true Altitude.

When the thermometer has been boiled at the foot and at the summit of a mountain, nothing more is necessary than to deduct the number in the column of feet opposite the boiling point below from the same of the boiling point above: this gives an approximate height, to be multiplied by the number opposite the *mean* temperature of the air in Table 2, for the correct altitude

	°	feet.
Boiling point at summit of Hill Fort of Parundhur, near Puna.........	204.2 =	4027
Boiling point at Hay Cottage, Puna....................................	208.7 =	1690
	Approximate height...	2337

Temperature of the air above..............................75°
Ditto ditto below...83

Mean 79 = Multiplier 1.098

Correct altitude... 2.566 feet.

When the boiling point at the upper station alone is observed, and for the lower the level of the sea, or the register of a distinct barometer is taken, then the barometric reading had better be converted into feet; by the usual method of subtracting its logarithm from 1.47712 (log. of 30 inches) and multiplying by ·0006, as the differences in the column of "*barometer*" vary more rapidly than those in the "*feet*" column.

feet.

Example.—Boiling point at upper station......185° = 14548

Barometer at Calcutta (at 32°) 29 in.75°

Logar. diff = 1·47712—1·47349 = 00363 + 0006 = 218

Approximate height............... 14330

Temperature, upper station, 76° } 80 = multiplier 1·100
Ditto lower, 84° }

Correct altitude.......... 15763

Assuming 30·00 inches as the average height of the barometer at the level of the sea (which is however too much), the altitude of the upper station is at once obtained by inspection of Table I, correcting for temperature of the stratum of air traversed by Table II.

Newman, Optician, 122, Regent Street, has been in the habit of making these instruments; he recommends the use of copper brazed, instead of tin, as more durable; and a free escape for the steam, or the results will be incorrect from the boiling taking place under pressure. The same optician constructs the thermometers and other instruments we have recommended, Sect. INSTRUMENTS.

Of course a bottle of pure water, and fuel and matches must be taken to the top of the mountain, as water may not be there found, or any fuel but such as is green and requiring time to kindle, the more so as at great heights, the air being more rare, there is a less abundant supply of oxygen. The surest and readiest way is, to be provided with a spirit lamp having three wicks, so that the flames may extend over the whole bottom of the pot and set the water boiling without delay. But as a quantity of alcohol cannot always be carried by the traveller, the lamp should be used only on emergencies. The water employed should be very pure; if such cannot be had it must be boiled and filtered before using.

The height to be found by the indications of the thermometer need not be calculated at the time, but the data must be noted on the spot. Col. Sykes very properly recommends, as well as Mr Prinsep, that every traveller, having a barometer, make a record of its indication at the same time that he observes the boiling points of his thermometer.

The following extract from Gerard's account of Koonawur will illustrate to the traveller the minute care and attention required to be bestowed on such researches as these, when results deserving of notice are desired to be attained: —

As every thing depends upon the accuracy of the instruments employed, I shall observe that the barometers used by my brother and myself in 1818, which were the first successfully carried through this quarter of the hills, were manufactured by a native of India, and every precaution was taken, to ensure precision. The mercury was revived from Cinnabar with iron filings, in an iron retort, and boiled in the tube, which from the thinness of the glass, we found a most tedious and laborious operation, occupying from ten to twelve hours each tube, and although we succeeded in boiling fourteen, yet we broke nearly as many: these tubes were of various lengths, from twenty-three to thirty-one inches: they were compared together, and found to agree as nearly as can be expected, there not being a difference of more than 1-100th of an inch, which is what the scale read off to; they were immersed in a basin of mercury, and placed perpendicular by a plummet; and the best proof of the air being completely expelled, is that tubes of half an inch and eight inches vacuum, shewed exactly the same height, and on applying a lighted candle to the top of the shortest, the mercury seemed to rise: whereas had there been the least air, it must have sunk by the expansion, which would have been clearly perceptible in so small a space. The scales were fir rods graduated by myself to 1-100th of an inch from a Troughton's standard brass scale, and they were fitted exactly to the surface of the mercury.

Two barometers were left at Soobathoo, and out of the fourteen which we took with us only two returned in safety, and these agreed exactly with the others, The barometer which I used in 1821 was constructed by Dollond, and was of the most improved kind, like those mentioned by Troughton in Dr Brewster's Encyclopedia. It had a vernier divided to 1-1000th part of an inch, a glass cistern and screw to adjust the mercury to zero of the scale. I received two of these barometers, with twenty spare tubes filled and boiled by Dollond, to fit into the frames. I left one at Soobathoo, and the other which I took with me, together with six spare tubes, after an absence of five months returned in safety, and on comparison was found to be only .002 or 1-500th part of an inch different from the former, and what was equally satisfactory is, that one of the barometers that we employed in 1818, which is still in existence, stood about 120th of an inch higher than the mean of four tubes boiled by Dollond; so the heights observed in 1818, are if any thing under than above the truth. The difference may arise from the mercury which we used being of a less specific gravity than Dollond's, but from the want of a sensible balance we were unable to determine this.

At altitudes of 14,000 and 16,000 feet, we generally remarked that the mercury in the cistern of the barometer appeared as if adulterated with lead or tin, and stuck to the fingers, but it seemed quite pure when we descended to lower places.

At lofty points of 15,000 feet and upwards, one tube was never trusted, but two or more were put up, and they almost coincided. At the highest peak, where the mercury shewed 14.675 inches, three tubes gave exactly the same result.

The temperature of the mercury and air were particularly attended to, and observed with a very sensible Dollond's thermometer; the latter is by far of the most consequence; but I have even found the temperature of the mercury, from being exposed to a burning sun, 25° hotter than the circumambient air, which amounts to above sixty feet.

The temperature of the mercury was ascertained by making the bulb of a very small thermometer touch the tube of the barometer in several places, from twelve-and-a-half inches, the lowest part of the scale, to the top.

The indications of the Aneroid are to be treated in the same way as those of the Barometer, but the instrument ought not to be relied on unless it has been tried at elevations as great, or under pressure as light—which comes to the same thing—as that to be looked for at the place of experiment.

BAROMETRIC OBSERVATIONS.

BEYOND the Tropics it seems to have generally, until of late, been considered of little consequence at what hours Barometric Observations were taken, provided they were fixed and uniform. One of the highest authorities on this point, holds convenience to be the best guide. However this may be beyond the 23rd parallel North and South, within the Tropics most unquestionably the hour of observation is a most important element—the Turning points, or Barostices, deserving to be studied with the utmost care. Speaking by unbroken time, the periods nearest to these within 20° of the line are 10 A. M. and P. M., and 3 A. M. and 4 P. M. At Calcutta, 9·50 A. M. has been fixed on as the morning maximum, in all likelihood with great justice. The Royal Society have prescribed 9 and 3 A. M. and P. M. as the barostices, and to these hours the Admiralty have adhered: in India they are unquestionably at least forty minutes wrong. In all our great observatories in India, those of Madras, Trevandrum, Bombay, Simla, Lucknow, and Singapore, magnetism formed the principal subject of investigation, and as magnetic irregularities occur simultaneously all over the world, and the reports of Göttingen, where these matters had first formed subject of investigation, possessed much the most ample and copious records, Göttingen time was adopted for all observatories. Where it so happens that the difference betwixt Göttingen and local time is a round number of hours without fractions, or where the fraction throws the local equivalent of the Göttingen hour close on the barostice, no harm arises. Madras time, for example, differs 4·41 from that of Göttingen, so that Göttingen noon is with Madras five o'clock—the hours of observation, therefore, 3·40 and 9·40 A. M. and P. M.—are all very near the barostices—the morning maximum, the most important of them, occurring in all likelihood close on the Gottingen 2·41. Bombay, again, is 4·15 E. of Göttingen, so that the hours of observation nearest to the barostice is 3·15 and 10·15 A. M. and P. M. For the morning barostice 3·15 is sufficiently near the mark—4·15 will suit for that of the afternoon; but for the maximum in both cases, 9·15 is too soon and 10·15 too late.

When it is remembered* that there is much reason to believe that there is a regular variation of pressure due to latitude, as well as to the hour of the day and season of the year, and that this in all probability follows a fine systematic law, it will at once appear that no precaution ought to be omitted which promises to assist in the elucidation of this. Sir John Herschel names 6 A. M. as a correct hour to commence the day's observation—this is three hours too late for the morning barostice, with which it would be well at all times to begin and end the barometric day. Within the tropics, three half-hourly observations at each barostice, or where this is found too troublesome, at 6 and 10 A. M., and 3 and 10 P. M., giving an observation at 8 A. M. as often as possible, will suffice. A slightly bending line, straight in the middle, connecting the barostices will be found in general within the tropics to give very nearly the true curve.

Few things are more desirable than hourly readings for 24 hours on end one day at least every month, and the 22nd is that which has been agreed on by Meteorologists; and twenty-four hourly readings at the solstices and equinoxes should always be given if possible. The Geographical Society has in general been able to obtain readings on four days of every month—the 1st, 8th, 15th, and 22nd, with three readings at the turning-points—all excepting the morning barostice throughout, and in this view one set of schedules have been ruled. All barometric observations should be made at a fixed hour: 6 A. M. and 1 P. M. give very nearly the means—10 A. M. and P. M. the maxima, and 4 A. M. and P. M. the minima: some of these hours ought always to be adhered to—the 10 A. M. and 4 P. M., from which an approximation to the mean may be obtained, being the best.

Time should always be reckoned from midnight, and where the great bulk of readers and observers are unlearned men, the common notation adhered to. The 10 A. M. and 4 P. M. observation will give not only the maxima and minima of pressure, but a close approximation to the mean and the maximum temperature of the day.

It is of great importance that the observer shall give a minute account of the instruments employed by him, of the nature of their adjustments, the position in which they are placed, and the hours at which they are observed.

In the case of observations made at sea, a note of the latitude and longitude of the vessel at the time should always accompany that of the hour of observation.

The following are the forms of tables that have been adopted by the Geographical Society for the return of observations. The Barometer is the only instrument that is registered twice over—once read without correction—once again when corrected for temperature.

* See Introduction.

OBSERVATIONS MADE AT LONG. , LAT. ALT., , DURING THE MONTH OF

N. B.—In the Register retained, the Barometrical Observations should be entered as read without correction, and corrected only in the Return forwarded. Unless the Barometer be perfectly trustworthy, and due attention can be given to accurate reading, and particularly as to time, the Pressure observations are of little value. The positions and description of the instrument, ought to be given in each return. If the whole of those wanted cannot be made, any set that may be deemed best may be selected, and the same ought to be strictly abided by.

Days of the Month.	Observations made at Sunrise.					Maximum Pressure Observed at 10 A. M.					Minimum Pressure Observed at 4 P. M.					Observations made at Sunset.					Observations made at 10 P. M.					Max. and Min. Therm.			Max. Therm in Sun's Rays.	Rain Gauge: Elevation.		Moon's Phases.	Remarks.*
		Temp.			Wind.		Temp.			Wind.		Temp.			Wind.		Temp.			Wind.		Temp			Wind.								
	Barometer.	Of the Mercury.	Of the Air.	Of Wet Bulb.	Direction at Sunrise.	Barometer.	Of the Mercury.	Of the Air	Of Wet Bulb.	Direction at 10 A. M.	Barometer.	Of the Mercury.	Of the Air.	Of Wet Bulb.	Direction at 4 P. M.	Barometer.	Of the Mercury.	Of the Air.	Of Wet Bulb.	Direction at Sunset.	Barometer.	Of the Mercury.	Of the Air.	Of Wet Bulb.	Direction at 10 P. M.	Maximum.	Mean.	Minimum.	Maximum.	Feet. In.	Feet. In.		
1																																	
2																																	
3																																	
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* It is most important to make remarks as full and minute as possible. They are, if copious, quite as valuable as the most extensive instrumental observations, which without remarks are comparatively valueless.

The corrected readings are forwarded monthly to the Society—the schedules for these are printed on thin post paper, nearly uniform with the register book. This last is forwarded or extracted at the end of each year if required—or kept till filled.

The following is the form in which the Aden and Kurrachee registers have been kept: they are meant as models for all observatories where hourly observations every day are impossible. The barometric observations give the true turning points and range of the Barometer every day—the morning barostice occurring at an hour so inconvenient for observation, that it is rarely procurable: the hourly observations for the 22nd, or, better still, for the 1st, 8th, 15th, and 22nd, of each month, give the barometric curve entire. They ought to be commenced at 4 A. M., the morning barostice: during all periods of disturbances the barometer should be read every hour or half hour till tranquillity be restored.

PRESSURE.—Hourly Readings of the Barometer at the Observatory, Seera Island, Aden, Lat. 12° 46′ 26″ *N., Long.* 45° 15′ *E., corrected to* 32° *Fahrenheit, for the* 1st, 8th, 15th, *and* 22nd, JANUARY, 185 , *commencing at* 4 A. M., *or the hour next the morning minimum, as the beginning of the Barometric day.—Elevation of the Barometer,* 187 *feet above High-water-mark.*

DATE.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII	IX.	X.	XI.	XII.	I.	II	III	IV.	MEANS.
MEANS.																										

BAROMETER Corrected for Expansion of Mercury and Brass, 32° *Fahr.—for the Month of* JANUARY, 1850.*—Turning-points*

Date	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	DAILY
Jan.	3·30	4·00	4·30	9·30	0.00	10·30	3·30	4·00	4.30	9·30	10·00	10·30	MEANS.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in	in.	in.	in.
MONTHLY MEANS.													

HYDROGRAPHY.

BY CAPTAIN F. W. BEECHEY, R. N.

[From the Admiralty Manual.]

MAKING A PASSAGE.

THE observer's attention is directed first to those objects which affect the passage of a vessel from one part of the globe to another; such as the movement, the duration, the limits, and the periodic occurrences of those great currents of the atmosphere and of the ocean, upon which the speedy and successful issue of a passage mainly depends.

Well recorded and established facts bearing upon the several points connected with these inquiries are highly important to navigation, and may be collected by every assiduous seaman in the ordinary course of his duties.

1. It is well known that in various parts of the globe there exist monsoons, and zones of trade and variable winds; and that these and other disturbances of the atmosphere which influence the surface of the ocean are the principal causes of the many currents which sweep over the face of the earth. The effect of these upon a vessel passing to and fro is one of the most useful inquiries a seaman can make; and as both (wind and current) perform an important part in the economy of nature, an additional interest attaches to a correct knowledge of them. The seaman should therefore not only carefully note the direction and force of the winds, but should connect with such entries notices as to when and where any continued or periodic wind commenced and terminated; what was its strength and effect upon the passage; whether it came on suddenly, and was furious while it lasted, or otherwise; whether it was preceded by any particular symptoms, and whether it was such as usually occurs at that season; and lastly, whether it be advisable to cross this wind in any particular direction, such as close hauled or large, &c.

2. To detect the current, a more than ordinary attention must be paid to the reckoning of the ship: the compass by which the course is steered should occasionally be compared with that by which the variation is determined, in every position of the ship's head; and the ship's place should be determined by observation at least once a day Sights for chronometer morning and evening should both be referred to noon, at which time the latitude will of course be observed; and all observations for latitude at night, or for fixing the ship's place at any time, should be referred to *one* period of the day, in order that the position of the ship *by observation*, as compared with her place by the *Dead*

Reckoning, may give the direction and force of the current, if any, for the twenty-four hours. These observations should all be entered in a table, and at the close of certain obvious and natural periods of a passage, such as that of entering or emerging from the trade wind, the calm latitudes, the commencement or termination of the monsoon, of any positive change of current, or from any continued state of things to another, the whole effect of the current for the period should be deduced, and an average of its daily rate and set be given, together with any remarks which may be considered useful.

3. With the direction of the current thus determined, it is very desirable to connect the temperature of the surface of the sea, for it has been by such observations that we have been able to trace, with a certainty amounting almost to proof, the continuous course of the same body of water for thousands of miles over the troubled surface of the ocean, and that other curious and important facts in physical hydrography have been ascertained. We would therefore urge attention to the subject as one of considerable importance to navigation. As a proof of its influence upon a passage, we need only instance the remarkable phenomenon of the Equatorial and Guinea currents: two streams in contact, but flowing in opposite directions, and having a temperature differing 10 or 12 degrees from each other, and yet pursuing their opposite courses for upwards of a thousand miles; and according as a vessel is placed in one or the other of these currents, will her progress be aided or retarded from 40 to 50 miles a day.*

Could we but obtain a register of the temperature of the surface of the sea from every ship in active service, we should be able in a short time to construct tables showing the normal temperature of the surface of the ocean for every 5° of latitude for every month in the year, and a comparison of these with the actual temperature of the surface at any particular spot, and in any particular month, would at once manifest an abnormal difference, if any existed, and lead to a knowledge of its cause, which might prove of considerable use to the mariner by acquainting him with the movement of the great body of water in which he was sailing; either retarding or accelerating his progress as the case might be, and at all events affecting his reckoning. Or it might lead to a closer determination of the limits and periodical changes of currents which, as before observed, are everywhere running over the surface of the sea as rivers run over dry land.

It is therefore recommended to add to the table of currents a column for the temperature of the open air, and another for that of the surface of the sea, which should be registered frequently during the twenty-four hours; but as such observations form an essential feature in the meteorological register of a voyage, they should be made at the times and in the manner indicated under the head of Meteorology.†

4. There should also be noted in the Remark column the occurrence of masses of sea-weed, or of any continued appearance even of small patches of this or of any other floating substances which may be seen; and if opportunity offers, deep-sea

* Sabine's 'Hydrographical Notices.'

† If passing Cape Horn, or through seas where icebergs may be moving about, these observations cannot be made too frequently in thick weather, especially as a precaution, for the water appears to be influenced to a considerable distance around these masses, particularly in their wake.

soundings should be tried at the spot. "It were much to be wished," says Humboldt, 'Person. Nar.' vol. ii. p. 11, "that navigators heaved the lead more frequently in these latitudes covered with weeds, for it is asserted that Dutch pilots have found a series of shoals extending from the banks of Newfoundland to the coast of Scotland, by using lines composed of silk thread." Flocks of birds should also be noted. In many places, the Pacific especially, the tern are useful monitors of an approach to those low specks of coral which endanger the path of the navigator through the labyrinth of the great South Sea. In short, everything that may seem to the voyager to be interesting or new, or likely to be useful, should find a place in the Remark column.*

At the end of the passage, a summary of these remarks should be given, the whole effect of the current for each particular portion of the passage recapitulated, such as that which was due to the N. E. or S. E. trade-wind, or to the monsoon, as the case might be, and distinguishing each; that which occurred in the calm latitudes or during a period of variable winds, or otherwise, averaging the daily rates; and then might follow any remarks you may wish to make either upon them or upon any other feature of the passage; together with any directions or hints which might be considered useful to those who should follow over the same ground; such as whether any advantage would have been gained by steering more to the east or west, or in any other direction; whether any time would have been saved by making the land on any other bearing than that in which you hit upon it; and in short any remarks which would be instrumental in conveying to others information which you would have wished to possess yourself at the outset of the passage.

CURRENTS.

5. It is very desirable that observations upon the course of the waters of the ocean should be made without intermission; and that *a continued register* of the temperature of the surface, and occasionally of its submerged strata,† should be kept, as it is only by numerous well-recorded observations of this nature that we shall ever be able satisfactorily to define the limits of the various zones of moving water which sweep over the face of the globe, mingling the waters of the Polar Seas with those of the equatorial regions, and even affecting the climate of extensive districts.‡ But if from various causes a connected series cannot be continued throughout these great currents, at least an endeavour should be made to commence a register on approaching the limits of such as are now approximately defined, and to continue it while any interest appears to attach to the subject: such as that of the Gulf-stream; the trade-wind drift; the Guinea and Equatorial current; the Cape of Good Hope current, blending with the south-east trade drift; and the Brazil current—in the Atlantic; the Mozambique and Agulhas current; the Trade drift; and monsoon current of the Arabian and Bengal gulfs—in the Indian Ocean. The remarkable Peruvian current sweeping along the western coast of South America; the

* For the form in which these observations may be tabulated, see Appendix, Table I.

† By means of self-registering thermometers, properly set and carefully lowered and as carefully hauled in (without jerks.)

‡ See Humboldt on the Climate of Peru; Sabine on the Climate of St. Thomas's Island, &c.

Trade drift, and Equatorial current; the Mexican current, passing along from Panama to the Gulf of California, according to the monsoon. The counter-currents north and south of these, and the moving belt along the coast of Japan and Corea to Kamtchatka—in the great Pacific Ocean; particularly noting, as of great importance to navigation, the limits of the outer currents around the Cape of Good Hope and Cape Horn, all of which will be found on a small scale delineated in a general chart at the end of this paper.

Some of these currents maintain a constant difference of several degrees between their own temperature and that of the mean state of the water about them, and all observations which can throw light upon this subject, and upon the limits, course, and velocity, of the stream, will be most acceptable.

6. In passing through any of these great currents, the observer should carefully define the extent of the belt of moving water at the parallel in which he crossed it; the limit of the eddy on either side of it; determine the rate and set of both; carefully note every barometrical or thermometrical change of the air, or alteration in the temperature or specific gravity of the sea, and if possible the depths to which these temperatures extend; and record all appearances and changes which may appear of interest or seem to be useful to those who may follow over the same ground.

To detect the motion of the stream the remarks in Art. 2 should be attended to, with the exception that here the position of the ship should be *frequently* ascertained during the day by astronomical observation, and the course and rate of the current deduced for *short intervals* of time instead of for the twenty-four hours. The observations should commence previous to entering the body of moving water, and be continued until after the vessel has quitted it, when it will be advisable to occupy a page of the journal with a graphic delineation of the several courses of the stream, indicated by arrows, and of the several stages of the vessel's progress by the *various* temperatures which have been observed, noting the places where ripples were seen, or where drift-wood, sea-weed, or other floating substances, occurred.

THE STREAM OR SURFACE DRIFT.

7. Currents have been spoken of under the head of "making a passage," as they affect a ship's route across the ocean, and may have been determined by the position of the ship by DR differing from that by observation. But it will be proper further to *try the set of the surface* of the water on all favourable occasions, by the ordinary method of anchoring, or of sinking a weight, endeavouring if possible to get observations on the same day at about six hours apart, in order that it may be seen whether the stream be due to a tide or not. If the ship be in soundings, and the day be calm, a very simple way of effecting this without the trouble of either anchoring or lowering a boat,* is to drop a heavy lead from the quarter, and after it has reached the bottom, to run out a small quantity of stray line, and then make fast the "nipper," or a billet of wood, to the line; and at the same time to fasten the end of the log line to it, and veer away both together.† Then mark by a watch the time *each knot* is in running out,

* An objection to trying the current in a boat, is the uncertainty of the compass.

† If the lead-line be not hitched to the nipper, the tide may drag the line through it, and there will be no result.

buoying up the line by a chip of wood; when all the line has run out, take the bearing of the nipper by a compass, and haul all in together. If currents be tried when there are no soundings, the result is merely the relative motions of the upper and lower strata of the water, and it would be difficult to say which way either were going; but if we can possibly determine by astronomical observations the course of the *upper* surface, we shall thence be able to deduce the set of the *lower;* and if there be found any difference of moment, it will be very desirable to ascertain the temperature of both upper and lower strata of the water, and to record them with the other observations. These observations ought always to be made on calm days, and the greater the depth to whichs the weight be sunk, the better. Bottles thrown overboard with alabel inside, containing the date and lat. and long. of the spot where cast into the sea, afford ready means of detecting the current if picked up afterwards, and ships would do well frequently to expend a few empty bottles in this way.* In the event of meeting any such drifting at sea, they should be picked up, their contents copied, and the date and position of the spot added to the label and carefully resealed: they should then be returned to the ocean, and a copy of the label forwarded to the hydrographer.

8. If near to any shore, a few points of which are well fixed, and the water be found too deep for anchorage, the course of the stream may still be ascertained by noting the drift of a float—a plank, for instance, weighted at one end, so that the other just floats above the surface; or a weighted *bareca*,—fixing its position from time to time by angles taken in a boat at the several places, and noting the intervals by a watch.

Such methods may of course be resorted to when circumstances do not admit of greater accuracy, but whenever it can be done, the course and rate of the stream should be observed *every hour* during *both* tides, and the times of slack water carefully noted, by anchoring a boat or vessel. Upon an open coast one set of such observations made here and there, well clear of the headlands, will be sufficient; but in channels and straits in which the tide enters at both extremities, the tidal phenomena are so varied and full of interest, that it becomes highly important to spread the observations over as large an extent of the channel as possible, and to pursue a regular system of hourly observation throughout both the *ingoing* and *outgoing* streams.

It is desirable to know at each place the time of slack water, the direction in which the stream turns, and the rate and course at which it runs during its several stages. The stations should be numbered, and the times all referred to one meridian. In such channels there will probably be one or more places where the streams meet, and there of course observations will be made; and as one of these places will probably be the *virtual head of the tide wave*, it may so happen that the time of the high and low water there *by the shore* will govern the turn of the stream either along the whole channel or until it reaches a spot where another meeting of the streams occurs. In such a channel also it will probably be found (as in the Irish Channel) that the same stream makes high water at one end and low water at the other at *the same time;* so that the observer must entriely divest his mind of the too often mistaken notion of the turn of the stream

* The bottles, before sealed, should be ballasted with a little dry sand, consolidated at the bottom with bees'-wax or pitch run in, that the bottle may be kept upright and not swim too light.

being governed by the rise and fall of the water in its immediate locality. As our space does not admit of further detail, I shall leave the subject in the hands of the observer, with a remark which, whilst it will put him in possession of what kind of observations are required, will at the same time I think insure his interest in the subject and his hearty desire to co-operate in the matter.

In the 'Philosophical Transactions, 1848,' Part I., it has been shown that in such a channel as that abovementioned there have been discovered two remarkable spots, in one of which the stream runs with considerable velocity without there being any material rise or fall of the water by the shore, and in the other that the water rises and falls considerably without there being any apparent motion of the stream. Such phenomena are highly curious, and worthy of all the attention that can be bestowed upon the observations. In tracing them, it is manifest that they are intimately connected with the height and progress of the tide wave along the shores of the channel, but this properly belongs to another section (see *Tides*.)

9. Passing the mouths of great rivers—such as the Amazon, the river Plata, Orinoco, Mississippi, Zaire, Senegal, Indus, Ganges, Yangtsee, or Irawady, &c. &c.—observations on the stream should be more closely made, and discolorations and specific gravity of the water noted.

These and such like stupendous rivers extend their influence to a considerable distance from the coast,* and occasionally perplex and delay the navigator, who finds himself struggling against a difficulty, wholly unconscious of the cause and ignorant of the facility with which he might escape it by changing his route.† River currents of this description vary their direction according to the courses of the stream along the coast, by blending with it, and forming a curve, which vanishes only with their influence upon the ocean current; so that we are not always to look for the outset from the river at a right angle to the coast, nor always in the same locality, but according to the prevailing offing stream.

The limits of the principal currents of the globe have been given in order to apprize the navigator of the places in which he should more closely attend to his observations. If, however, from any cause he may have been prevented continuing the series throughout ny of the great currents, and should desire to define their limits, he should begin at east a day's run from the places, aud continue his register until he is certain of having passed the boundaries, attending closely to the temperatures; for although limits have been assigned to these belts of moving water, yet they vary so much acccording to season, and the data for defining them have hitherto been so insufficient, that it cannot be said they are known with any tolerable degree of precision.

In the China Sea and among the islands of the great Indian Archipelago, the tides run strong and are very indifferently known, and observations are especially desired at those places.

In the southern passages it would be well to try during the westerly monsoon, whether the equatorial current may not be found pursuing a subaqueous course to the westward, notwithstanding the surface current be found running in the opposite direction.

Upon the east coast of North America, between the Gulf-stream and the coast, observations upon the set of the stream are also muchwanted.

* The River Plata, at a distance of 600 miles from the mouth of the river, was found to maintain a rate of a mile an hour; and the Amazon, at 300 miles from the entrance, was found running nearly three miles per hour, its original direction being but little altered, and its water nearly fresh.—*Rennell, Sabine.*

† See the effect of the Equatorial and Guinea current before-mentioned, at p. 126.

APPROACHING A COAST.

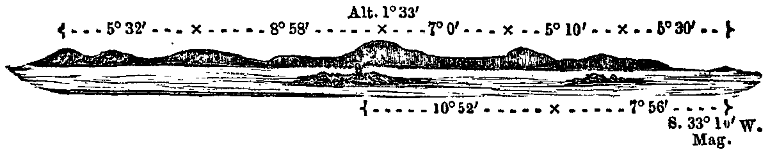
10. When approaching a coast or any extensive banks in the ocean, the temperature of the surface of the sea should be more closely attended to, for it has been found in many instances that after a certain shoaling of the water, the surface partakes of the temperature of the lower strata of the sea, which are in general colder than the upper. If such should be found to be the case always, and if from well-authenticated facts it should become possible to fix zones of certain temperatures about particular localities, the result would be highly useful to the navigator when out in his reckoning and perplexed with thick and hazy weather.

11. Hydrography requires that the general feature and aspect of every country should be noted from the moment the hills rise above the horizon; that all remarkable objects by which it may be recognised, and by which the position of any port or other locality may be known, either at a distance when the weather is clear, or close in when haze or mist prevails, should be described as graphically as possible; that the extent, direction, and outline of the coast; its capabilities of affording shelter to shipping; its dangers, or freedom from them; its navigable rivers, harbours, and inlets; and the objects adverted to under *Sailing Directions*,—should be fully and carefully recorded; and here it is difficult to avoid infringing upon what properly belongs to *geography*. The two sciences are indeed here so nearly allied, that it is scarcely possible to avoid encroaching upon the province of the sister branch. The observer will, however, do well to describe or delineate the character of the country as far as he can become acquainted with it; the form and elevation of such hills as are visible from the coast; the direction of the valleys and ravines; and to mark the places where they pour their mountain-torrents into the sea; to portray the bold topping cliffs, or low rocky promontories and their reefs; the jutting headlands or deep sinuosities; or the low undulating country with its lagging streams and muddy or sandy fringe of coast; its shallows, bars, and deltas, each as the case may be; with its lighthouses, beacons, buoys, and landmarks, stating the distance at which they may severally be seen; with even the forts, towers, churches, and silvery little clusters of cottages upon the inland elevations; with such other varied features as the coast may present, and as may serve to convey a just idea of what may be expected to meet the eye of the navigator, or be required to keep him clear of danger, and to guide him in safety to his place of destination.

At a distance there is generally some object more remarkable than another which may be singled out as a useful landmark. Note what it is, describe its appearance, and state in what direction the port, or any danger that may lie off the coast, bears from it.

Should the coast be low, buildings will possibly be seen first: large square houses or towers, church-spires, &c.; any of these afford useful guides. Some localities may be distinguished in hazy weather by *patches of white* near the coast, such as masses of sand, chalk cliffs, &c., or one or more large white houses; and these, when viewed against the land or other dark objects, will occasionally afford excellent guides when all other objects are obscured, and at such times are doubly useful. But avoid as marks all *white* objects which have only the sky for a back-ground; such objects are seen only when the sun shines upon the surface presented to the observer, but utterly fail in *hazy* weather, when they are wanted.

Always bear in mind that no description can equal a tolerably faithful sketch, accompanied by bearings. In all your sketches take angles roughly, with a sextant between objects at the extremities of your drawing, and two or more intermediate ones, and affix them to the objects at the moment, and have at least one angular height in the picture; et that be of the highest and most conspicuous or best defined object; thus—



and let your bearing refer to one of the objects between which you have measured angles. Always write under the sketch at the time the name of the place, and especially the native name if you can possibly learn it, and the date; and if you intend any of the objects for leading marks, place an arrow at the head of a perpendicular line above and below the objects; thus—

Lighthouse in one with East Peak of Mount Auckland, clears reefs in 4 fathoms, and kept open (S. by E.), leads through the passage, mid channel.

12. Besides marks which are apparent to the eye, the depth of the water and the nature of the bottom are all important, and in all descriptions of a coast, as well as in directions for approaching it, these are to be carefully attended to. State as nearly as possible the distances at which certain zones of soundings extend from the shore, and from what part; whether the bottom shelves gradually or abruptly, whether the coast may be boldly approached, or more than ordinary caution be necessary; and whether any peculiarity of the bottom may assist in determining a ship's position or distance from the coast at night, or in thick weather. Always give your depths reduced to low-water spring-tides if possible,* and always give *the least water* upon a reef or shoal; and if it dries, state what water there is over it at high-water springs, and at what time of the tide it becomes dry.

13. When nearing a coast, and at all times when at a *greater distance from the shore in miles than the amount of dip in minutes due to the height of your eye*, the height of mountains, or of other objects, may be determined with considerable accuracy if the weather be clear, and proper precautions be taken. To do this, if the distance of the object be not known, it must be found by measuring a base with the patent log. There are various methods given in navigation-books for determining this problem; I shall therefore here merely describe the observations required to be made. At each end of the base measure carefully with a sextant the altitude of the object *off and on;* and if one of Cary's double sextants be on board, measure the terrestrial refraction by bringing the opposite horizons in contact with the arc both above and below the index, and then reading off each time, divide the difference by 4: this will give the dip and terrestrial refraction combined, which is the proper quantity to be allowed in correcting the observed angle.†

In Raper's 'Navigation,' p. 90, 2nd edition, the method of determining a ship's distance from an object by two bearings is briefly explained; and in Belcher's 'Surveying' it is set forth in a manner so clear and ample as to leave nothing to be desired: I shall therefore merely observe here, that according to the accuracy of the observations and the value of the

* See page 136, Art. 24.

† If the terrestrial refraction alone be required, take from this quantity the true dip due to the height of the eye, and the remainder is the terrestrial refraction required.

means adopted, will be the correctness of the result. It is clear that the *true* earing of the object at *each* station should be observed; that the course steered shoul , if possible, be equally well known; (this is effected in the best manner by observing the magnetic bearing of the object with the compass which directs the base, or that which is to be steered by in-running the base; *at the same time that its true bearing is observed;*) that the distance run should be determined by patent log; that the ship *should be on her course at starting when the bearings are observed;* and that the log should be put over and hauled in at the *instant of making* the observations. If the ship should of necessity alter her course during the operation, it should be carefully noted, the log looked at, and fresh bearings of the objects taken.

Two observers are necessary to accomplish these observations nicely, and without hurry.

With these data the height of the object may be found with considerable accuracy,* especially if the dip-sector be used. Having determined the height of a mountain, you may often find it useful to know your distance from it when cruising off the coast; and it will also afford amusement and practice to see how near you can fix the ship by it, as compared with cross-bearings or other observations. For this purpose it will be convenient to make a constant for the height.†

LIGHTHOUSES.

14. If lighthouses are erected upon the coast, describe exactly their locality, geographical position, appearance, height of the lantern above mean water-level, height of the tower, whether the light be fixed or revolving, intermittent, coloured, or otherwise; the distance which it may be seen, and the bearings on which the light is visible. If the light be made use of for the purpose of avoiding any danger, state what the danger is, give its bearing from the lighthouse, and if the light be blinked or changed for this or any other purpose, state what it is, and give the exact bearing on which the change takes place.

If there be a *lower light* in the tower for this, or any purpose of tide work, state as before the bearing on which it opens and obscures, or the times of tide when it is exhibited and extinguished, and how many feet it is below the upper light. State whether pilots are required for the port, and where they are likely to be met with, and the rate of pilotage.

IN PORT.

15. When at anchor, give the depth of the water, nature of the ground, and whether any precautions are necessary, with respect to protecting the cables if hempen, and whether it be proper to moor in consequence of the difficulty of keeping a clear anchor, or from the treacherous holding or sloping of the ground. Fix the spot by cross-bearings of conspicuous and well-known objects, and note the direction and rate of the tide, and the duration of both ebb and flood stream.

16. The geographical position of a port will necessarily occupy the attention of the persons in whose hands these remarks may be placed, and by assiduity much may be done in a short time with a sextant and artificial horizon only. But if to these be added a transit and a good achromatic telescope, the longitude by occultations, moon-culminating stars, and eclipses of Jupiter's satellites, will form a valuable addition to that by observations of lunar distances with the sextant.

The earliest opportunity should be taken of determining the error of the chronometers

* See Appendix No. 2. † See Adpendix No. 3.

upon mean time at the place, by morning and evening sights, or by *equal altitudes*, which is better. Chronometers will sometimes change their rates on the transition from a passage in which they have been constantly in motion to a state of rest. Besides which, early sights afford a longer interval for rating the watches again.

SURVEY OF A PORT.

17. A survey of the port and description of the anchorage will always be desirable if carefully made. If former surveys have been executed, it will afford a useful comparison, and detect alterations of the banks and channels, and the silting up of the port if any. If they have not, such a survey will be doubly useful, and the industrious observer will find very few plans of ports to which he may not usefully add a few soundings or explanatory remarks.

It is not intended in this manual to enter much into the manner of executing a survey, as there are several treatises on the subject, which contain the necessary information; but these works may possibly not be on board, and as "golden opportunities" of acquiring a knowledge of distant ports may thus be lost, from the want of knowing how to construct a rough survey of a place, by persons who probably never contemplated the performance of such an undertaking, it may be useful to describe as briefly as possible the process. Make choice of two stations at as great a distance apart as the survey will admit of, and from which the eye can see over a considerable portion of the ground to be mapped. Put up marks or select objects at all convenient places around the survey, so as to be able to form a network of triangles over the whole space, and include every conspicuous feature around, such as hills, cliffs, rocks, and especially objects at, or near, high-watermark.

18. Having decided upon these marks, a base may be measured on shore if there be a convenient spot at hand; but it would be useless to devote much time to this purpose, for the survey of a port in general does not so much require that the absolute distances between places should be *accurately* known, as that the *angles should be carefully observed*, and therefore the relative distances preserved. If it be necessary to measure a short base of a quarter or half a mile, and the ground be uneven plant staves (boarding-pikes) in the line to be measured, and stretch the lead line along from pike to pike in the direction of the wire of the theodolite when levelled; and measure along the line with a tape, or with rods; then shift the pikes and line on, until the required distance has been measured, the length of which should not be less than 1-7th of the distance between the objects, the distance of which is required.

If a micrometer be on board, a very fair base may be obtained with it,* or even with a sextant, by measuring the angle subtended by a staff placed at right angles to the observer, and the distance carefully measured between two well-defined marks, one at either end of the staff (such as the clean edge of a sheet of white paper wrapped round each end): the best way of ensuring the staff being at right angles nearly, is to place it upright by a plumbline. Then treating the figure as a right angled triangle, the staff will be the perpendicular, and the base the distance between your eye and the station, which may be readily computed, as all the angles and a side are known; but if a micrometer be used, the distance is that between the staff and the *object-glass* of the telescope. If neither of these methods be adopted, or if the field of operations be very extensive, a base by sound, though much less accurate, may be found convenient.

* See the Book of Tables and Directions supplied with an instrument of this kind, by Rochon.

19. The measurement of a base by sound, if several trials are made, and the distance be more than a mile, will, in most cases, be sufficiently exact for the above purposes. If possible land a swivel or small gun upon one of your stations, and go yourself to the other, the more distant the better. Appoint a signal to be shown half or a quarter of a minute before each explosion, in order that the eye may rest between. When the signal is made begin to note the beats,* but not to count until you see the explosion, and then let the next beat be one, and so count up until you hear the report. Let this be done several times, and at the end mean the beats, and turn them into seconds of time by the number of strokes your watch makes in a minute. Then, by multiplying this number of seconds by 1090, and adding *one foot* for *every two degrees* of the thermometer *above freezing-point*, you will obtain the length of the base in feet.

To give *a direction* to the base, the readiest way is to observe the passage of the sun's limbs over the wires of the theodolite nicely levelled, and to note the time by a watch, or to take corresponding altitudes, in order to compute the azimuth. If you have only a sextant, astronomical bearing will be found convenient and sufficiently correct, provided the horizon can be seen at a sufficient distance. By either of these methods the angle between the base and the limb of the sun will be known, and hence the true bearing of the object obtained; or if the magnetic bearing of the object be observed by an azimuth compass, and the variation be determined at the same time, it will still be known near enough for the common purposes of navigation. Having arranged the direction and length of the base, measure angles between the base and all the stations, taking care that the angles (if measured with a sextant) are as nearly as possible parallel with the horizon, and at all other convenient stations do the same. By this means the relative position of all the stations will be obtained, from any *three* of which the position of another, or of a boat for instance, may be determined by measuring two contiguous angles between them with a sextant. But whenever you have occasion to do this (and in sounding there is no more convenient method of fixing the place of the boat), be careful not to select stations which lie in a curve *concave towards you*, since cases will often arise when stations so situated will give very inaccurate results.

20. While operations on shore are going forward, boats can be sounding out the harbour, and fixing the points of reefs, rocks, &c., bearing in mind that it will always be found more satisfactory to land upon every rock or point, &c., than to lie off in the boat, and fix them by estimated distances or by intersections, either from these or from other stations.

In sounding, fix the boat at starting by two sextant angles; note the direction in which it is intented to run out the line of soundings, and note any two objects distant from each other, that are *in a line* upon that bearing, or if the port be not too extensive make use of staves with flags—shifting them along the coast at the end of each line of soundings the exact distance it is intended to run them apart—the boat showing a signal when the flags are to move; then keep the marks on, and sound at regular intervals 6, 5, 4, 3, 2, or fewer casts in a minute according to the depth; and at given short intervals note the time and fix the position of the boat by two angles as before mentioned,† as also whenever there is any material alteration in the depth, or whenever the number of casts alters in a given time. When arrived at the end of the line, fix the boat's position, and alter the course, sounding

* The stop-watch by Mr. Dent is very convenient for the purpose.

† See the form in Appendix for entering these angles and soundings, No. 4.

all the time until far enough for running back the second line of soundings parallel with the first. Fix the boat's station here again, and take a new leading mark. If the eye cannot catch a leading object at the moment, drop the grapnel to maintain the spot, for much more time is lost by over-running the lines than by coolly waiting for a guide to direct the course. Proceed in this manner, running all the soundings in parallel lines or nearly so, until the anchorage is all sounded out.

Having mapped all that is intended to be comprised in the survey, protract the work carefully on board upon a sheet of drawing paper. Draw in the coast line, rocks, shoals, hills, &c., and every other feature from your rough, attending to the hydrographic method of delineation represented.

21. The soundings follow next, when reduced to the low water standard of the port by the tide gauge.* If there be no station pointer on board, protract the angles upon a piece of transparent paper, and mark the station with their proper number. If the soundings have been taken equally, divide the spaces between the Δ's in as many parts as there are casts, and fill in the corrected soundings in the order in which they occur. All soundings which may have been taken when the tide was up and by reduction to low water, are *dry: draw a line under.* In every chart-box in the service will be found the abbreviations adopted in Admiralty Charts; these are to be strictly followed.

Lastly, put a meridian line and scale to the plan. Insert the variation, geographical position, time of H. W. F. and C., the low-water standard, *to which the soundings are reduced,* and the range at springs and at neaps; note the duration of the ebb and flood, both by the shore and by the stream; draw leading marks and put in views, heights of mountains, &c.

If time does not permit of a regular survey being executed, still a useful record may be made by an itinerant survey, or even an eye sketch, assisted by sextant angles, a few soundings judiciously taken, the true bearing of one object, and the measurement of a base by sound, or with a Rochon micrometer as before-mentioned.

SAILING DIRECTIONS.

22. Whenever a survey is executed, *sailing directions* should accompany it, and too much care cannot be bestowed upon this important part of a surveyor's duty.

They should contain a description of the coast (see Art. 11); directions for making the land; for approaching, and sailing into or out of the port both by daylight and with the aid of marks, and also by night or in thick weather, when the lead and the lighthouse, if there be one, must be the seaman's principal guide. How a vessel is to proceed with a leading or a beating wind, and with or against the tide—how far she may stand on either tack—what water she may expect to find at low-water springs—and how she may ascertain the depth by calculation on any other day—within what limits a vessel may safely steer in bad weather and when no pilot is on board—where the best anchorage lies, the depth in which a vessel should anchor, and directions for bringing up. With other particulars which have been mentioned under the heads of approaching a port, especially noting all beacons, buoys, lighthouses, and landmarks, &c. (*see Art.* 11.)

Affix to these, views of the land and sketches of the leading marks. The geographical position, the time of H. W. F. and C., rise at springs and neaps, the low

* See *Art.* 24.

water standard of the port, &c., and the variation of the compass, point out the best watering-places, and let all bearings given be *magnetic*, and noted as such.

Port regulations and quarantine laws will not be misplaced at the end of these directions.

TIDE POLE.

23. When a survey is determined upon, a tide-gauge should be set up, and from *half an hour before to half an hour after every high and low water* the place of the tide should be registered *every ten minutes.** In addition to this, *whilst the sounding of the port is in progress*, the place of the water must be noted every half-hour to facilitate the reduction of the soundings to the low water standard. The tide gauge should be fixed in a well-sheltered spot, with its zero such a depth as to ensure its being below the low water at springs. When the pole is properly secured and settled down, paint a mark in the rock corresponding with one of the divisions on the gauge, and *note which* in your book, in case the pole should be washed down. If you remain long enough in port, let your observations be continued at least through an entire lunar month. When you come away, mean the high and low water heights of each day, and take a mean of them again for the *mean place of the water*, and cut *a mark in the rock corresponding with that mean level of the sea before you remove the pole*. As this is the true scientific level of reference in all matters relative to the tides, refer this level again to some mark in a contiguous building, that a reference may at any time be made to it, by persons who might not be able to find the rock.

Let the watch be always at *mean time* at the place. The high and low water observations should be continued night and day with equal carefulness in order to determine the amount of diurnal tide ; and every observation should be recorded, although it may not seem to agree with the others.

If tides are taken at coral islands, or at stations within a belt of coral, it should always be noted in the journal whether the sea or land breeze be blowing and with what strength, and also whether the surf be high upon the reefs and sending its water into the lagoon, filling it faster than it can escape.

In the Appendix will be found two forms, one of which (No. 8) is for registering the tides every half hour, the other (No. 7) is for the high and low water only.

For further information upon *the tides*, see that section.

SOUNDINGS.

24. Before any soundings are inserted in the chart they should be reduced to *a standard* obtained by meaning the three or four successive lowest waters of each spring-tide, and meaning them again for a general mean. This standard should be noted in a very conspicuous and *unmistakeable* manner as being so many feet below the mean water level, and recorded as the *low water standard of the port.* It is a quantity which would nearly correspond with half the range of an *ordinary spring* tide, a term often written without any direct reference to the low water standard, and so ambiguous that it is to be hoped it will soon disappear from the face of our charts. With this standard, and the known daily height of the tide above mean water level, soundings taken at any hour may be prepared for comparison with the depths upon the chart by the simple formula

* See Forms, Nos. 7 and 8.

$$R + r.\ \text{cosine}\left(\frac{t}{D}\,.\,180^\circ\right)$$

Where R = the low water standard to which the chart is adapted.
r = the height of tide for the day above mean water level.
D = the duration of the tide.
t = the time from high water previous.

Or, enter the traverse table with the time from the nearest high water as *a course* (allowing 5° of arc to every 10 minutes of time), and with r = (half the range of tide for the day) as a *distance;* in the *latitude column* will stand a quantity which applied to the *low water standard of the port* + or —, according as the arc is *less* or *greater* than 90°, will give the reduction required. If the arc exceeds 90° take its supplement. But it is to be observed that all these corrections, although preferable to the old method of reducing soundings, are but approximations. In many places, especially in such as have great tides, it is necessary to distinguish between *rising* and *falling.*

If in a country subject to earthquakes, carefully watch the tide-pole during and after the shock, and if any undulations of the water are observed, note them, and the direction whence they proceed.

Be careful never to place the tide-pole at the mouth of a river, and especially guard against having it within *a bar*, sand-bank, or any such impediment to the free action of the water.

THE BORE.

25. If any place should be visited by that peculiar phenomenon, the bore, a wave which in some places comes rolling in with the first of the flood, with a crest foaming and rushing onward, threatening destruction to boats and even to shipping; note the time of the tide at which it begins, whether there be *one wave* only or more, the height to which it rises, and *where it first* appears with respect to any alteration in the feature of the river; and especially note the situation and extent of shoals at or below the spot. The bore is said to occur only at spring tides; note particularly whether this observation be correct.*

FRESHES.

26. Connected with the rise and fall of the water is that periodical elevation of the surface of rivers by "freshes," occasioned by heavy and continued rains in the interior of the country. These torrents not only raise the general level of *the river*, properly so called, but where a bar exists, also raise the level there, so that vessels which cannot enter during the dry season are at such times able to pass over the bar. The time when the water begins to rise, when it attains its maximum, when it begins to subside and regains its mean or ordinary level, should be carefully noted, and with it the elevation of the water in feet, both in its ascent and descent.

DISCOVERY OF LAND.

27. On the discovery of any unknown lands or dangers, the first endeavour, after the vessel is placed in safety, should be to fix the position of the place as accurately

* The remark made in "How to observe [p. 35], "that either rocks or shoals, or great depth of water secure a river from the inconvenience of the bore," is not always correct; or the Severn is incumbered with shoals, and has a bore which has proved destructive to vessels grounded upon the sands.

as the means of observation admit, and not to quit the spot until the danger is satisfactorily placed upon the chart.* Describe it as accurately as you can; determine its extent, height, and configuration; the adjacent soundings, and the quality of the ground; and give a sketch of its outline. If it be extensive, a running survey will be desirable.† If it be within sight of other land, its position must be fixed by bearings or angles between known points of the coast, and some conspicuous objects upon the land selected, which being *brought in a line* will lead ships clear of the danger. Do this for *both sides*, and give correct bearings of the transits, and, if possible, sketches of the objects.

As regards coasts, and islands which are but little known, I have given in the Appendix a list of such as are most deserving of attention, extracted from a return made by the able and indefatigable officer at the head of the Hydrographic department, to an order of the House of Commons, 1848, and all general directions for acquiring information which may have been already given must be considered to apply with double force to these countries. The limits of this paper do not permit of our entering into particulars as to the probable position of places which may be imperfectly determined, nor of the reported position of islands which are considered doubtful. In the Atlantic alone, for instance, there are islands reported continually where none could possibly exist; and the islands of the Pacific have been multiplied by the errors of the longitudes of persons visiting them; but wherever the charts place any islands as doubtful, which you wish to seek (as it is always more probable that the latitude is correct than the longitude), the *parallel* of the supposed latitude should be gained, at a meridian sufficiently distant from that given to exceed the probable limit of error in longitude, and a due east or west course pursued until a similarly distant meridian is gained on the other side; and if there should be any change in the colour of the water, sounding ought by all means to be tried; and especially we call attention to soundings upon the site near the equator marked as the seat of volcanic action from about $3\frac{1}{2}$ S. and 15° to 24° W., and also to the vicinity of the great bank S. and S. E. from the Falkland Islands, called Burdwood Bank, on which there has been found recently as little as 24 fathoms; the Agulhas Bank, and the sites of any volcanic islands which may have risen and disappeared.‡

SAILING ALONG A COAST.

28. When sailing along a coast or islands which may even be known and charted, it is advisable, as a general practice, to *verify* the position of the points and headland as the ship sails along; and when the coast is new, or but indifferently explored, no opportunity should be omitted of determining as accurately as possible the position of every part within your power.

The position of places is determined from a ship with the least disadvantage, by being brought to bear east or west when the latitude is taken, and north or south when longitude is observed. And as these observations may be made during several hours of the day§ much may be done in a single day's run, especially if patent log bases connect the stations,

* See Raper's 'Navigation,' 855, p. 328; and 856, p. 329. "No commander of a vessel," observes that talented officer, "who might meet unexpectedly any danger (before unknown), could be excused, except by urgent circumstances, from taking the necessary steps both for ascertaining its true position and for giving a description as complete as a prudent regard to his own safety allowed."

† See Art. 29. ‡ See also Art. 4.

§ See Raper's Navigation, 830 et seq., p. 320; also p. 834, p. 321, second edition.

and astronomical bearings be employed. And upon all occasions the noting of transits, or the coming in a line of remarkable objects and of points of interest, should form a necessary portion of our duty, although we may believe them to be already satisfactorily determined, as they afford the most critical test of the accuracy of former surveys, and are especially useful in cases where longitudes of contiguous places may have been had by different observers.

If time admits of more than this being done, and in some of the countries which are but little explored, it is extremely desirable that no opportunity should be lost of perfecting their outline, the heavy boats may be hoisted out and sent in shore of the ship to run in the coast line and the detail, whilst the ship carries on a triangulation and continuation of bases in the distance, making what may be termed a running survey.

RUNNING SURVEY.

29. Whenever this can be done, send the boats to a distance of 4, 5, or 6 miles at starting, and let them and the ship anchor, if possible, to measure a base by sound (Art. 19), and to get astronomical bearings and angles to the *same points*. Fix the ship's position by repeated observations for the latitude and by chronometer; then weigh and put the patent log over and steer a steady course along the land (sounding, if the depth of water admit of it, without stopping). One boat now runs along the land from point to point, putting in the coast line and its detail, getting astronomical bearings and angles as she proceeds, especially of all transits of points and headlands, and measuring her distance between them by patent log, and sounding, but without stopping. The other boat attends principally to the soundings, fixing herself as she requires, by angles and bearings between the points determined by the other boat and the ship.

At the end of a few miles' run, or at noon, or when necessary to renew the angles and bearings, a signal is to be shown and the logs are then to be hauled in and read off, but not reset, fresh angles and bearings to be taken and a new base commenced, the distance between the ship and boats being again measured by sound. The log is then again put over and the course of the vessel resumed. In this manner the day passes, the bearings and observations all being worked out at the moment—the outline run in, views taken, and every particular mapped and booked at the time so as to leave nothing to memory. At the close of the day's operations anchor in position, measure a base by sound, and repeat operations as at starting, recall the boats, and in the grey of evening get the ship's position by stars and planets, which may at this time be observed with great accuracy before the horizon becomes too obscure. If the ship can remain at anchor, she will observe the set of the stream and the rise and fall of the water, however roughly it may be done.

As early as possible commit the triangulation to paper that the vessel may start in the morning with some points of land well fixed so as to enable the ship to continue her triangulation throughout the day without the aid of the boat—although her co-operation as before should be renewed.

If there be no anchorage, the ship will maintain her position during the night under canvas, and in the grey of the morning picking up the place where she left off on the preceding evening, send the boats away, get altitudes of stars for latitude and longitude, measure a base by sound; get astronomical bearings and angles, &c., and putting over the patent logs continue along the coast as before.*

* For further information, and a more extensive application of this method, see Belcher, Mackenzie, and other works on nautical surveying.

Thus far we have considered the observations as being wholly confined to the vessel, but it will add considerably to the accuracy of the survey if landings be occasionally made, and the stations be critically determined by astronomical observations, *i. e.*, by latitudes and chronometers, and the positions connected with the rest of the work.

30. It is not necessary to be provided with a regular chart for this purpose; the projection may proceed as you advance. Thus, consider how the coast runs, and draw a line along the paper to represent the meridian at starting; set off on this a degree of latitude according to the scale on which the survey is to proceed, 1 inch or 1½ inches to the mile, or more or less according to circumstances, and begin at once to lay off the bearings and angles. As you take up other stations proceed to throw out meridians and parallels in the manner described in Appendix No. 10. A chart upon this projection will be found easy of construction and more satisfactory than any other; and when the survey does not extend over more than 8 or 10 degrees of latitude, is sufficiently correct. In laying off bearings upon it, it must be borne in mind that they are to be projected with reference to the meridian passing through the spot. Mercator's projection, in which the meridians are all parallel, and which is in such general use in the navy, except in very low latitudes is not adapted to the purposes of a survey, as the bearings and the protraction will never agree together nor with the observed latitude and longitude of the stations.

With reference to the longitude I may remark, that the absolute longitude of the place is not required, but it is necessary to determine the *difference of meridians* as you proceed; and these should afterwards be compared with some well-determined meridian. I may observe here, once for all, that the longitude of a place, by chronometer, from Greenwich, should never be given without the *accompanying longitude from which the deduction of the meridian was made;* in short, that chronometers should be referred to only as a *measure of* DIFFERENCES.

CORAL ISLANDS.

31. Should coral islands be fallen in with, determine their position, extent, and map their outline; fix the openings into the lagoons, and describe their general appearance, whether wooded or not, and whether any high clumps of trees (distinguishing the palms) be conspicuous upon them, and at what part; you should then particularly notice the slope of the coral on both the outside of the island and the inside, and run off lines of soundings in various parts from the water's edge to as great a depth as you can reach, and at each cast particularly note the bottom, whether it be living or dead coral; note the greatest depth at which live coral is brought up: the existence of living coral at great depths is a point of interest. A swab fixed to the lead will often bring up specimens of coral which might otherwise be missed.

Point out the place of the anchorage in the lagoon by an anchor, and state whether vessels can sail in with the trade wind or not, and the best time for going in, for in many of these islands there is so strong a current running out through the channel after the trade wind has set in, in the morning, as to render it imprudent to attempt the passage; and in some it is only after the sea wind subsides, and the land breeze has commenced, that the passage can be effected. It is the sea getting up with the breeze and beating over the reefs into the lagoon that occasions such a current through the opening. Inquire into this on the spot, and do not commence any tide observations in the lagoon if the reefs are low and the channel small; if, however, the lagoon be open on one side and sheltered on the side of the prevailing wind, these spots in the ocean afford excellent places for observations upon the tides.

Currents occasioned by the trade-wind prevail about all the islands situated in those latitudes; their direction and force should be ascertained and stated in your remarks.

RIVERS.

32. All rivers should be traced to the furthest possible point that time will allow, for although it is the usual practice to limit hydrographic inquiry to the vanishing point of tidal influence, yet there are many reasons why we should not here so circumscribe our views. Rivers are the great arterial features of our globe; they define the valleys, give boundaries to the hills and mountain ranges, and if traced to their source enable us, with the aid of a few well-determined culminating points of contiguous ranges, to trace upon our charts the general feature of the country through which they flow. Besides which they are so far connected with the navigation of our ports and harbours that their aid is often indispensable to free access and egress, by affording a powerful means of scouring channels and removing impediments to shipping, which would otherwise be denied admission. They may therefore be said to be of almost equal importance to hydrography as to physical geography. In all cases then where rivers approach or flow into any of the ports under examination, you should acquire as extensive a knowledge of them as you possibly can, map as much of the windings and feature as is practicable, and especially of such parts of those that are not navigable as may be made available to be improvement of the navigation of the port, or in any way be converted to hydrographic use, particularly noting the depth, extent, and variations of surface, of all widenings of the stream, or basins affording back water and capable of being retained, or converted to a scouring power, carefully determining the elevation of the surface above the *mean level of the ocean*, and, if the river does not run into the port, whether it could not be conveyed to it, and with what facility. These inland basins are occasionally greatly affected by mountain torrents, melting of snow, and rainy periods, raising their surface to an extraordinary height even in a few days; while, on the other hand, long dry seasons depress them as much below the mean level. Our endeavour should be to ascertain these variations and the mean level of the water of the basin; we may often see, for weeks after the event, the mark of the wash of the water around the lake or basin far above the existing level; this may be measured and compared with the place of the mean level, and be coupled with the place of the water according to the best information to be procured at the place (noting the informant).

Note the depth and capability of transport or of inland navigation, and the power of traversing the stream for military purposes; also the nature and peculiarity of construction of the vessels employed and the means they have of advancing against the stream, &c., and the distance to which navigation is practicable, severally for vessels, boats, or barges.

In large rivers communicating with the sea, note the facility of access and egress, the depth of water on the bar, if there be one,* the position and nature of shoals or rocks, and the navigable capabilities of the stream, the rate and duration of flood and ebb, that is, of the *ingoing* and *outgoing* stream. The distance to which the stream runs up, and the extent to which the rise and fall of the water is felt, or what may properly be called the end of the tide; and here always, if possible, determine the elevation of the high-water line above the *mean level* of the ocean.

Lastly, in speaking of rivers, let it be understood that the *right* or *left* bank should have reference to the *downward direction* of its course, so that, when descending the stream,

* What has been already said on leading marks, lighthouses, beacons, buoys, &c., &c., of course applies here also.

the *right* bank is on the *right hand* and *vice versâ*. It is better to adopt this phrase than to say east or west, which might at the least be ambiguous, for it is clear that if a stream meander much, its course being always of necessity downwards, it might be successively diverted to every point of the compass.

LAKES.

33. Lakes, properly so called, or which have no rivers running through them, can scarcely ever be turned to the uses of hydrography, except when they are upon a level with the sea, when a communication has been or may be made, and a scouring power obtained by the admission of the tide through the port. However, what has been said of river basins may be applied to these enclosed sheets of water. The principal points are, their distance from the port, height above mean water line of the ocean, depth, dimensions, and fluctuation of surface, the quality, temperature, and sweetness, of the water, the nature of the bed and borders, inland navigation, if any, &c.

ARTIFICIAL HARBOURS.

34. In all harbours, but especially in the vicinity of those which are formed by piers carried out into deep water, it is proper to notice whether there are shoals formed about the piers, and the pier-heads especially. If there are, obtain information as to the probable cause, when they were first noticed, carefully note their extent and direction, and connect with them the direction of the tide, ebb and flood, and if there be any stream through the piers out, or in, note its rate, direction, and the distance it extends. The form and construction of artificial harbours, piers, and breakwaters, does not properly belong to hydrography; but it may be well to describe and record the form of the breakwaters, the pitch or slope of the stonework, *the depth* in which it is erected, the material of which it is composed, the nature of the work, and how it has resisted the sea. Or if there be an opportunity of seeing it in a gale of wind, the power any peculiar form or construction of breakwater may have in repelling a heavy sea, or the effect any peculiar form of pier may have in diverting the sea at the entrance from the anchorage within. The position of the entrance with regard to the offing stream and prevailing wind, the width of the channel, the protection of the anchorage, the number of square acres enclosed. If there be any backwater, state its extent, how the scouring, if any, is managed, at what time of tide and what is its apparent effect—and at all places wherever backwater is used, it may be as well to sound off the mouth of the port to as great a distance as the effect of the scouring action can possibly extend—for occasionally injurious effects have been produced by this powerful agent at a distance scarcely contemplated. State all deposits, siltings up, and at what rate it proceeds.

FOREIGN PORTS.

35. In visiting foreign ports, a particular account should be given of the resources of the place in the event of vessels requiring either a repair or a refit. Such as whether there are any docks, wet or dry? what sized vessels they are capable of receiving, and how many at a time; is there a patent slip or gridiron, &c. How near vessels, of particular dimensions, can approach the wharfs, or at what time of tide lie alongside of them; whether there are sheers for removing masts, and of what size, or cranes for lifting machinery and boilers; whether there be a dockyard or arsenal, or whether stores can be procured from other sources. Whether there is a steamyard, and to what extent they cast and manufacture machinery or boilers, or can repair steamers?

Whether there is a coal depot, and what quantity of coal can be generally relied upon as at hand; nature and quality of the material? &c.

Are there any piers, jetties, or wharfs for landing passengers, or cranes for carriages, and at what time of tide available? If the country be low, are there any sea walls, and would the country be flooded by their removal?

WAVES.

36. Lastly, the attention of the observer should be directed to the measurement of the height, the extent, and the velocity, of the waves of the ocean. Not only of those high swelling seas which are common to every gale, but especially of those gigantic ridges which are occasionally met with off Cape Horn, the Cape of Good Hope, and even in the Atlantic; coming in couplets and triplets in the course of a gale, and occasioning fearful lurches which are long remembered. Opinions differ greatly as to the dimensions of these stupendous bodies, and any observations which will assist in determining their limits cannot fail to be acceptable. The inquiry is, *first*, as to the height of the solid wave above the mean water level. *Secondly*, the distance of the ridges apart. *Thirdly*, the rate at which the wave travels, and whether the height and distance of the ridges vary with the velocity. *Fourthly*, what is the greatest estimated extent of any one of those ridges.

The most simple way of measuring the height, is, when the vessel is in the lowest part of the trough between two following seas, to ascend the rigging to such a height as will bring the top of the wave on with the horizon, to put a mark, note the inclination of the vessel, and *at leisure* to measure the perpendicular height of the eye above the water line, which we may presume will be double the height of the wave above the mean water level. It will necessarily require several observations to be made before any satisfactory conclusion can be arrived at. The distance of the waves apart may possibly be tested by actual measurement, by means of the lead-line and a float veered out to such a distance that the float shall be on the crest of one wave when the ship is on the top of the other. And the rate may be determined by the time occupied by the wave in passing from the float to the ship: the rate of the ship through the water and the angle her course makes with the route of the wave being known. There are other methods of determining this interesting problem which will no doubt occur to the intelligent observer, and they are sufficiently numerous to afford ample exercise of his ingenuity, but all are attended with difficulty owing to the circumstances under which the observations are required to be made.

APPENDIX No. 1.

DATE.	LATITUDE.	LONGITUDE.	CURRENT.		VARIATION.	WIND.		TEMPERATURE.		BAROMETER.	REMARKS.
	N. or S.	E. or W.	Direction.	Rate.	E. or W.	Direction.	Force.	Air.	Sea.		

Remarks upon the Currents which prevailed in the passage across the Atlantic.

"From the time we quitted Teneriffe, with the N.E. trade-wind, until we lost the breeze in lat. 7° 40′ N., long. 26° 40′ W., the current set on an average S. 54° W. true, at the rate of 11¼ miles per day. On losing the trade and entering the calm latitudes, the westerly current ceased, and the next 24 hours the ship was set N. 83° E. true 23 miles. The meeting of the opposite currents was marked by a strong ripple, which was traced to a considerable distance. The four succeeding days, in which we changed our position from lat. 7° 20′ N., and long. 26° 58′ W. to lat. 3° 56′ N., long. 26° 41′ W., the current ran S. 76° E. true 13 miles per day. Here we met the S.E. trade, and with it experienced a strong current, which carried us N. 62° W. true 23 miles per day, until we made Fernando Norhona. Hence to a position 100 miles due east of Cape Ledo the current set between S. 78° W. and S. 21° W. (true), on an average daily rate of 27 miles," &c.

"While in Rio Janeiro, H.M. ships A. and B., the packet C., and a fast-sailing schooner the D., arrived, and we learnt that the A. had crossed the equator in 18° W., the B. in 25° W., the C. in 29½° W., the D. in 39° W., whilst we crossed in the E. in 30° W.; and upon inquiry it appeared that the passages from England were as follows, viz: the A. was 49 days, B. 40 days, C. 38 days, the E. 36 days, and the D. 110 days, having got *so far to the westward that she could not weather Cape St. Roque*, and was obliged to stand back to the variable winds to regain her easting. Thus it appears that, with the exception of the D., *the passages were shortened in proportion as the equator was crossed to the westward*," &c. &c.

APPENDIX No. 2.

To find the Height of an Object the distance of which is known.

Rule.—To the observed altitude apply the true dip, less the terrestrial refraction.* The result call corrected altitude; to the log. of the distance in yards add the constant 8·073007, and find the log. of the sum, which turn into arc and add to the corrected altitude; then to the log. tangent of this sum add the log. of the distance in yards as above mentioned, the result will be the log. of the height of the object in yards.

Example.—Mount Etna was seen at 57 miles distance, and subtended an angle of 1° 30′ 00″ with the horizon; elevation of eye 20 feet, required the height of the mountain?

	°	′	″		
Altitude...............	1	30	00	Distance 57′, in yards 115650 log. 5 063157	
† Dip..............		— 4	43	Constant... ... .8·073007	
	1	25	17	60)1368″ log. =3. 136164	
† $\frac{1}{11}$ of Dip... ...		+	26		
Corrected Altitude	1	25	43		
		+ 22	48	.........................Correction...22.48	
True Altitude.........	1	48	31	Tangent...... ......8·4993668	
				Constant...... ......5·0631570	
					Yards.
				3·5625238 log.	3652 height required.
					× 3
					10956 feet.

APPENDIX No. 3.

To find the Constant for a Height, in order to compute its Distance readily from its observed Altitude.

Rule.—From the log. of the height in yards subtract the constant log. 6·5424481, halve the sum—find its sine, and take out the corresponding co-sine, which is the constant required. (*a*)

To find the Distance.

Rule.—From the observed altitude subtract the dip less the terrestrial refraction,‡ and call the remainder corrected altitude. To the constant above mentioned 6·5424481 add the cosine of the corrected altitude, and from the cosine of the sum subtract the corrected altitude. The remainder is the log of the approximate distance in arc. Divide the approximate distance so found by the proportion of terrestrial refraction allowed, and subtract the quotient from the before found corrected altitude for the true altitude.

Lastly, add the cosine of the true altitude to the constant due to the height of the object (*a*); find the cosine of the sum, and substract from it the true altitude; the remainder is the distance in arc required.

* The terrestrial refraction varies from $\frac{1}{8}$ to $\frac{1}{12}$ part of the arc.

† If the Dip Sector had been used, the observed Dip should be substituted for these two quantities.

‡ The terrestrial refraction varies from $\frac{1}{8}$ to $\frac{1}{12}$ of the arc.

	′	″
EXAMPLE.—Observed the altitude of Snowdon to be, its height being 3565 feet = 1188 yards, required its Constant and its Distance, height of eye being 14 feet.		
On	45	00
Off	45	10
	45	5 means.

Log of height 3·0722499
Constant......6·5424481

2)16·5298018

Sine... = 8·2649009

Cosine = 9·9999265 Constant required.

To find the Distance.—

Constant for Snowdon 9·9999265
Cosine corrected Alt. 9·9999686

°	′	″	
1	15	33	= Cosine 9·9998951
—	41	20	Alt.
$\frac{1}{16}$)34	13		Approx. dist.
3	25		Correction.

	′	″
Observed Alt... ... .45		05
Dip for 14 feet..... ....−	3	45
	41	20
Terrestrial ref. $\frac{1}{10}$ of Dip...+		22
Corrected Alt... 41		42
Correction......... ....−	3	25
True Alt......................38		17

Constant......... ......9·9999265
Cosine true Alt... ...9·9999731

	°	′	″	
	1	13	55	Cosine = 9·9998996
True Alt.	—	38	17	
				miles.
		35	38	= 35·6 = distance of object.

APPENDIX No. 4.

TUESDAY, 24th. Sounding in the 1st Cutter, WILLIAM REEDER, Leadsman. AUGUST 24, 1847.

Sextant used, D 56. Line correct at starting. (Officer's name, Mr. D. HALL.)

Red to LW	Mean Time.	SOUNDINGS. High Water. 5·36 P. M., Low Water. 11·42 A. M. (h. m.) } Range... 33·9 (ft. in)	Course.	P. Log.	DATE AND REMARKS. Spring Range 44 ft.	Objects.	Angles.	Objects.	Angles.	Objects.
fm.	h. m.	fms.		m.			° ′		° ′	
$\frac{6}{8}$	11·45	∠[1] $2\frac{4}{8}$ $2\frac{4}{8}$ $2\frac{4}{8}$ $2\frac{4}{8}$ $2\frac{3}{8}$ $2\frac{3}{8}$ $2\frac{4}{8}$ $2\frac{4}{8}$						∠[1]		
		Reduced $1\frac{6}{8}$ $1\frac{6}{8}$ $1\frac{6}{8}$ $1\frac{6}{8}$ $1\frac{4}{8}$ $1\frac{4}{8}$ $1\frac{5}{8}$ $1\frac{6}{8}$			Pulling in the direction of Clevedon church, tree in one with house on the side of the hill.	Denny Island	63·46	Clevedon Church	79·11	Worle mill.
	11·55	∠[2] $1\frac{6}{8}$ $3\frac{4}{8}$ $3\frac{3}{8}$ $3\frac{3}{8}$ $4\frac{5}{8}$ $6\frac{1}{8}$ 7 $5\frac{2}{8}$						∠[2]		
		Reduced 1 $2\frac{6}{8}$ $2\frac{4}{8}$ $2\frac{4}{8}$ 4 $5\frac{2}{8}$ $6\frac{1}{8}$ $4\frac{3}{8}$				Do.... ..	61·12	Do.... ...	84·18	Do.
1	12·0	∠[3] $3\frac{3}{8}$ $3\frac{3}{8}$ $2\frac{1}{8}$ $2\frac{2}{8}$ $2\frac{4}{8}$ 3 $3\frac{2}{8}$						∠[3]		
		Reduced $2\frac{3}{8}$ $2\frac{3}{8}$ $1\frac{1}{8}$ $1\frac{2}{8}$ $1\frac{4}{8}$ 2 $2\frac{2}{8}$			Altered course, and pulled towards Denny Island, in one with church.	Usk light house	89·4	Walton castle	103·22	Worle mill.
$1\frac{1}{8}$	12·5	∠[4] $2\frac{1}{8}$						∠[4]		
		Reduced 1				Do.... ...	109·21	Do.... ...	71·32	Do.
		At 6 o'clock left off sounding and measured the line over, found it correct.								

NOTE.—The objects are here placed according to their observed relative positions, and should always be so written down; the *right-hand* angle being invariably read off *first*.

APPENDIX No. 6.

The number of Miles or Minutes of the Equator contained in a Degree of Longitude under each parallel of Latitude for the Spheroid. $\frac{1}{301}$ Compression.

Lat.	Length of Degree.	Lat.	Length of Degree.	Lat	Length of Degree.
°	′	°	′	°	′
0	60·000	31	51·475	61	29·161
1	59·991	32	50·930	62	28·240
2	59·964	33	50·370	63	27·310
3	59·918	34	49·793	64	26·372
4	59·854	35	49·202	65	25·426
5	59·773	36	48·596	66	24·471
6	59·673	37	47·975	67	23·509
7	59·556	38	47·339	68	22·540
8	59·419	39	46·688	69	21·564
9	59·266	40	46·021	70	20·581
10	59·094	41	45·346	71	19·592
11	58·905	42	44·654	72	18·596
12	58·697	43	43·948	73	17·595
13	58·472	44	43·229	74	16·588
14	58·229	45	42·495	75	15·577
15	57·968	46	41·750	76	14·560
16	57·690	47	40·992	77	13·539
17	57·394	48	40·220	78	12·514
18	57·081	49	39·437	79	11·485
19	56·751	50	38·642	80	10·452
20	56·403	51	37·834	81	9·416
21	56·038	52	37·015	82	8·377
22	55·657	53	36·185	83	7·336
23	55·258	54	35·343	84	6·292
24	54·842	55	34·400	85	5·246
25	54·410	56	33·627	86	4·199
26	53·962	57	32·754	87	3·150
27	53·496	58	31·870	88	2·101
28	53·015	59	30·977	89	1·050
29	52·518	60	30·074	90	0·000
30	52·004				

APPENDIX No. 8.—DAILY TIDE JOURNAL.

of 18 ☽'s Transit, h. m. A. M. ☽'s Transit, h. m. P. M.

Place,
Lat.
Long.
Var. of Compass.

Time. Mean.	Height.	Direction of Stream Magnetic.	Velocity of Stream.	Winds. Direction Magnetic.	Winds. Force	Weather.	Barom.	Therm.	Remarks.
UPPER TRANSIT.									
H. M. 0 30 A.M.	Ft. In.		Knots						
1 0 ...									
30 ...									
2 0 ..									
30 ...									
3 0 ..									
30 ...									
4 0 ...									
30 ...									
5 0 ..									
30 ..									
6 0 ..									
30 ..									
7 0 ..									
30 ...									
8 0 ...									
30 ...									
9 0 ..									
30 ..									
10 0 ..									
30 ..									
11 0 ...									
30 ...									
12 0 ..									
LOWER TRANSIT.									Moon's Age.
0 30 P M.									
1 0 ...									
30 ...									
2 0 ..									
30 ..									
3 0 ...									
30 ...									
4 0 ..									
30 ...									
5 0 ...									
30 ..									
6 0 ..									
30 ..									
7 0 ..									
30 ..									
8 0 ..									
30 ..									
9 0 ..									
30 ..									
10 0 ..									
30 ...									
11 0 ..									
30 ...									
12 0 ..									

Remarks — Upper Transit.

Additional Observations.

H. M. F. I.	
.. 0 ...	From ½ hour before to ½ hour after H. W.
... 10 ...	
.. 20 ..	
.. 30 ...	
.. 40 ...	
.. 50 ...	
.. 0 ...	

H. M. F. I.	
.. 0 ...	From ½ hour before to ½ hour after L. W.
.. 10 ..	
.. 20 ...	
.. 30 ...	
.. 40 ...	
... 50 ...	
... 0 ...	

Remarks — Lower Transit.

Additional Observations.

H. M. F. I.	
... 0 ...	From ½ hour before to ½ hour atfer H. W.
. 10 ..	
.. 20 ...	
... 30 ..	
.. 40 ..	
50 ..	
.. 0 ...	

H. M. F. I.	
.. 0 ..	From ½ hour before to ½ hour after L. W.
.. 10 ...	
. 20 ..	
.. 30 ...	
.. 40 ..	
.. 50 ..	
. 0 ...	

RESULTS.	H. M. A. M.	H. M. P. M.		feet.	inches.
High Water at...............			Rise, A. M.		
Low Water at...............	...	...	Fall........	..	...
Flood Stream terminated at	...	..	Rise, P. M.	..	...
Ebb *ditto* *ditto*	...	...	Fall........	..	..

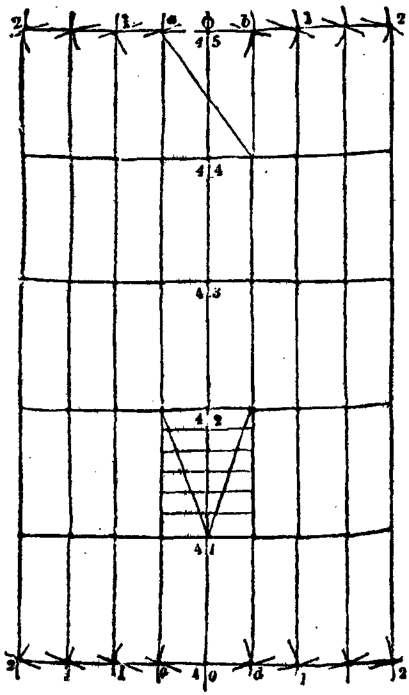
APPENDIX No. 7.

Register of TIDES observed at Portished in the Month of October, 1847. (Observer WM. QUIN, Qr. Master.)

Date.	High Water. A.M. or P.M.	High Water. Time.	High Water. Height.	Barometer at High Water.	Low Water. A.M. or P.M.	Low Water. Time.	Low Water. Height.	Barometer at Low Water.	Range of Tide.	High Water. P.M. or A.M.	High Water. Time.	High Water. Height.	Low Water. P.M. or A.M.	Low Water. Time.	Low Water. Height.	Range of Tide.	Interpolated High Water.	☽'s transit.	Diff.	Mean Water Level.	Wind. Direction.	Force.	Stream. Flood turned.	Stream. Ebb turned.
		h. m.	ft. in.			h. m.	ft. in.		ft. in.		h. m.	ft. in.		h. m.	ft. in.	ft. in.	h. m.	h. m.	h. m.	ft. in.			h. m.	h. m.
1	A.M.	5 53 6 3 6 13 6 23 6 33	43 2 43 8 43 11 43 8 43 2	29·95 A.M. 29·74 P.M.	A.M.	0 20 0 30 0 40 0 50 1 00	2 10 3 2 3 00 3 2 2 10	29·91 A.M. 29·70 P.M.	40 11	A.M.	6 20 6 30 6 40 6 50 7 00	44 3 45 2 45 2 44 8 44 0	P.M.	0 50 1 00 1 10 1 20 1 30	3 0 2 5 2 7 2 · 2 11	43 0	6 15 A.M. 6 38 P.M.	11 19 A.M.	7 16 7 19	23 5 23 8	North N.N.W.	2 1	6 0 6 20	12 20 1 00
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								
11																								
&c.																								

APPENDIX No. 9.

A



B

APPENDIX No. 10.

To construct a Chart for a Running Survey of a Coast.

Draw the meridian line A B (Appendix No. 9) through the centre of the chart, and set off the degrees of latitude upon it, of equal lengths, according to the scale which it is intended to construct the chart upon—draw short lines at right angles to each of these.

At the extremities of the degrees of latitude, as at 40° and 45°, set off right and left upon the perpendiculars distance equal to half a degree of longitude in these parallels respectively (taken from Appendix No. 6), as at *a b c d*; then with the diagonal distance *a d* or *c b*; and with the foot of the compass at 40° sweep the small arcs 1 1 at top, and likewise the arcs 1 1 at bottom from 45°. Again, with the length of a degree of longitude in 40° cut the small arcs 1 1 before described: these intersections will be corners of parallelograms, each of a degree of longitude, extended over as many degrees of latitude as your chart contains. Repeat the process for other meridians right and left of A B, and connect the points 1 1, &c. by meridian lines. Set off upon these from either the top or bottom the degrees of latitude before laid off upon A B, and connect them all throughout the chart by straight lines, as at 40, 41, 42, 43, 44, 45, &c. For a scale, divide the degree of latitude into sixty equal parts, or into such equal portions of it as the scale admits of, and it will give a similar proportion of geographic miles of distance; and for longtitude, if each degree of latitude be so divided by lines extending from meridian to meridian, and the corners of the parallelogram be connected by a straight line, as is shown in the plan between the 41st and 42nd degree, a scale of miles will be given for that parallel.

When bearings are taken, they must be laid off from *the Meridian passing through the station.*

APPENDIX No. 11.

COASTS AND ISLANDS OF WHICH OUR HYDROGRAPHICAL KNOWLEDGE IS IMPERFECT.

Abstract from a Return made to the House of Commons, 10th February 1848, from the Hydrographic Department of the Admiralty.

THERE is wanted a critical examination of " the eastern islands of the Mediterranean, along with the coasts of Syria and Egypt, and as much of the northern shore of Africa as would meet the French survey, which, having commenced with Algiers and Morocco, will very probably be continued along Eastern Barbary and Tunis.

" From the Strait of Gibraltar the western coast of Africa has been sufficiently surveyed and published as far as Cape Formosa, in the Bight of Benin; but as there is much legitimate traffic in the eastern part of that great Bight, as well as further to the southward, both it and many of the ports and anchorages on this side of the Cape of Good Hope require a more careful and connected examination.

" The charts of the whole of the Cape colony are exceedingly defective, and from thence to the Portuguese settlements of Delagoa we know scarcely anything.

" From Delagoa to the Red Sea and the whole contour of Madagascar are sufficiently represented on our charts for the general purposes of navigation, through many further researches along the former coast might still be profitably made.

" The Red Sea, part of the coast of Arabia, the Gulf of Persia, and many detached portions of the East Indies, have been already executed by the Company's officers; and no doubt it is intended that the coasts of Malabar and Coromandel shall soon be undertaken by the same hands. The long Malay Peninsula and the Strait of Malacca will require much time and skill to complete, and to combine with each other those parts that have been surveyed.

" With the China Sea we are daily becoming better acquainted, but much is still to be done there; for probably not one of the multitude of rocks and shoals with which it is almost covered is put exactly in its right position; and while some are repeated two or three times, others have been omitted.

" On the coast of China the charts are excellent from Canton round to the mouth of the great river Yang-tse-Kiang; but of the Yellow Sea we know very little, and still less of the Corea, Japan, and the coast of Tartary, and up to the confines of the Russian Empire.

" The southern passages into the China seas have never been examined with the care they deserve; and all that is known of what are called the eastern passages through the Great Malay Archipelago are only the results of the casual observations and sketches made years ago by industrious seamen.

" The islands and surrounding shores of Arafura Sea, if better known, would offer many ports of refuge, and probably an increased opening to commercial enterprise.

"The Strait of Torres has been satisfactorily surveyed; but before it becomes the great highway for steam-vessels to and from Sydney, its approaches, and also its contiguous coasts of New Guinea, should be more intimately known.

"The whole circuit of the great island of Australia has been well explored, and the; general characteristics of its several shores are sufficiently known for all general purposes but far more minute surveys of its immediate waters and maritime resources must precede their being inhabited, beginning with the eastern coast, along which the tide of colonization seems to be already creeping.

"The shores of Tasmania, in like manner, are but very roughly laid down, and even to this day there is no chart of the harbour and entrance to Hobart Town, its capital and principal seat of trade.

"A full survey of New Zealand has just been commenced, and will no doubt answer all the wants of both the settler and navigator.

"In advancing to the eastward across the Pacific Ocean, there are many groups of islands with which our merchant-vessels have occasional traffic, or in which the whaling vessels refit, and which ought, therefore, to be more sufficiently examined.

"On the opposite side of the Pacific some progress has been made in surveying the coast between the Russian territory and the Strait of Juna del Fuca; but with the long interval between the Oregon district and the entrance of the Gulf of California we are very superficially acquainted, and but little is known of the interior of that extensive Gulf. In the present state of those countries it does not appear necessary to push our survey into their inner waters; but there can be no doubt that the coasts of Mexico, Guatemala, and New Granada, which contain many valuable harbours and innumerable trading ports, ought to be minutely and connectedly surveyed.

"From the Equator to Cape Horn, and from thence round to the river Plata, on the eastern side of America, all that is immediately wanted has been already achieved by the splendid survey of Captain Fitzroy.

"Some parts of the great empire of Brazil we owe to the labours of Baron de Roussin and of other French officers; but there is much yet to be done on that coast between the Plata and the Amazon rivers, and again along Guyana and Venezuela up to the mouth of the Orinoco.

"The shores of the main land between Trinidad island and the Gulf of Mexico have been charted and published by the Admiralty; but many of the West India islands are still wanting to complete a wholesome knowledge of those seas.

"The United States are carrying on an elaborate survey of their own coasts; and to the northward of them a part of the Bay of Fundy has been done by ourselves, as well as all the shores of Nova Scotia, Canada, and Newfoundland; and when these surveys are finished, we shall only want to complete the eastern coast of America, those of Labrador and of Hudson Bay, which, being in our possession, ought to appear in our charts with some degree of truth."

As it is impossible here to open the question of the positions of the multitude of islands, of the Pacific especially, the apparent number of which has been so greatly increased by the errors of observation of navigators who have reported them, we can only recommend to the observer the propriety of fixing astronomically every island which he may fall in with, and to note any peculiarity by which it may be identified hereafter.

TIDES.

BY THE REV. DR. WHEWELL.

[*From the Admiralty Manual.*]

DIRECTIONS FOR TIDE OBSERVATIONS.

1. In making tide observations, the main object is, in the first place, to refer the tides to the motions of the *moon*, by which they are, in most places, mainly governed.

For this purpose, the *time* and *height* of *high water* (and of *low water*) at each place must be obtained; and this *time* will have to be compared with the *time* of the moon's passage across the meridian of the place.

The latter time (the *time of the moon's transit*) may be known by the common table given in the Nautical Almanac, or in other books of the same kind.

2. The time of high water (and low water) may sometimes (when the sea is calm) be observed with sufficient accuracy by observing the surface of the sea, where it washes a vertical scale fixed in the open water, and divided into feet and inches. The moment when the water is highest (and lowest) must be observed by a watch or clock, well regulated, or corrected for its error.

3. In general, the waves will make it difficult to observe the moment of the highest (and lowest) open water with much accuracy. The following methods may be used to make the observations more accurate:—An upright tube, open below and above, may be placed in the water, reaching above the high water, and below the low water (or two tubes, one for high water and one for low water, if this mode be more convenient). In this tube must be a float (a hollow box or ball, for example), which must carry an upright rod, or else must have attached to it a string which passes upwards over a pulley and is stretched by a weight; and the part of the rod or of the string which is outside the tube must carry an index, which shall mark on a vertical fixed scale the rise and fall of the float.

By making the tube close below, except one or more small openings, the motion of the waves will very little affect the float, and the true rise and fall of the surface may be observed with much accuracy.

4. It may happen that the moment of the highest or lowest water is difficult to determine, either with or without the tube, on account of the water, while near the highest or lowest, stopping or hanging still, without either rising or falling, or else rising and falling irregularly.

If there is a considerable time during which the water neither rises nor falls decidedly, note the moment when it ceases to rise, and the moment when it begins to fall, and take the time half way between these for the time of high water.

5. Another method is the following:—At certain intervals of time near the time of high water, for example, every ten minutes, or every five minutes, let the height of high water be observed, say for half an hour or an hour, and from the height so observed pick out the highest for the high water, and note the height and the time; and in like manner for low water.

6. But the following is a better mode of dealing with observations thus made every five or ten minutes. Let a number of parallel line (*ordinates*) be drawn at intervals corresponding to the intervals of observations, and bounded by a line perpendicular to them on one side (the *abscissa*), and on these lines (the ordinates) let the observed heights of the surface be set off (from the abscissa) and let a line be drawn through the extremities (of the ordinates). This line, if it be tolerably regular, will give the time of high water; and if it be somewhat irregular, it can be smoothed into a curve, and then the time and height of high water read off. And in like manner for low water.

Suppose, for example, that we have the following observations of the height of the water made every five minutes for an hour:—

Times of Observation.	h. 0 m. 0	m. 5	m. 10	m. 15	m. 20	m. 25	m. 30	m. 35	m. 40	m. 45	m. 50	m. 55	m. 60
Heights observed . ft.	6	6	6	6	6	6	7	6	6	6	6	6	5
in.	0	6	6	9	10	11	0	11	11	9	5	2	10

The selection of the greatest height (as in Art. 5) would give high water at 0h. 30m.; but the general run of the height (Art. 6) would give the high water two or three minutes later, as appears by drawing the dotted curve in fig. 1.

7. It is easy to draw such curves, if we have, ready prepared, *paper ruled* into small squares, the divisions in the horizontal line representing hours and minutes, and the divisions in the vertical line representing feet and inches.

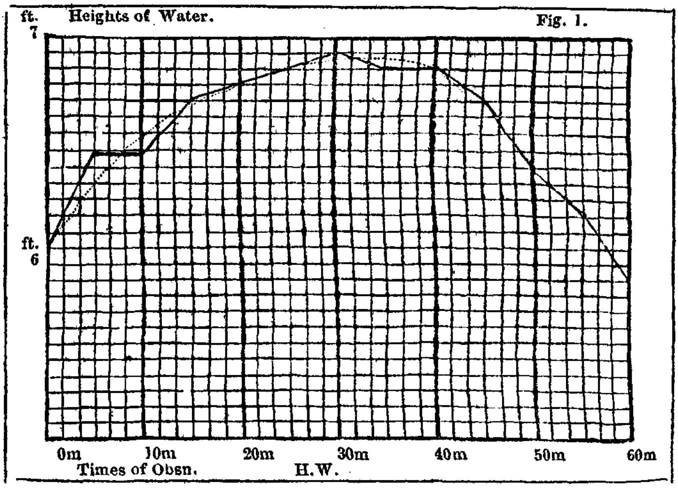


Fig. 1.

8. It is well to begin a series of tide observations at any place by observing the height of the water during the *whole of the day and night* every half-hour or every quarter of an

hour. For if the rise and fall be very irregular, or have any features which make it differ much from the common rule, it will, by this means, be seen that the case is a peculiar one, and that peculiar methods must be used: but if there is nothing peculiar in the case, the common methods may be used.

For instance, if, instead of there being two tides in every (lunar) day, there be one only, or four (both which cases occur at several places), these peculiarities will be discovered by observations continued during the day and night, in the way just recommended. If there be a periodical rise and fall of the sea's surface not depending in any obvious way upon the moon, the periods of maximum and minimum should be carefully and exactly observed, in order to determine upon what the rise and fall does depend. This is the case in some parts of the Pacific, the rice and fall at those places being small.

9. If *the tides are tolerably regular*, it will not be necessary to observe, except for every five minutes near the time of high water and low water; say for an hour, so as to include the exact time near the middle of the hour. From these observations, by laying down the heights as ordinates, and drawing curves, as directed in Art. 6, the height and time of high water and of low water will be deduced.

10. It is desirable to compare the observations of the time of high water and low water with the time of the moon's transit (see Art. 1) *while the observations are going on:* for if the tide follow this transit at very irregular intervals, the common modes of observation will probably be of no use, and the time and trouble employed in making them will be lost.

11. The time of high water at any place on the day of new or full moon is commonly called the *establishment* of the place; because, this being established, the time of high water on any other day may, in most cases, be known.

12. But if the tides are very irregular, this is not the case; and then the establishment of the place is of no use; or, rather, there is no proper establishment. And if the tides be regular, the establishment may be got from observations made *on other days*, just as well as from those made on the day of new or full moon. See Note A.

13. To compare the times of high water with the times of the moon's transit (see Art. 10), we must take the moon's transit from the tables (see Art. 1), and reckon how much the time of high water is *after* the time of the moon's transit, and put down these intervals, which are called the *lunitidal intervals.**

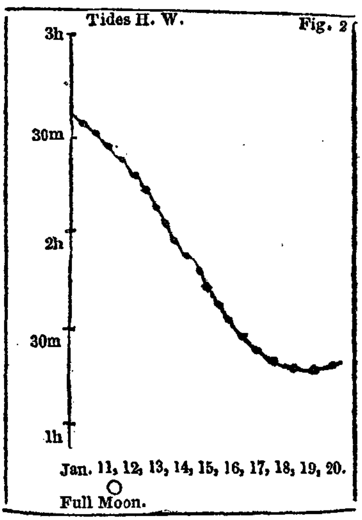
Suppose, for example, that we have the observations of high water contained in the following table: we add to them the other columns, containing the moon's transit and the lunitidal interval calculated therefrom. The alternate transits are interpolated midway between the others, which are given by the table. The A. M. transit which happens on the

* It is not necessary, for the purposes considered in these directions, to calculate the time of the moon's transit *at the place* of observation by differences of days. It is sufficient to take the time of the moon's transit at Greenwich, and to *add* two minutes for every hour of *west* longitude of the place. For the moon (on the average) moves away from the sun so that her distance from the sun is increased 48 minutes in time for every 24 hours, and therefore the transit of the moon is later at every other place by two minutes for every hour.

14th is given in the table as 12h. 32m. on the 13th, the hour of the table being reckoned from noon.

1847. Jan.		Times of H. W.	Time of Moon's Transit.	Luni-tidal Interval.	1847. Jan.		Times of H. W.	Times of Moon's Transit.	Lunitidal Interval.
		h. m.	h. m.	h. m.			h. m.	h. m.	h. m.
11	A. M.		[10 33]	2 34	16	A. M.	3 54	2 6	1 40
	P. M.	1 7	10 57	2 32		P. M.	4 9	[2 29]	1 34
12	A. M.	1 29	[11 21]	2 26	17	A. M.	4 26	2 52	1 28
	P. M.	1 53	11 45	2 20		P. M.	4 43	[3 15]	1 24
13	A. M.	2 11			18	A. M.	5 3	3 39	1 20
	P. M.	2 29	[0 9]	2 16		P. M.	5 23	[4 3]	1 18
14	A. M.	2 48	0 32	2 8	19	A. M.	5 47	4 27	1 18
	P. M.	3 3	[0 55]	2 2		P. M.	6 9	[4 51]	1 18
15	A. M.	3 21	1 19	1 52	20	A. M.	6 34	5 16	1 20
	P. M.	3 36	[1 42]	1 48		P. M.			

14. To see whether the lunitidal intervals follow the regular law, the best way is to put them into a curve, setting off the lunitidal interval belonging to each tide as an ordinate, as in fig. 2.* If the curve drawn through the extremity of the ordinates be tolerably regular, the tides may be presumed to be so.



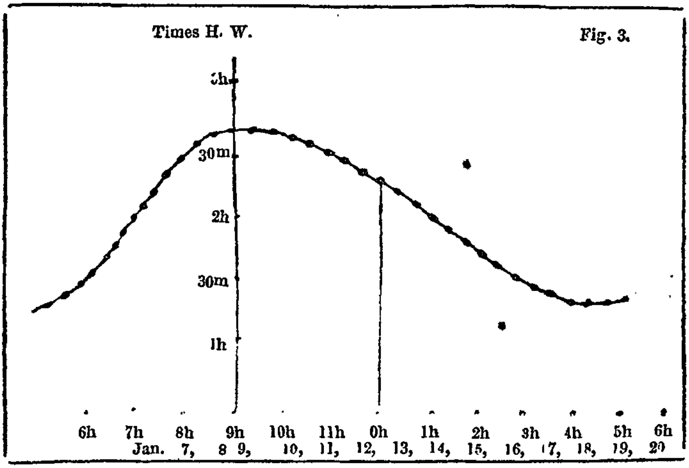
15. In the observations given in Art. 13 we may see how loose a term the "*establishment*" is. The 13th is the day of full moon, for in the course of that day the moon is 12 hours from the sun. The time of high water on the 13th is—A. M., 2h. 11m.; P. M., 2h. 29m; and either of these might, in the common use of the term, be called "the establishment."

* In actual practice it will be better to draw the figures on a larger scale than those here given.

16. If the lunitidal intervals be set off for a fortnight or more, the curve (Art. 14) will descend and ascend alternately every fortnight, as in fig. 3.

This curve is the curve of the *semi-mensual inequality;* and when this curve has been determined by observations at any place, the hour of high water at any time at that place may be predicted.

17. But the curve will be better determined if, instead of taking for the abscissa the day of the month, as in fig. 2, we take for the abscissa the time of the moon's transit as in fig. 3.*



In this case *the establishment* is the ordinate of this curve which corresponds to the time of moon's transit 0h. or 12h. In the figure it is 2h. 16m.

The mode of calculating the hour of high water on any day, when the establishment of the place is known, as in Art. 17, is given in Note A.

The establishment of the place may be known by observations made at any age of the moon, as well as at new and full moon, by the same kind of calculation.

18. It is also advisable to set off the *height* of high water as ordinates, and to draw a curve through the extremities. This curve also will ascend and descend every fortnight (ascending at spring tides and descending at neap tides.

The heights may be set off as ordinates, taking for the abscissas equal intervals to represent successive half-days, as in Art. 16.

But the curve will be better determined if we take for the abscissas the hour of the moon's transit, as in Art. 17.

19. The *maximum* or greatest ordinate of this curve of heights (that is, the spring-tide height) follows the day of new and the day of full moon, by one, two, or three days; and as

* Since the moon's transit is about 48 minutes later every day, there will be along the abscissa five days of the month for every four hours of moon's transit.

the new or full moon is supposed to produce the spring tide, this interval of one, two, or three days is called *the age of the tide.*

20. If the heights be set off from an abscissa which is the hour of the moon's transit (see Art. 18), the distance of the maximum ordinate from the hour of transit, 0h. or 12h. (which are the same thing), will give the *age of the tide* more exactly than Art. 19.

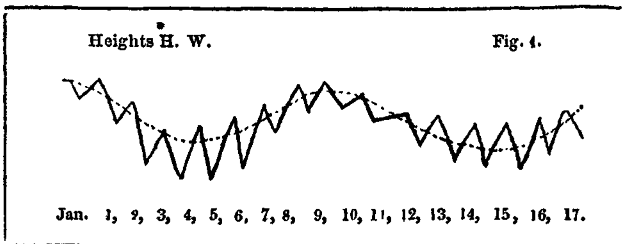
21. The lunitidal intervals and heights of *low water* may be laid down in curves in the same manner as those of high water.

22. The curve of the semi-mensual inequality of times and heights should be determined, when opportunity allows, for several weeks or months in succession: for from such observations we can obtain other scientific results (the effect of the sun, of the moon's parallax, and the like).

23. Besides the changes which are produced from day to day by the semi-mensual inequality of times and heights, there are at many places other considerable changes produced between the two tides of the same day by the *diurnal inequality.*

For example, there are many cases in which the height of high water is alternalely lower and higher in successive tides.

24. In this case, if we set off the successive heights of high water as ordinates at equal intervals, and draw a line through their extremities, this line will have zigzag form, as in fig. 4.



The width of the zigzag increases from nothing to a maximum, and then diminishes to nothing again, generally in the course of a fortnight; and so on perpetually.

25. In consequence of the diurnal inequality, it sometimes happens that the afternoon tides are higher than the forenoon tides, or the reverse, for many weeks together. And hence, it has sometimes been stated as a rule, at such places, that the afternoon tides are always the highest, or the reverse. But this is not the rule. If the afternoon tides are the highest at one time of the year they are the lowest at another.

The rule of the diurnal inequality depends on the moon's declination, and will be given in Note B.

26. There is often a diurnal inequality of the height of low water, and at some places it is greater than the diurnal inequality of high water (as at Sincapore, and at Port Essington in Australia).

27. Also there is often a diurnal inequality in the times.

When this is the case, if we set off the lunitidal intervals as ordinates (see Art. 14), the line drawn through their extremities will have a zigzag form, like that of the heights in fig. 4.

28. When this is the case, we cannot determine *the establishment* (see Art. 17) without making allowance for the diurnal inequality.

We make allowance for the diurnal inequality by drawing a curve, cutting off from the zigzags equal portion above and below. (See fig. 4.) This *mean line* will be of a wavy form in consequence of the semi-mensual inequality; and the ordinate corresponding to the new or full moon, or to the hour 0 or 12 of moon's transit, will give the establishment.

But if we apply this establishment to predict the time of tide on any day, we must also apply the diurnal inequality predicted according to its rule. (See Art. 25, and Note B.)

29. The diurnal inequality sometimes becomes so large that there is *only one tide in 24 hours* (and then we have *single-day tides*). But this does not generally happen through a whole lunation; it happens only for a few days in each semi-lunation; and at other times there are two tides as usual. Cases of one tide in 24 hours should be particularly observed, making the observations every half-hour, or, if possible, oftener, say every 5 minutes.

30. In some places the tide rises and falls *four times* in the 24 hours. The cases where this occurs are to be particularly observed.

They may be observed, as in Art. 29, by making observations every half-hour, 10 minutes or 5 minutes.

These may be called *double half-day tides.*

31. Where double half-day tides exist, they do not commonly extend over any considerable length of coast. If there be time and opportunity, it will be well to examine, by observation, how far they do extend. But if the object be to determine the laws of the tides in a larger area, it is better to make the observations out of the region of these anomalies.

32. It is well to be observe the *direction* of the stream of flood and of ebb, and the *time* at which the stream turns.

We must take care not to confound the time of the *turn of the tide-stream* with the time of high water. Mistakes and errors have often been produced in tide observations by supposing that the turn of the tide-stream is the time of high water. But this is not so. The turn of the stream generally takes place at a different time from high water, except at the head of a bay or creek. The stream of flood commonly runs for some time, often for hours, after the time of high water. In the same way, the stream of ebb runs for some time after low water.

33. The time at which the stream turns is often different at different distances from the shore; but the time of high water is not different at these points. In general, what is wanted in tide observations is the time of *high water*, not the time of *slack water*.

With regard to the streams of flow and ebb, they are often not merely two streams in opposite directions at different times of the tide; they genarally turn successively into several directions, so as to go quite round the compass in one complete tide; either in the direction N. E. S. W. (with the sun), or N. W. S. E. (against the sun). It is desirable to note which of these ways the tide-stream goes round, as this fact may help to determine which side of the tide-wave comes from.

34. One important object to be answered by means of tide observations is to trace the progress of the tide from one place to another.

This may be done in some measure by determining the *establishments* of a series of places in the region which we have to consider. For these establishments, reduced to Greenwich time by allowing for the longitude, give the time at which the tide is at each place, and hence its progress.

35. The progress of the tide may be conceived as the progress of a very wide *wave* which brings the high water to each place in succession.

But the motion of this *tide*-wave is not that motion of the water which makes the stream of flood. Nor does the motion of the wave coincide with any motion of the parts of the water. The tide-wave may be going one way when the water is going another, as happens in some rivers when the tide is travelling upwards in them.

36. The *establishment*, which is wanted in order to determine one progress of the tide wave (see Art. 34 and 35), may be known from observations made at any age of the moon as well as at new or full moon. (See Art. 17 and Note A.)

37. In tracing progress of the tide-wave, instead of using the *vulgar establishment* hitherto spoken of, it is better to use the *mean establishment*, namely, the mean of all the lunitidal intervals.

For the vulgar establishment is affected by the age of the tide (Art. 20), which the mean establishment is not.

The mean establishment is (say) 10m., 20m., 30m., or 40m. less than the vulgar establishment, according to the age of the tide. (See Note A.)

38. When the tides are regular, good observations, made for a few days or a week at each place, may give the establishment (either vulgar or mean) with sufficient exactness to determine the progress of the tide-wave.

39. But the progress of the tide-wave may be much better determined by means of *simultaneous observations*, namely, observations made at different places on the same days for a few days or a week.

For such purpose persons must be posted at different points of the shore or shores where the motion of the tide-wave is to be traced; say 10, or 20, or 40, or 80 miles from each other, as may be convenient. They must observe the tides at these places *on the same days*, morning and evening, by the methods already described. The time of high water at the different places on each half-day, being compared, will give the progress of the tide-wave.

40. In order to trace the progress of the tide-wave still more widely, the observer described in the last article, after having made the observations there spoken of, may be removed to new positions of the same kind, and thus trace the tide farther.

When this course is adopted, it will be well to have one (or more) fixed or standard station, at which tide observations are constantly made; and the observations made at any time at any other place may be compared with those made at the standard station.

41. The tides which take place far up deep bays, sounds, and rivers, are *later* than the tides at the entrance of such inlets; but they are not more irregular: on the contrary, the tides in such situations are often remarkably *regular*.

42. The progress of the tide-wave up inlets may be determined by the method described in Art. 39.

43. The tide in its progress up inlets and rivers is often much magnified and modified by local circumstances.

Sometimes it is magnified so that the wave which brings the tide at one period of its rise advances with an abrupt front of broken water. This is called a *bore* (as in the Severn, the Garonne, the Amazons River).

Sometimes the tide is divided into two half-day tides in its progress up a river (as in the Forth in Scotland).

In all cases, after a certain point, the tide dies away in ascending a river.

44. The tide observations made at any place, when the times and heights of high water (and of low water) have been deduced in the way directed in Articles 2, 3, 4, 5, 6, may be entered in a table of which the form will be given, and must then be sent to the Hydrographer's Office in the Admiralty.

45. It is to be remarked that, though there is generally an A. M. and a P. M. tide, there is one day in every half-lunation on which there is only one tide.

(Because the interval of the two tides is, on the average, about 12h. 24m.; so that if there be a tide at 11h. 50m. A. M., there will be no other tide till 12h. 14m. P. M., that is 0h. 14m. A. M. of the next day.)

46. *Self-registering tide-machines* are used in several places, and may be constructed at no great expense. (They are made by Mr Newman, of Regent Street, for about 30*l.* : they are constructed so as to work with a tube and float, as described in Art. 3.)

These machines give the whole course of rise and fall of the tide; and record several successive tides on the same paper.

47. The wind often produces a considerable effect upon the tides, especially upon the height, and should be noted, although it is difficult to give any general rule for the effect.

48. The surface of the sea rises and falls as the barometer falls and rises; namely, about 1 inch in every $\frac{1}{20}$ inch of mercury. This may be applied as a correction when very exact observations are made

NOTE A.

Note to Articles 17, 19, and 37.

To find the Hour of High Water on any day, at any place, when the Establishment of the place is known.

The rule is different (as to amount) according to the *tidal force* of the sun; for though the tidal force of the sun in theory is the same at all places, it is found by observation to be different at different places.

This difference appears in the different ratio of the rise of spring-tides to the rise of neap-tides: (this difference is the semimenstrual inequality of heights.) In general the rise of spring-tide is about double that of neap-tide, which gives the solar tide *one-third* of the lunar tide. But in some cases the spring tide exceeds the neap tide only by one-third, which gives the solar tide *one-seventh* of the lunar tide.

Also the difference of the greatest and least lunitidal intervals (that is, the semimenstrual inequality of times: see Art 13 and 16) shows the difference of the solar tidal force at different places. The difference of the greatest and least intervals is 1h. 28m. at London and Liverpool, but at Playmouth it is 1h. 36m., and at Portsmouth 1h. 21m. On the coast of North America it is generally less than 1h. 20m., while at some places on the coasts of France and Ireland it is above 2 h.

We may take 1h. 28m as the mean value of this difference, which agrees with the supposition that the solar tide is about one-third the lunar tide.

In finding the hour of high water on any day when the *vulgar* establishment is known, the rule will also be different according to the age of the tide. We shall give the rule when the tide is a day and a quarter old, and also when the tide is two days and a half old. In general, the tides will be between these limits.

(1.) *Tide a day and quarter old.* Minutes to be added to or subtracted from the establishment according to the hour of the moon's transit on the half day in question :—

Hour of the Moon's Transit after Sun.	h. 0	h. 1	h. 2	h. 3	h. 4	h. 5	h. 6	h. 7	h. 8	h. 9	h. 10	h. 11
Correction of the vulgar Establishment to find the Lunitidal Interval......	m.	m. —16	m. —32	m. —47	m —57	m. —60	m. —47	m. —16	m. +15	m. +28	m. +25	m. +15

For example—if the establishment be 2h. 27m., at what hour will the high water come from a moon's transit which takes place at 4h. A. M. ? The minutes to be added to 2h. 27m. for 4h. transit are, by the table,—27m. ; therefore the high water will be at one 1h. 30 m. after the moon's transit, that is, 5 h. 30 m.

(2.) *Tide two days and a half old* :—

Hour of Moon's Transit.	h. 0	h. 1	h. 2	h. 3	h. 4	h. 5	h. 6	h. 7	h. 8	h. 9	h. 10	h. 11
Correction of the Establishment..	m.	m. —15	m. —31	m. —47	m. —62	m. —72	m. —75	m. —62	m —31	m. 0	m. +13	m. +10

This table is to be used in the same way as the other.

Hence we see that the age of the tide most affects the lunitidal interval when the time of moon's transit is between 7 and 8 hours *

The mean lunitidal interval, or *mean establishment*, is 16 minutes less than the former and 31 minutes less than the latter establishment supposed in the above tables. (See Art. 37.)

If the tides are observed for a semilunation, or any complete number of similunation the mean lunitidal interval or mean establishment (see Art. 37), will be found by taking the mean of all the lunitidal intervals observed.

The lunitidal interval *corresponding* to any given distance of the moon from the sun

* Hence it is desirable to make tide observations in the first place and fourth quarters of the moon, rather than in the second and third quarters.

may be found by the following table. But the tide corresponding to the given distance may not really *occur* till one, two, or three days later, according to the age of the tide.

(3.) Correction of *mean* establishment.

Hour of Moon's transit (1, 2, 3 days preceding)	h. 0	h. 1	h. 2	h. 3	h. 4	h. 5	h. 6	h. 7	h. 8	h. 9	h. 10	h. 11
Corresponding Correction of Mean Lunitidal Interval	m. 0	m. −16	m. −31	m. −41	m. −44	m. −31	m. 0	m. +31	m. +44	m. +41	m. +31	m +16

This table may be used when we know the age of the tide. Thus, let the age of the tide be a day and a quarter, and the mean lunitidal interval 2h. 11m.; let the moon's transit take place at 4h.; then at the *birth of the tide*, a day and a quarter earlier, the transit took place at 3h.; therefore the correction of the lunitidal interval is, by the table, —41m. and the interval so corrected is 1h. 30m., which, added to 4h., the time moon's tra nsit gives 5h. 30m., as the time of high water.

To find the Establishment at any place when the Hour of High Water on a given day is observed.

On the given day, the time of the moon's transit is known, and hence the lunitidal interval; and, by the above tables, the correction by which this differs from the establishment is known.

Thus, if high water occur at 5 o'clock when the time of moon's transit is 3h., the lunitidal interval is 2h.; and the correction (if the table be applied) is—47m.; thence th e establishment is 2h. 47m.

NOTE B.

NOTE TO ARTICLE 25.

The Rule of the Diurnal Inequality.

The Diurnal Inequality depends upon the moon's declination, as has been said already. It increases from 0 up to its maximum, and decreases to 0 again, as the declinatio n does so; following these changes at an interval of one, two, or three days, according to the age of the tide. The rule is expressed in this way :—

For *north* declination of moon.

Add to the tide following moon's *south* transit;

Subtract from the tide following moon's *north* transit.

For *south* declination of moon,

Subtract from the tide following moon's *south* transit;

Add to the tide following moon's *north* transit.

The south transit is the superior transit in the northern hemisphere, and the north transit the inferior. The contrary is the case in the southern hemisphere.

FORM FOR TIDE OBSERVATIONS.

Tides observed at , *Lat.* , *Long.* *By*

Mode of observation .... { Fixed scale in open water? Tube with float? Self-registering gauge?

Mode of deducing H. W. and L. W. .... { Mere looking? Ordinates every 5 m. near max?

1848.		High Water.		Low Water.		Wind Barom.	Moon's* Transit.	Lunitidal Interval. H. W.*
Month.	Day.	Height.	Time.	Height.	Time.			
	1 A. M.							
	P. M.							
	2 A. M.							
	P. M.							
	3 A. M.							
	P. M.							

* These columns to be filled at leisure (see Art. 13, 41.)

GEOGRAPHY.

BY W. J. HAMILTON, Esq., Pres. R. G. S.

Before alluding particularly to the individual objects to which, in reference to Geographical observations, the attention of travellers should be more immediately directed, it may be, perhaps, expedient to mention a few general points which should be constantly bore in mind as the basis of all observations, inasmuch as without them, all individual remarks, however carefully made, must be desultory and unsatisfactory.

Most prominent amongst these general points is the necessity of acquiring a habit of writing down in a note-book, either immediately or at the earliest opportunity, the observations made and information obtained. Where numbers are concerned, the whole value of information is lost, unless the greatest accuracy is observed; and amidst the hurry of business or professional duties the memory is not always to be trusted. This habit cannot be carried too far. A thousand circumstances occur daily to a traveller in distant regions, which, from repeated observation, may appear insignificant to himself, but which may be of the greatest importance to others, when brought home in the pages of his note-book, either as affording new information to the scientific inquirer, or as corroborating the observations of others, or as affording the means of judging between the conflicting testimonies of former travellers.

It is also important, in order to secure accuracy, that the observations should be noted down on the spot. It is dangerous to trust much to the memory on such subjects, and if the observation be worth making, it is essential that it be correct. And here it may not be inappropriate to hold out a caution against too hasty generalization. A traveller is not justified in concluding that because the portion of a district, or continent, or island which he has visited is wooded or rocky, or otherwise remarkable, the whole district may be set down as similarly formed. He must carefully confine himself to the description of what he has himself seen, or what he has learned on undoubted authority.

Again, to the geographer, the constant use of the compass is of the greatest value. No one attempting to give geographical information should ever be without an instrument of this kind, as portable as is consistent with correctness. The bearings of distant points, the direction of the course of a river, however they may be guessed at by the eye, can never be accurately laid down without the compass; and these should be immediately transferred to the note-book. This and his compass should on all occasions be his constant and inseparable companions. In using the former, he should not forget that slight sketches of the country, and of the peculiar forms of hills, however hastily and roughly made, will often be of more assistance in recalling to his mind the features of the district he has visited then long and elaborate descriptions. Let him then acquire the habit of never quitting his ship without his note book and pencil and his pocket-compass, and although at times it may seen irksome to have to remember and to fetch these materials, the traveller, if he acquires the habit of constantly using them with readiness, will never have reason to regret delay or the inconvenience which may have temporarily arisen in providing himself before starting with such useful companions.

Having made these few introductory remarks, I shall proceed to describe as briefly and succinctly as possible some of the principal features to which the attention and the inquiries of the young geographer should be chiefly directed. For this purpose I propose dividing the subject into two heads, which, without straining the use of words, may be not inappropriately called Physical and Political Geography. By physical geography I mean everything relative to the form and configuration of the earth's surface as it issues from the hand of nature, or as it is modified by the combined effects of time and weather, and atmospheric influences. By political geography I would wish to imply all those facts which are the immediate consequences of the operations of man, exercised either on the raw materials of the earth, or on the means of his intercourse with his fellow creatures.*

1. Physical Geography.

The principal heads under which this branch of the subject may be divided, and respecting each of which it will be necessary to say a few words, are—

1. Form of country; whether consisting of hills, valleys, or plains.
2. Mountain ranges; their direction, height, spurs, woods, and forests.
3. Rivers; their sources, obstacles, size, affluents, and confluents.
4. Springs; whether hot or cold or mineral, their localities, temperature, &c.
5. Lakes, marshes, lagoons; how surrounded, &c.
6. Coast line, mouths of rivers, their beds and banks, habours, nature of shore; sandy, rocky, or muddy.

1. *Form of country; whether consisting of hills, valleys, or plains.*—The general configuration of a country is the first object which engages the attention of a traveller on entering a new locality, and this may be described in general terms as flat, undulating, hilly, or mountainous; or the country may be divided into districts, to each of which one of the above terms of configuration may be applied. Each of these, however, is susceptible of great modification. A *flat* country may be a sandy desert, a rich alluvial plain, or a marshy, boggy tract; it may be well watered by rivers and streams, or arid and parched up; it may contain numerous lakes; it may be barren or wooded, or cultivated as arable or grass land: each of these features may be of importance, or at least of interest; nor must the nature of its soil be omitted, whether sand, or marl, or clay, as the appearance of the country will often depend greatly on this circumstance. Another important characteristic is its general form and extent, and the natural features by which it is bounded, whether mountains, rivers, or seas; how many miles wide, and how many long; whether extending parallel with the coast, or running up between hills into the interior.

Many of these characteristics, it will be observed, belong equally to the other forms which constitute the character of the district. An *undulating* country may be barren, wooded, or cultivated; it may be arid, or watered by streams &c. The undulations may be abrupt, or only gently sweelling, and this may be in a great measure owing to the

* An Italian writer of considerable eminence, Count Annibale Ranuzzi, in a little work published at Bologna, 1840, entitled 'Saggio di Geografia Pura,' divides geography into two branches, which he calls pure and statistical geography: the former professes to describe the results of physical forces, the latter the effects of moral force; the former expressed by measurement, the latter by numbers.

nature of the sub-soil, whether it consists of gravel, or sand, or rock; but a country of this description is easily described. A *hilly* country, on the other hand, is more complicated. Not only is the term vague and uncertain, but other features have to be considered. Neither hills nor mountains can exist without valleys, and these also deserve to be considered and described. Then, again, the hills themselves may be of various forms and characters; do they extend in long parallel chains or ranges, or are they detached and isolated? Do they radiate or converge? Do they rise abruptly or gradually from the low country? and how are they wooded? What do the rocks which constitute their nucleus consist of? If possible, it is desirable to ascertain their height, which, in the absence of complicated instruments and barometers, may be very fairly obtained approximatively by marking the exact point at which pure fresh water boils. Of course the same accuracy cannot be obtained as with the barometer, but much may be done with the help of well-graduated thermometers.

2. *Mountain ranges.*—The most important features in the configuration of a country, are the mountain ranges by which it is traversed. The exact point of the distinction between a hill and a mountain is difficult to describe; in some cases it will be purely comparative, in others it will depend on the general character of the country, and in some it will be arbitrary. But in all cases it will be desirable to endeavour to ascertain the height of the principal points, the direction of the main ranges or chains, and whether they are parallel or not. The ridges also may be *serrated* (jagged like a saw), or smooth and even, and the summits themselves will be either pointed, or dome shaped, or flat. Is the mountain insulated or not? and if so, is it conical, and sloping on all sides to the surrounding plains, or does it consist of a detached ridge? Many of these points will be found to depend on the geological formation of the country, and this branch of our subject is very closely connected with that science. It is also desirable to ascertain how far the mountain tops are covered with perpetual snow, and how far down their sides snow lies during the whole year. Is there any marked difference in the slope on the one side or on the other? Does vegetation abound more on one side than on the other? *e. g.* in Asia Minor all the mountain ranges which extend from E. to W., and this is their principal direction, are covered on their northern flank with luxuriant vegetation and magnificent forests, while the southern flanks, exposed to the rays of an almost tropical sun, are void of vegetation, barren and generally rocky. Here, again, we trench on the province of the botanist; and yet the geographer should inquire how far vegetation extends up the mountain side, and what are the changes which it undergoes. How far is it influenced by the change of soil, or the abundance or absence of springs? Nor can we complete our information respecting a mountain chain, unless we know the length to which it extends, and the breadth of country which it covers.

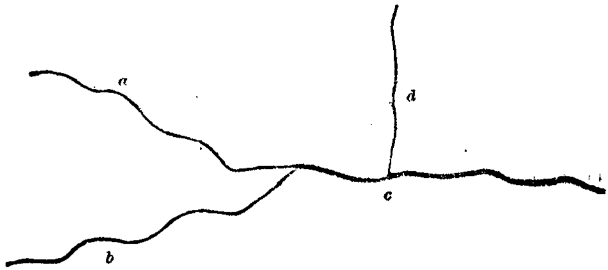
Valleys are a necessary complement to mountain masses, and there are many peculiarities connected with them well deserving observation. Are the sides precipitous or sloping? are they wide or narrow? well watered or arid? wooded or barren? Do the rocky sides correspond with each other in their salient and re-entering angles? How far do they extend into the bosom of the mountains? and how are the subordinate valleys connected with the principal one? But there is another peculiarity of valleys not to be lost sight of. There are some which convey to the traveller the impression that he is passing through a mountainous or hilly country, so steep, rugged and lofty are the hills by which he is surrounded. It is only on reaching their summit that he becomes aware that the country through which he has been passing in an extensive plain, or table-land, intersected by deep chasms and valleys, cut through the soft soil by the constant efforts of the streams by which it is traversed; such valleys of excavation as these have been sometimes not unaptly called negative valleys.

3. *Rivers.*—Scarcely less important than that of mountains is the effect of rivers in modifying the geographical configuration of a country. From their sources in the mountain recesses to their final disemboguing in the sea, their course, their currents, and their shores afford an endless variety of remarks and observations. The depth and colour of the water, the rate at which it flows, the eddies and currents by which its course is marked, are all deserving of notice, as are also the rocks and shoals which obstruct its uniform progress, either interfering with its navigation, or, by projecting beyond its ordinary banks, throwing back the rushing torrent on the opposite shores, as has been so eloquently described by the Latin poet:—

> Vidimus flavum Tiberim, retortis
> Littore Etrusco violenter undis,
> Ire dejectum monumenta regis,
> Templaque Vestæ—

thus causing the gradual fall of the cliffs by undermining their precarious foundation. Nor in describing the size or extent of rivers should we neglect to state how far up they are navigable, to what vessels, and by what means, whether the mouth is constantly free, or whether closed by a bar, and how much water there generally is over it. Some rivers, however, are not only closed by a bar, but, as in the case of Western Australia, are during periods when the water is low, completely masked by the sand-hills or dunes which are blown up, forming a continuous bank with the hills which skirt the shores, and only when freshets of more than ordinary force come down are these sandy barriers overthrown, and the rivers enabled to find an uninterrupted outlet. In other cases the effect of beaches thrown up by the constant set of currents in one direction is not so absolutely insurmountable, the streams are only partially deflected from their proper course, and instead of flowing into the sea in a continued line, are compelled to run for some distance parallel to the coast, until the accumulated backwater has acquired sufficient power to overcome the diminished resistance of the sea-beach: this, however, more properly belongs to the consideration of the coast line.

But the description of a river will be imperfect, unless we also state the number and character of the streams which fall into it. And here we have to consider the angle at which the rivers join each other, whether the direction of the main stream is altered or not by the junction, the relative size of two confluent streams, and which of them may be said to preserve its former course with the smallest deviation. On the true description of these details must depend the question as to which of two confluent rivers should be considered as the main or parent stream. Rivers are said to be confluent when both branches are nearly equally deflected from their former direction, and that of the united streams may be said to be the resultant of two contrary forces. An affluent is a stream which falls into another called the recipient without changing the direction of the latter, and entirely losing its own.



a and *b* are confluent streams, *d* is an affluent falling into *c*, the recipient.

And affluent, too, may generally be said to be smaller than its recipient, and may often be more correctly called a rivulet or a torrent; and here it may be remarked that there is a great advantage in attending to the true and proper use of these relative terms, rivers, torrents, rivulets, or brooks, the two latter being more or less synonymous, and a torrent being generally applied to a rapid mountain stream; all these, more or less, bring down detritus from the hills, which is deposited at the mouths of the streams, or wherever other natural causes retard the rapid flow of water. In these cases deltas are formed, which deserve examination, and are either fluviatile, lacustrine, or marine, according as the river empties itself into another river, a lake, or the sea.*

But there are other important characters which deserve attention in the description of a river; and chiefly the *name* of its importance. Does it change during its course, and where and when? How far up from the mouth is the same name preserved? and is it the same on both banks? What is its origin, and by whom was it first given? Then we must inquire what islands are met with in its course? Where are they situated? Are they low? subject to inundation? marshy or rocky? or do they stand high above the level of the stream? Are they cultivated or not? What are their natural productions? By what creatures are they inhabited? Again, is the river at all affected by rapids, or shoals, or cataracts? and what are the peculiar characteristics of these impediments to navigation? Does the tide flow in them, and how far up is it felt? Does the river abound with eddies or whirlpools, and how are they occasioned? Do they interfere with navigation or not? Are they accompanied by rocks or shoals? Again, we must ascertain what fords a river offers, and what depth of water is generally found over them: the nature of the bed of the river, particularly in the case of a ford, should also be carefully ascertained.

In addition to these remarks, many other important peculiarities will often be discovered by the careful observer. In some countries, particularly in secondary limestone districts, the rivers are remarkable for their subterranean courses.† Suddenly emerging in large

* See Col. J. J. Jackson's work, 'What to Observe. London, 12mo., 1841.

† Styria and the neighbourhood of Trieste.

volumes from the base of a lofty mountain, they flow across rich alluvial plains, and are then as suddenly lost in the cavities of another mountain, again to issue forth to the light of day, in a distant region, after their subterranean course. Nor should the traveller omit to notice, when crossing a river, the direction in which it flows as regards his own course, whether to the right or to the left. Several distinguished travellers have been unable to connect their observations from not having attended to this point.

4. *Springs.*—The phenomena connected with the outbursts of water from the surface of the earth are not only of the greatest interest, but a correct observation of them is attended with the greatest practical advantage. The traveller should state, approximatively at least, their size or volume, and the nature of the rock or soil out of which they rise ; also whether they are pure or mineral, and what deposits are formed about the orifices through which they issue ; how they are affected by different seasons ; whether they are of ordinary temperature or thermal, and if the latter, it is desirable to ascertain the degree of heat by means of a thermometer : the touch alone is a very vague and uncertain guide. It is also desirable, when it can be done conveniently, to procure specimens, in closely sealed bottles, of the water of such springs as appear to possess mineral properties, or to contain salts in solution, for the purpose of analysis at home. Naval officers whose ships are at hand have in this respect great advantages over those whose only means of transport is on horseback or on camels.

5. *Lakes.*—These sheets of water varying greatly in size, form very important features in the geographical description of a country, and the traveller should carefully remark their connexion with the other hydrographical features of the district. Whether they constitute the sources of rivers, or are their ultimate recipients, whether they are or are not connected with the ocean or other great seas, their levels with regard to the ocean, particularly when at a lower level, what rivers flow into or out of them, and whether they are fresh water or salt.

I cannot here do better than quote the following remarks from Colonel Jackson's work, who says, " With regard to lakes in general, the observations to be made upon them may be comprehended under the following heads :—

" Name ; geographical and topographical situation ; height above the level of the sea, and as compared to other neighbouring lakes ; subterranean communication ; form, length, breadth, circumference, surface, and depth ; the nature of the bed and of the borders ; the transparency, colour, temperature, and quality of the water ; the affluent streams and springs ; the outlets, the currents ; the climate, soil, and vegetation of the basins ; the height and nature of the surrounding hills when there are any ; the prevailing winds ; the mean ratio of evaporation compared with the quantity of water supplied ; and any particular phenomena ; the navigation and fisheries of the lake ; formation and desiccation of lakes." This latter point, depending as it mainly does on the relative elevation or subsidence of the country, may indeed be said almost to belong to the kindred science of geology, and yet it bears so immediately on the physical configuration and geographical features of the country, that it may fairly be mentioned in this place.

Connected with the question of lakes, are the scarcely less important features of lagoons and marshes, and smaller hollows called ponds; the extent of these marshes and lagoons should be ascertained, also whether connected with the sea or not; and what portions of them become dry and passable during the summer or other periods of the year. Peat bogs, in many cases the remains of former lakes, may also be classed amongst these features, and their extent and depth and qualities should be ascertained.

6. *Line of coast*, &c.—This may be indeed said to be the peculiar province of the naval officer; but as forming one of the chief boundaries of those great geographical subdivisions, details of which we have been here alluding to, we must not omit a brief allusion to some of its most important features. And 1st, with regard to the actual line of coast itself, the traveller should remark the various headlands jutting out into the sea, as well as the deep bays and recesses running up into the land, and affording refuge from the dangers occasioned by the neighbouring headlands; all gaps and breaks in the continuity of hills or cliffs, or mountain ranges, the occurrence and nature of rivers and streams emptying themselves into the sea, the character and extent of their mouths, the nature of the detritus and alluvial matter brought down by them, and whether or not deltas are formed near their mouths. In another aspect he should inform us whether the coast is bold or flat; whether formed by cliffs or by sloping plains, and whether the rivers enter the sea by one or by numerous channels; whether the coast is clear from danger, or whether sunken rocks and reefs render more than usual precaution necessary in approaching it; whether the sea deepens gradually or suddenly, and whether there are any extensive shoals or sand-banks. Soundings also may be given when practicable, as well as the nature and colour of the sand, clay, or other substances brought up from the bottom by the lead. Do these appear to belong to the same formation as the adjacent mountains, or to have been carried thither by tides or currents, &c.

The nature of the shore, also, should be carefully ascertained, whether it consists generally of sand or mud, or rocks, either in the shape of reefs, or occurring as detached blocks, also whether the landing is easy or not on the beach, and whether this consists of sand or shingle. What bays or coves occur along the line of coast to serve as harbours of refuge? What is the nature of the anchorage? Are there any harbours along the coast? and how far have natural harbours been rendered more available and safe by the erection of breakwaters or piers?

In concluding this portion of the first division of physical geography, I would also mention a few points connected with the physical features of the country which deserve notice, but which, being of accidental rather than of a normal character, did not easily find a place in any of the natural subdivisions of the subject. The traveller should always pay particular attention to those phenomena in the physical structure of the country which may be called by some persons natural curiosities. Amongst the principal of these are grottoes, caves, and caverns; some of them are not only strikingly beautiful, but of great scientific interest. They are more usually met with in limestone districts than in any other; it is interesting to ascertain their size and extent, and the distance to which they have been traced. Are they traversed by subterranean streams, and if so, do these streams enter or escape by known channels or mouths, as is frequently the case in Istria and Carniola, and in the west of Ireland? Natural bridges present another instance of this kind of phenomena. How have they been formed, and what is the nature of the rock of which they consist? Are they stalactitic, or of a more compact nature? Mines are also to be noticed, although they come more directly under the head of geological observation. All volcanic phenomena and earthquakes are also deserving of notice. Springs of fresh water rising up in the sea are not of unusual occurence; and any information respecting them is always desirable, such as the depth of water and the effect of the fresh water on the surrounding ocean. Any instances of that remarkable phenomenon observed in Cephalonia, where the sea-water flows inland into a hollow in the rocks, should also be carefully described. In short, it may be safely asserted that there is no single fact connected with the physical structure of the earth, falling under the notice of an intelligent observer, which may not be of value or importance either to himself or others, if he will only give himself the trouble of carefully noting down the main facts on the spot itself, with as much accuracy and detail as circumstances will permit. With this view we must again urge what was stated at the beginning, and would add in the words of Mr Darwin, "Trust nothing to the memory; for the memory becomes a fickle guardian when one interesting object is succeeded by another still more interesting."

II. Political Geography.

We now proceed to notice some of the principal features to which attention should be directed on the subject of political or statistical geography. In many respects this branch of our subject approaches very closely to that of statistics, to the consideration of which a distinct and separate article will be devoted; we will however endeavour to steer clear of collision, by confining ourselves to the definition already given, and by avoiding those questions of detail which are more peculiarly the province of the statist. Nor can it be expected that the casual visitor should devote to the examination of documents and books the time that is necessary to arrive at any important results in reference to these questions, or to make much progress in the investigation of a subject, however important, the whole value of which depends on the extent and minute accuracy of its detail; but yet there are many matters connected with man's social state which the traveller may easily elucidate by availing himself of the opportunities thrown in his way, and carefully preserving the information he obtains.

This branch of our subject may properly be divided into the following heads:—

1. Population; different races of inhabitants.
2. Language; words and vocabularies.
3. Government; ceremonies and forms.
4. Buildings; towns, villages, houses.
5. Agriculture; implements of labour and peculiarities of soil.
6. Trade and Commerce. Roads, and other means of communication.

1. *Populatian.*—One of the most interesting inquiries on visiting new countries relates to the people by whom they are inhabited. It is not enough to ascertain the mere amount of population, although even this is by no means easy; and unless obtained from official documents, it cannot always be relied on. The oral information first obtained by a stranger is almost invariably incorrect, and particularly so in barbarous countries and amongst an ignorant population, where truth and accuracy are equally disregarded. Various sources must be referred to before we can venture, in such cases, to place confidence in our information. Another and more interesting question, as regards the population of a country is the nature and character of the races by which it is inhabited; we wish to know whether they all belong to one of the great races of the human family, or to a mixture of several; how far the national character has been affected or modified by such mixture; whether it to place long ago, or is an event of recent occurence. In

many instances, casual intercourse with the natives will lead to information on this subject; local traditions will be found to have been preserved, which, after making due allowance for exaggeration and prejudice, will generally give a clue to the details required. It is also worth noticing, when the population consists of various races, whether one race of nation is more confined to a rural or a town life than the other; whether there exists any feeling of hostility or jealousy between them; whether any particular trades or occupations are more exclusively practised or followed by one race than the other; whether one race is kept down or oppressed by the other, or whether they enjoy a state of comparative equality.

When the population of a country has up to a certain period consisted of one race, and mixture has subsequently taken place, this change may have been occasioned in three different ways. The new race may have come down with force and violence on the original inhabitants, and having gained possession by right of conquest, may have constituted themselves the masters of the country; or, secondly, they may have been introduced, as slaves in the first instance, captured in war or taken by stratagem by their more successful neighbours; or, thirdly, they may have come gradually, few at a time, with the free consent of the inhabitants, seeking to make their fortunes in a new country as settlers or as colonists. Any information on these points, where a mixture of races does exist, will be interesting. Not only will the moral character of the united people be differently influenced, but even their political rights, their institutions, and form of government, will have been greatly modified, according to the different modes by which the union of the two people was effected.

In many cases, too, the traveller may have opportunities of making useful observations respecting the general character and disposition of a people. Are they of a warlike or a peaceful disposition? Have they made any progress in the arts of civilization or of commerce? Do they possess any and what extent of literature? Are they remarkable for their honesty, or for contrary propensities? Are they open and frank towards strangers, or the reverse? Do they made any distinction in their dealings between natives and foreigners? How do they dress and live? What are their domestic habits and relations? Do they encourage or prohibit polygamy, and are woman treated with respect and consideration? Without going profoundly into the study of these questions, the attentive observer cannot fail to pick up many interesting details and facts on these subjects, all of which may hereafter be of use to himself or to others.

2. *Language.*—The traveller will have many opportunities of collecting much interesting information respecting the languages of those countries which he visits, by taking notes of all the peculiarities he may have an opportunity of observing respecting them, when he feels confidence in the accuracy of his information. These observations do not of course apply to the languages of Europe, and to those of the more civilized nations of the East, viz. the Arabic, the Persian, or Mahratta, &c., but are rather intended for the guidance of those who visit the islands of the Pacific, or the Indian Archipelago, Australia, Africa, and other lands, of which the languages are still unknown.

In this respect there will in all probability be great analogy with the previous subject. Where a nation has sprung up from the mixture of two races, it will generally, if not universally, be found that the language bears traces of the same admixture. Analogous elements of combination will have produced an analogous result in a language partaking of the essential characters of those of which it was composed. Any information, therefore, showing how far the grammatical construction of the resulting language or particular words are derived from one or the other of the parent tongues, will be important. Nor should these observations be confined to mere words, and their affinities in different languages. It is equally desirable to obtain information respecting the genius and character of languages; to remark how far the idoms of one correspond with those of another; and whether the resemblances observed between the languages of various nations can in any way be traced to any original connexion between the nations themselves, or to political or commercial relations existing between them at a former period.

But it is not alone with reference to the comparisons to be made between different languages that it is desirable to obtain correct information. Even when the traveller has no opportunity of comparing several languages, he may collect much valuable matters by attention to any one in particular. Above all things, let him endeavour to make as complete a vocabulary as possible of all those words, of which he can depend on obtaining the true and precise meaning. Nor are words alone to be attended to: all peculiarities of diction, all idiomatical expressions and phrases, ought to be remarked and carefully written down. With respect to the languages of many barbarous, yet interesting people, it is only by the repeated observations of successive travellers, and by the comparison of such observations with those of others in different regions, that we can at last obtain any idea of their nature, their genius, and their origin. It may also be useful to ascertain how far foreign words have been introduced into the language, and to what extent they are used,—whether confined to one or more classes of the population, whether they are more particularly used by the military, the commercial, or the manufacturing classes.

3. *Government.*—It is hardly to be expected that those for whom these remarks are principally intended will have the time or opportunity to make many inquiries, or to collect much correct information on the details of government in its various branches, in the countries they may visit. Many of these details, even if they could be obtained, would be more appropriately noticed under the head of Statistics. There are, however, several points connected with this subject on which an intelligent traveller can hardly fail to make useful and interesting observations. Amongst these we may mention all kinds of forms, ceremonies, and processions, whether of a religious or civil nature; the observance of religious rites, where strangers are not superstitiously excluded; the ceremonies and processions which are generally a part of such rites, and which for the most part take place in the open air, afford many opportunities for remark. Royal pageants and processions, military manœuvres and encampments, the dress and bearing of the troops, are all worthy of notice. Many municipal institutions necessarily come under the observation of travellers, as matters of police and surveillance, passports and other documents required by the authorities, as well as any other regulations necessary, or supposed to be so, for the maintenance of peace and order. What are the principal taxes, and how are they levied, and on what articles are they imposed? What is the principle of taxation—direct or indirect? Public institutions, also, in those countries where the state of society warrants their existence, and can secure their continuance, whether maintained by the liberality

of the state or supported by the zeal and resources of individuals, may well deserve a passing notice, even if more detailed information is not accessible. These, too, may be of very different characters, and may have various objects in view: they may be intended for the promotion of literature amongst the old, or of education amongst the young; they may tend to the furtherance of trade and commerce, or they may only look to affording amusement and relaxation. Something at least on all those subjects will not escape the eye or ear of the most casual observer.

4. *Buildings.*—In considering the buildings of a people, they may present themselves to our notice under several points of view. We may, in the first place, consider them as public or private. Amongst the former we shall find such as belong to the nation generally, either as the residence of the sovereign, or as belonging to the different departments of the executive government, or to the legislature, or as devoted to the alleviation of suffering, or to the maintenance of health, as poorhouses, hospitals, and infirmaries of various kinds. They may be devoted to the service of God, or to the deities worshipped by uncivilized nations, as churches, temples, mosques, and other similar edifices; or they may be intended for the advancement of literature and science, such as colleges and university buildings, museums, picture galleries, &c.; or erected for the amusement and recreation of the people, or for the furtherance of public business, as market-places, town-halls, theatres, &c. With regard to private residences, the different purposes are not so numerous; but even here we may distinguish the habitations of the rich and of the poor, and those intended for town or country residences; the different styles of villages in the country, and the character of streets and houses in the towns, villas, farm-houses, &c., and, in some cases, the different dwellings of different tribes. This, in the case of those nomadic people who still dwell in tents, is very remarkable.

Again, we may consider the buildings of a people either with regard to the degree of civilization of which they may be considered as the evidence, or to the progress in art and architecture which they may be held to indicate. For this purpose, not only is it desirable to point out the style in which they are erected, but also the materials which have been used, and the mechanical contrivances by which they have been assisted. In this case, slight sketches will often convey a clearer idea of the object than long and minute descriptions. Nor should we neglect altogether another class of buildings, partly private and partly public in their nature, which often convey much information with respect to the character and progress of a people: I mean their tombs, and other sepulchral monuments, erected to the memory of the dead, or for the purpose of preserving their bodies. It may be observed that few things indicate more directly the progress of a people through different stages and degrees of civilization than the successive changes which have taken place in the style and character of their buildings, and of the arts by which they have been embellished, from the first rude attempts of Druidical and Cyclopean structure to the more elaborate and symmetrical proportions of what may be called the Palladian style. Any information of this description which falls under the notice even of the most hurried traveller cannot fail to be productive of great interest.

5. *Agriculture.*—The geographer will have numerous opportunities, in his examination of a new country, of obtaining much valuable information on this and its collateral subjects by a little attentive observation, and a few concise inquiries. Amongst the chief

points to which his attention should be directed, we may mention the use of tools and agricultural implements, for the purpose either of cultivating the soil, or of transporting its produce from one locality to another, the mode of ploughing and preparing the land for different crops, the manner of raising the crops themselves, of sowing, planting, and transplanting, of reaping and gathering in the crops, of threshing, and other similar occupations, the rotation of crops, and whether, and under what circumstances, more than one crop is raised in the year.

Other inquiries may be usefully directed towards the animals used for agricultural purposes or domestic economy, in the field or in the farm yard; whether they are indigenous, or brought from distant or neighbouring countries; to what uses they are applied, whether for draught, for food, or for clothing. How are they fed? Are they of a hardy or delicate constitution? Have any changes taken place of late years in the state of agriculture and tillage? Is it in a course of progress or decay? What is the feeling of the inhabitants towards it? Is it practised by the majority, or only a small portion of the population? What buildings form a part of agricultural capital, farm houses, barns, and cottages? All these depend on the social state of the inhabitants. Is the pursuit of agriculture esteemed or despised? What are the usual prices of provisions—animal and vegetable? To which do the inhabitants give a preference? What is the principal produce of the country—vegetables, fruits, cerealia, meat, or poultry? What is the tenure of land? Is it distributed in large estates, or subdivided into small properties? Is it chiefly in fee, or held on long or short leases from year to year? What is its chief feature—arable, meadow grass, or woodland? What are the respective quantities of each? What is the nature of the soil, and what distinctions are there in it? Is one kind more adapted for one species of cultivation than another, and whence is this difference derived, and by what natural causes has it been occasioned or modified?

6. *Trade and Commerce.*—Our information respecting a country cannot be complete without some knowledge of its trade and commerce, and the manner and the means by which they are carried on. In this respect, also, without stopping to inquire very minutely into the statistical details of the resources and means of a country, the travellers for whom we write can add much to our information by the mere recording of the facts which come under their own observation. What is the nature of the trades chiefly exercised by the different classes of the population, and by different tribes, when such exist? Are they principally employed in working up the raw materials produced in their own country, or those imported from other quarters? Are they workers in metal, and whence are the metals obtained? Or are they workers in leather and similar materials? Or do they spin and weave, and what are the materials worked up in their looms—whether wool, cotton, flax, or silk—and which, if any, of them are raised in their own country, and from what other districts do they draw their supplies when requisite? Is their commerce chiefly domestic, foreign, or transit, and by whom is it carried on? What are the principal articles of import and export? Where do they come from, and whither are they sent? What is the medium of exchange? What progress have they made beyond the mere principle of barter? Is money used as a medium of exchange? What coins are known? Have the natives any knowledge of bullion, paper, or bills of exchange? Have they any system of credit or bill-discounting? How is commerce conducted? What are the means of communication—water or land? If by water, what is the nature of their ships and

vessels? Are they employed at sea, or on rivers or canals? What is the character of their sailors? If by land, have they yet learnt the use of railroads? What is the nature of the roads and other tracks? Are they available for carts and waggons, or only for beasts of burthen? What beasts are used—horses, mules, asses, bullocks, or camels? Which are most useful? How are the roads kept up? Are they in good or bad condition? Are the bridges well built and well kept up? What is the ordinary rate of travelling, and the expense of carrying goods? What are the weights and measures used in the country? Are they the *same* in trade or commerce as in private life? Many of these questions are easily answered, and all will be found useful for one purpose or another.

There remains one subject on which it may *not* be irrelevant to make a few remarks, although there may be some question as to whether this is the proper place for its introduction. Our information respecting distant lands and their inhabitants cannot be said to be complete, without some knowledge of their past history and their antiquities; and we therefore propose briefly pointing out to the traveller a few of the points to which his attention may be advantageously directed. In the first place, in his excursions in the country, let him carefully examine the sites and remains of ancient buildings. This identifying *of ancient* positions, and fixing the names of ancient cities, has not unfrequently been called comparative geography, as establishing a comparison between the ancient and modern state of things. Where the remains appear to indicate the site of a ruined city, let him carefully trace the line of the ancient walls, ascertain the position of the gates, describe or sketch the style of architecture, and state the materials of which they have been built. If the fallen fragments indicate the site of a temple or analogous building, let the traveller endeavour to obtain precise measurements of its different component parts, the length and diameter of the columns, the details of architraves, capitals, and cornices, and whatever other features may attract his attention. Above all things, let him diligently search for *inscriptions*, and then carefully copy *all* that he may find, endeavouring as much as possible to *preserve the precise form of the* characters in which they are written.

Two or three other evidences of ancient art or history remain to be noticed—coins and manuscripts, and works of art. With respect to the former, he cannot be too industrious in collecting all that his means allow him to procure of those which come in his way—taking care, of course, in those countries where such practices obtain, that he is not imposed upon by forgeries. Manuscripts are of more rare occurrence, but even these may safely be collected when possible, and there is less danger of deceit than in the case of coins. With regard to works of art, it is more difficult to lay down any precise rule, on account of their greater variety, and a certain degree of vagueness attaching to the term, and also on account of their bulk and cost. Two classes, however, may be mentioned, which particularly deserve attention—statues and gems. Of the former of these, the traveller will generally be enabled only to make drawings: their size will in most cases prevent their being moved. Gems, on the other hand, whether cameos or intaglios, are amongst the most valuable and portable works of art which a traveller can collect. But let him beware of imposition: nowhere is it more frequently and more notoriously practised. With due attention to these hints, the traveller whose *fate* or duty may lead him to the shores of classic land, cannot fail to obtain much information which will prove not only a source of interest to himself, but will be received with satisfaction and delight by every cultivated mind on his return to his native shores.

PROMISCUOUS EXTRACTS

FROM

JACKSON'S "WHAT TO OBSERVE."

THE scientific traveller, adequately supplied with proper instruments, needs no instruction from us regarding the application of them to the several operations he may have to perform in the course of his travels; but for the unscientific, and for those who cannot take instruments, or may have lost them, we shall point out various modes of operation sufficiently exact for general purposes. Many of these operations comprise what is termed *practical geometry on the ground*, on which subject a treatise was formerly published by Professor Landemann, of Woolwich, some of whose more necessary problems we shall give as eminently useful to the traveller.

Previous, however, to treating of operations requiring the aid of even the simplest contrivances, we will speak of—

MEASUREMENTS BY THE EYE.

There are many cases in which the traveller is desirous of ascertaining heights and distances, which he cannot measure for want of even make-shift instruments, or because he has no time for measuring, or because the objects are inaccessible. It is therefore of great consequence that he should have so practised his eye previously, as to be able to judge by it alone, with considerable accuracy, of heights and distances; and this he must learn to do under all circumstances of atmospheric influence, as objects appear nearer or further removed, more or less high, larger or smaller, according to the different states of the atmosphere. In estimating heights and distances by the eye, it must be remembered that the angle subtended diminishes with the distance, so that in measuring a height or distance by the repetition of any unit, whether it be a hundred yards or ten feet, a less and less apparent space must be taken for the unit, as the part to which it is applied recedes from the eye. Thus it will be found, that if a person who can judge very accurately of the distance of 100 yards along the ground, from the place where he may be standing, were to take the same apparent length in his eye for a second 100 yards, it will, on measuring, prove to be too long: a third unit of 100 yards, extended in this way, would be still farther from the truth, and so on; he must therefore take less and less as he measures onwards with his eye. The same is true of heights: the first 10 feet from the ground may be very correctly estimated, but the last 10 at the top will in reality appear shorter to the eye, and therefore a space successively shorter must be taken for the 10 feet as we ascend. We have hitherto supposed the ground horizontal, and the object whose height is to be estimated, vertical and in the same plane; now it is clear that if the ground rise or fall in front, or is wavy, and if the plane of a lofty object recedes, as in a mountain, or if the planes are different, as in the several parts of the building, or the different buildings of a citadel, *etc.*, the measurements by the eye must be modified accordingly. Thus, if the ground rise gradually, the unit of measure must be less diminished in proportion as the rise be greater, and *vice versâ*, if the ground descend from the spectator. If the ground be undulated, it is very difficult to measure it by the eye, and if the bottoms of the hollows are not visible, or a broad river unseen intervene, it is almost impossible : in either case the best way, perhaps, is to judge of the distance by the apparent size of any object whose natural dimensions are known, such as men, animals, trees, buildings, *etc.* But distances so estimated are little to be relied upon. As regards heights, the higher portion of a mountain is more remote than the lower, and hence, in judging of its height, the unit of admeasurement, as in judging of distances, must be successively diminished. If one hill be in front of another, or one building, or part of a building, be in front of another, it is extremely difficult to judge of the height of the more remote object, not only because the measurement of the eye, as applied to the nearer, is not applicable to the more remote, but because a greater or less portion of the more distant is cut off by the nearer, and the portion cut off is greater or less, according to the height of the nearer object and its distance from the more remote. It need hardly be observed, that greater of units of measure should be used for distant than for near objects. In clear weather, and also immediately after rain, distances appear less, because the objects, being better defined, seem nearer to the eye. In a mist, objects appear larger than they really are, not only because the image painted on the retina is magnified, but because the indistinctness of the object induces us to believe it further removed from us than it really is. It should not be forgotten also, that refraction makes objects on the horizon appear higher than they are, and the curve of the earth's surface depresses objects more or less below the horizon according to their distance. The greater the density of the atmosphere, the greater its refractive power : hence this power is decreased by heat and augmented by cold, and hence the height of the same object will appear different at different seasons and at different times of the same day. It is therefore very difficult to make a correct allowance for the effect of refraction in all cases, more particularly when the precise distance is unknown,—for even tables are of no use without this latter *datum.*

Independent of height and distance, other appearances are often judged of by the eye, and as these are greatly affected by distance, by light and shade, the traveller should be careful not to be led into error by optical delusions. Thus the colours of objects are greatly modified by the quantity of air which intervenes between the objects and the eye. Every one knows that distant mountains have a greyish tint approaching to blue, while in reality they may be clothed with a rich verdure, or be barren rocks of various colours, *etc.* Distance also softens the asperities of objects far removed, so that what may appear to have a smooth surface or regular contour, may, on a near approach, present the greatest ruggedness. But to enter into such details would lead us too far; we must leave the traveller to form his own experience in these matters; recommending only that he so tutor his eye as to be able to reckon upon it with some degree of certainty. We shall now proceed to objects of a more positive character.

ESTIMATION OF DISTANCES AND HEIGHTS BY ACTUAL MEASURE.

And first let us premise that the instruments required are—sticks, the straighter the better; they may be cut rough from the forest, or straight reeds or canes ; or if these cannot be had, men may supply their place, and in some cases stones will answer the purpose, as we shall presently see; a rope or line, or for want of such, the traveller may twist one of grass, straw, or other similar material, which will sometimes answer well enough. In some climates there are long climbing plants or trailing roots which may occasionally do for cords.

STANDARD MEASURES OF LENGTH.

The chief purpose of the sticks and lines just mentioned, or their substitutes, is for measuring; but before they can themselves be used as measures their own length must be determined; hence the traveller, before setting out, should ascertain precisely what parts of his own body correspond to a yard, a foot, *etc.* he should also know the exact height of his eye above the ground, and have learnt to pace regularly, both as to the length of his step and the number of steps he takes in a given time; (he should also ascertain the value of his horse's paces as regards their length and time.) Having thus his standard measures always with him, he can at any time transfer them to his sticks or ropes. As the measurements from the body will, however, always be liable to inaccuracy from the want of sharp lines and angles, the joints and extremities being rounded, this kind of standard should be had recourse to only as a last resource: the traveller would therefore do well to have the foot or yard ascertained on some part of his habitual dress, on his gun, *etc.*

TO WALK IN A STRAIGHT LINE.

It may appear to many, that any one who is sober can walk in a straight line, and that directions for such a simple operation are altogether superfluous; but this is by no means the case. To walk in a straight line, fix your eye upon two objects, such as two trees or bushes, or stones, or the corner of a wall and a house, *etc.*, so as to have them exactly in a line before you, then step out, keeping these objects constantly in a line; on approaching within a few paces of the first object, look forward for a third in the same line, keeping it and the second in a line; arrived near the second, look out for a fourth, and so on. Should there be no objects such as we have mentioned, there will generally be found marks, as tufts of grass higher and of deeper colour than the rest, or low plants easily distinguished, or irregularities in the surface of the soil, *etc.*, which will answer the purpose. If not, two men, if you have any with you, should plant themselves in a line in front, and then, on approaching the nearest, stop and send him on to place himself in the line behind the other, and so on. In using fixed objects, one should be chosen as far off as possible, with which the intermediate ones should always be in a line, and the reason is, that the slightest deviation from the straight line is instantly detected. It is also desirable to have the objects as nearly as possible in the same line of vision,—thus the stems of two trees are better objects than a stone on the ground and a tree in the distance, that can be seen only by raising the eye.

TO MEASURE DISTANCES BY PACING AND TIME.

Let the traveller accustom himself to walk so as to take exactly $2\frac{1}{2}$ feet at a step; then, 120 paces will be 300 feet.* He may thus measure short distances by pacing them. If the distance be too great for this, and the traveller's attention be required to various objects as he proceeds, which would interfere with his counting, it may be estimated by the time required in going over it.† Thus, if the traveller accustom himself to walk 600 paces in five minutes, or 120 in one minute, he has only to look at his watch on starting and on arriving, and multiply the number of minutes he has been walking by 120, to have the number of paces, and this by $2\frac{1}{2}$ will give him the number of feet; still greater distances may be calculated at about four miles in an hour and a quarter. Halts, if only for a

* In sand or slippery ground, the pace, though of equal length, measures less ground, for the foot slips back at each step.

† A pedometer is a useful instrument for measurements by pacing.

minute, must of course be deducted in estimating by time. If the traveller be on horseback, he should know the value in length and time of his horse's paces in order to measure by them. It is not an uncommon thing to estimate great distances by days' journeys. In such case the value of the day's journey should always be indicated, for it is different on foot, on horseback, on camels, asses, *etc.*, different on firm soil, or on difficult ground, as sand, or through woods; different in ascending and descending hills, *etc.* Persons who have a good ear for time, may greatly assist the regularity of their walk by singing as they go along, some tune in which, as in a quick march, the measure is distinctly marked, or knowing how long they take to sing a song, may repeat this air over and over as they go, making a knot on a string, or otherwise marking the number of times they have repeated their melody. A Catholic or a Mahometan thus repeating his prayers with a rosary, may convert the latter into an itinerary measure.*

OF MEASURING DISTANCE BY SOUND.

Sound flies at the rate of 1,142 feet in a second, or about a mile in 4¾ seconds, or a league in fourteen seconds, or thirteen miles in a minute; but sea miles are to land miles nearly as seven to six; therefore sound moves over a sea mile in 5⅝ seconds nearly, or a sea league in sixteen seconds. Sound can be heard nearly twice as far on the water as on the land. From the velocity of sound, then, distances can be measured when the cause of the sound can be seen. Thus by observing with a stop-watch or otherwise, the time which passes between the flash of a musket or cannon, and the sound of the discharge, the distance from the place of discharge may be estimated. The distance of a thunder cloud may be known in the same way by observing the lightning, and counting the number of seconds which elapse before the thunder is heard. The stroke of the woodcutter's axe may sometimes be heard at a considerable distance, and if the blow can be seen, the distance may be estimated.

The banks of rivers sometimes echo any sharp noise produced upon the water, and this in a dark night, on a broad river, may be sometimes useful; for, by striking the water a smart blow with the flat of the oar, and observing the time between it and the echo, the distance from the bank may be guessed at; or, if both banks produce an echo, the difference between them will serve to indicate which bank is nearest, for the nearer the bank the more immediately will the echo follow the blow.

TO MEASURE A STRAIGHT LINE.

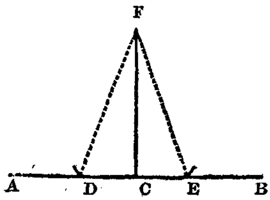
This may be done either by pacing it, taking care to walk in a straight line as already directed, or by means of rods, or a cord. When a rod is used by one person alone, he must begin by marking off his line, which may be done with little sticks or stones; then let him measure with his rod, taking care at each remove to place the rod exactly at the spot where its extremity reached before it was taken up. If there be two persons, it is not necessary to mark off the line by sticks or stones. One person must keep some objects in a line by his eye, and direct the other, who measures, to keep in the direction, by word or a signal with the hand. In measuring with a cord of any kind, if there be but one person to perform the operation, he should begin by placing sticks in the direction to be measured, but backwards from his starting point: he must next make a loop at one

* Far be it from us to insinuate that so holy a thing as prayer should be profaned: but surely there can be no harm, after a lonely traveller has beguiled his weary way with orison to his heavenly Protector, to learn from his beads how far he has journeyed.

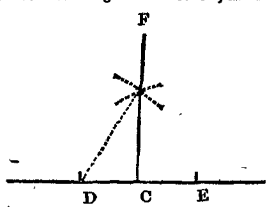
end of his cord so as to fix it by a stick in the ground; then going forward and stretching his cord, having his back turned to the place where he is going, he looks along the row of sticks (three are sufficient), and stretches his cord in the exact line. He then fixes a stick for a mark, goes back to pull up the stick which fixed the end of his cord, fixes it again at the new mark, and repeats the operation as far as may be necessary. If there be two persons, each walks forward with one end of the cord in his hand, the one in advance sticking up a picket at the end of the stretched cord, which the one who follows takes up. The number of pickets mark, of course, the number of times the length of the cord has been gone over. In this mode, it is the business of the hinder person to see that the other stretch the cord in the direct line, which he does by keeping certain advanced objects, natural or set up by him, in his eye. If no sticks are to be had, stones may supply their place, and if there are no stones, the spot where the cord ends must be marked by scratching the ground, and each should count to check the other.

TO RAISE A PERPENDICULAR FROM ANY POINT ON A GIVEN LINE.

Measure on the given line AB, two equal distances D and E, on either side of the given point C; fold a cord in two, marking the middle; fasten the two ends of the cord by pickets at D and E. Stretch the cord tight, and from its middle F draw the line C, which will be the perpendicular required. Care must be taken in fastening the two ends of the cord, after the middle has been found, to take up exactly the same quantity of cord, or the two sides of the triangle, when the cord is stretched, will be of unequal length.

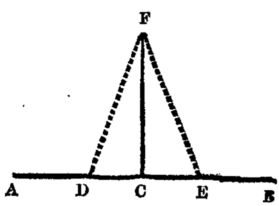


For want of a cord, a long stick or perch may be used. Having measured off, as before, equal distances on either side of the point C, let one person hold the perch by one end at D, while another describes an arc with it, then doing the same thing at E, the intersection F of the two arcs will be the point from which to draw the line to C.



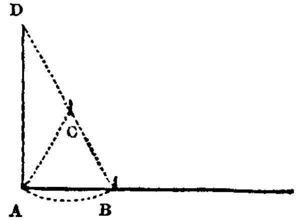
FROM A GIVEN POINT OUT OF THE LINE, TO LET FALL A PERPENDICULAR TO IT.

Fold a cord, whose length must be more than double the nearest distance from the point to the line, into two equal parts; fix the middle at the given point F; stretch the two halves till they meet the line A B in D and E, find the middle between D and E, as at C, and draw F C.



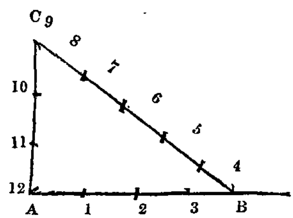
TO RAISE A PERPENDICULAR AT THE END OF A LINE.

Having marked the middle of your cord, fix one end at A, and the other end at such a distance from this, that when the cord is stretched at the middle it may form nearly an equilateral triangle ; fix a stick at the apex C of the triangle ; detach the end A and move with it towards D, then keeping the cord touching C, stretch it straight in a line with CB, and its extremity D will be the point from which to let fall the required perpendicular.



The operation may be performed by sticks. For this purpose lay the stick or perch with one end at A, and in a direction to form an angle with AB of about 60 degrees; then keeping fast the end C, where a picket must be placed, move the perch round this point, as round a pivot, till the other end coincide with the line A B ; plant a picket at B, and slide the perch along towards D, keeping it in a line with C B ; in such position, one end of the perch touching C, the other extremity D will be the point for the perpendicular required.

Another and more expeditious method of raising a perpendicular is by means of the numbers 3, 4, and 5, or any multiples of these. Thus, measure off and mark upon your cord 12 equal divisions, say feet, fix the two extremities of the cord at the point where a perpendicular is to be raised, as at A ; stretch the cord along the given line towards B ; set a picket at the 4th division ; turn the cord tight outside of this picket, then seizing the cord at the ninth division, stretch it into a triangle, and fix the picket at C, when CA will be perpendicular to AB.



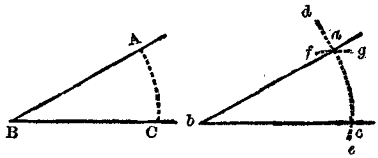
A cross-staff is very useful for setting off perpendiculars ; but we have supposed the traveller to be without instruments ; he may, however, have the means of supplying the place of a cross-staff by a very simple contrivance, which will answer well enough for certain purposes. Draw two lines perpendicular to each other on a piece of paper ; place this on the cover of a book, keeping it there by five pins or needles, one at each extremity of the lines, and one at their intersection ; place the book as horizontally as possible on a stone, or raise a little mound of earth for the purpose, and use this as a cross-stick : or stick the pins at one of the angles of the book-cover and along its two contiguous outer edges. Two flat sticks may be fastened cross-wise, and stuck firm on the top of another stick, having first marked two lines perpendicular to each other along the upper surface of the flat sticks, on which lines set up pins as before. Perpendicular lines are easily obtained by folding a piece of paper.

TO DRAW A LINE PARALLEL TO A GIVEN LINE.

From the extremes of the given line, or at any convenient distances along it, raise perpendiculars by any of the means already mentioned: take equal distances along these, or a given distance, if required, and the line joining the two points marking such distances will be the parallel line required.

TO MAKE AN ANGLE ON THE GROUND EQUAL TO A GIVEN ANGLE.

Set off any number of equal parts from B to C, and from B to A, and with the same parts, measure A C ; then from any point *b*, with the length or radius B A, describe



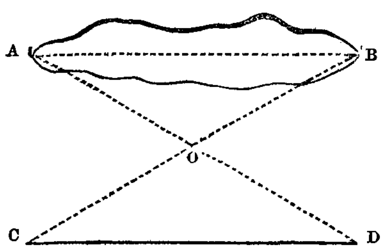
an indefinite arc *de;* from any point *c* in this arc as a centre describe with the length A C an arc *f g* intersecting the arc *d e* in *a;* join *c b* and *a b,* and the angle *a b c* will be equal to the angle A B C.

TO MEASURE AN ANGLE OF A BUILDING, *etc.*, HAVING NO PROPER INSTRUMENT.

If from the inside, measure off equal distances along the two walls from the angle, and place pickets or stones at the points, then measure across from point to point, that is, the cord of the arc subtended by the angle which the walls make. Now draw a line on paper, and take from a line of equal parts (a slip of paper frequently doubled will do for a make-shift scale of equal parts), as many as you have measured feet or paces *etc.*, and mark that distance on your line; from one end describe an arc with this length as a radius, and intersect this arc by another struck from the other extremity of the base line, with a radius corresponding to your measured chord. Draw a line from the first point of the base to the intersection, and you will have on paper an angle similar to that you measured. Apply a protractor and you will have the value of the angle. At all events it will be thus set down, and may be ultimately measured. If it be more convenient to measure the angle from the outside, draw lines in prolongation of the two walls or faces of the building, and operate with these as just described. This method is equally correct with the former, as opposite angles are equal. This problem may be usefully applied by the traveller, when, being without instruments, he would give as correct a plan as possible of the exterior walls of ruined cities, edifices, *etc.* On the spot it will be sufficient to draw the plan as correctly as possible by the eye, writing the dimensions by the sides of the lines.

TO ASCERTAIN THE LENGTH OF A LINE, (AS A B,) ACCESSIBLE ONLY AT ITS TWO EXTREMITIES.

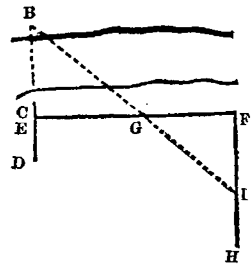
Choose a point, O, accessible to A and B, draw A O, O B, prolong A O to D, and make



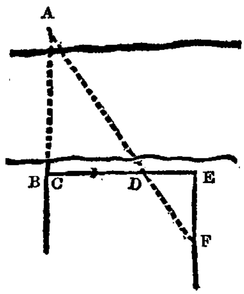
O D equal to A O ; prolong B O to C, and make O C equal to B O, and C D will be equal to A B the required line. The length of a small lake or marsh may be taken in this way.

TO ASCERTAIN THE BREADTH OF A RIVER, MARSH, *etc.*

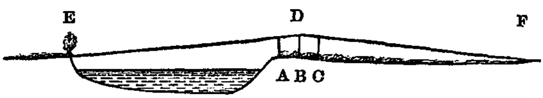
This may be done in different ways. *First Method.*—Fix upon some tree, or bush, or stone, or other fixed object on the opposite edge of the river, as at B; trace a line C D in the direction of B, and perpendicularly to the axis of the river. From E, or some other convenient spot, raise the perpendicular E F, of any convenient length predetermined, so as on arriving at half the intended distance E F, a stick may be set up at G. Arrived at F, trace the line FH perpendicular to E F, and walk along it backwards till the stick at G come in a line with B, as at I, and plant a picket there; then measure I F, which will be the same as E B, from which take the distance C E, and the remainder will be the breadth of the river.



Second Method.—If the river be very wide, plant the stick G not at the half of E F but at 2-thirds or 5-sixths. Thus, suppose A B, the breadth of the river, be very great, the preceding mode would require the line E F to be of equal length at least. To save trouble and time, therefore, make C D equal to 2-thirds of C E, as in the figure, and planting a stave at D, proceed as before, till, being on the line E F, you find D in a line with A; plant your picket at F, and measure F E, then D E will be to E F as C D is to C A, from which take B C, and the remainder will be the width of the river.

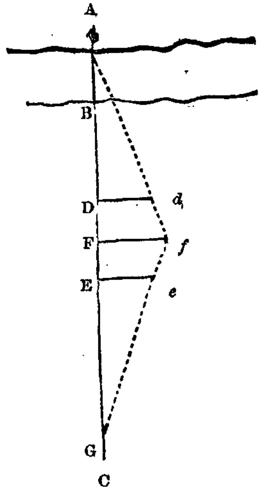


Third Method.—Set up perpendicularly at the edge of the river, a stick, A, about four feet long, then going back a few paces, set up another, B, somewhat longer, say five feet, in such a direction as that the two sticks may be in a line with some distinct object, E,



directly opposite, and that the visual ray DE, passing along the tops of the two sticks, may fall upon the foot of the object E on the other side. Then, in any direction where the ground is most level, set up a third stick C of equal height with the stick A, and at the same distance from B as B is from A, then, looking over the tops of the sticks B and C, observe where the visual ray falls, as at F, then measure B F, which will be equal to B E, and by deducting the distance A B, the remainder will be the width A E of the river. Or the same may be done horizontally thus:—

Fourth Method.—Draw the line B C in the direction of the chosen object A; at any parts D and E, raise perpendiculars of equal length, more or less, according to circumstances; plant staves at the ends *d* and *e* of these perpendiculars, then at half the distance D E raise another perpendicular, and walk along it till *d* A come in a line, and plant the stave *f*, then go back on the line A C, and walk straight along it backwards till you bring *e f* into line, which will be the case at G. Measure G F, and deduct from this the distance B F, and the remainder will be the breadth of the river. This method, though more tedious, is more correct than the former or third method.

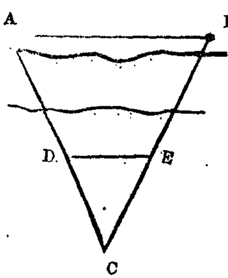


N. B.—Be it observed, however, that all these modes of measuring the breadth of rivers, or other inaccessible distances cannot be even tolerably exact, but in as much as the ground on which the operations are performed, and the object on the opposite bank of the river, *etc.* are on the same plane. The traveller should, therefore, choose his position accordingly.

Different expeditious make-shift methods have been given for ascertaining inaccessible distances, as by looking over the two edges of a hat, so as to bring them into a line with the object whose distance is required, and then, holding the hat and head steady, turning upon the heel, and observing where the visual ray falls upon the ground, and measuring to that spot; but it is very difficult to keep both the hat and head quite steady in turning, and as the slightest variation in their position will most materially affect the measured distance, we by no means recommend this mode, unless indeed the traveller, by long practice, is able to accomplish it with sufficient precision.

TO MEASURE THE DISTANCE OF TWO INACCESSIBLE OBJECTS FROM EACH OTHER.

Plant a staff at C, from which both A and B may be seen; now, by any of the preceding problems, find the length of C A and C B. Make C D as many parts of C A, as you do C E of C B, and join D E. Then, as C D is to D E, so is C A to A B.

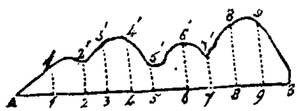


TO TAKE THE PLAN OF A WOOD, A MARSH, A LAKE, A CRATER, OR OTHER HOLLOW, ETC

Set up stakes at the angles, measure from stake to stake by pacing or otherwise, taking also the value of the several angles as previously directed. Make a rough sketch as you go, on which set down the length of the lines and the value of the angles. At a convenient time, protract it.

TO TAKE THE PLAN OF ANY CROOKED LINE, AS OF A RIVER, A NECK OF LAND, ETC.

Trace the line A B by pickets or stones, measure along A B till you arrive at the first bend, then strike off perpendicularly towards it, and measure 11′, come back and walk from 1 to 2 on the line A B, strike off again to the next bend measuring 22′ and so on, noting the distances A 1 and 11′, 12 and 22′, 23 and 33′, &c.



To map a country in this way, without even a compass, would not only be an endless task but would, after all, give but a very incorrect representation: all these methods therefore are only make-shifts, and very good in particular cases for want of better.

Before we speak of the measurement of heights and depths, we may observe that it is not sufficient to have the form of objects such as woods, lakes, &c., but they must be laid down in their true position as regards the meridian; this is therefore the place to show how to obtain a meridian line.

TO OBTAIN A MERIDIAN LINE.

There are various ways of doing this approximately.

First Method.—Place a stick upright in the earth, a little before midday, having previously drawn two or more concentric circles of which the stick is in the centre. Observe the length of the shadow, and when, after twelve o'clock, the shadow is observed to be of the same length, take half the distance between the point where the shadow was, and where it now is, and a line passing through the bisection and the centre of the circles will be in the plane of the meridian.

N. B.—This method is imperfect by reason of the change in the sun's declination between the observations, and from the indistinctness of the termination of the shadow.

Second Method.—Suspend two plumb lines at the two ends of a rod turning horizontally on a pivot; now, when the star Alioth of the great Bear is near the meridian, bring the plumb lines exactly in a line between it and the eye, and when the polar star comes into the line also, the four objects are in the plane of the meridian nearly. The plumb lines may be kept steady by plunging in pails of water.

N. B.—This is as exact as can be expected without the assistance of a telescope, but it will only do for the Northern Hemisphere.

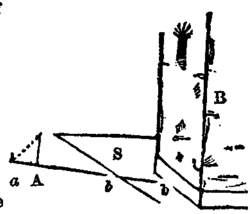
Third Method.—A little before midnight observe the altitude of a star and note the time by a chronometer or good watch; continue looking occasionally, till the star, sinking again, attains the same altitude. Note again the time. Half the time elapsed between the two added to that of the first observation, will give the hour when the star is on the meridian. At this hour precisely the next night, fix a telescope so as the star may be in its axis, and the instrument will be in the plane of the meridian. Or bring two plumb lines, as descibed above in a line with the star at the exact time, and the two plumb lines will be in the pláne of the meridian.

The north and south may sometimes be known sufficiently for certain purposes by the effects of the sun, and of the known prevailing winds of a country on its vegetation. Thus, in our northern hemisphere, there is a marked difference between the appearance of the north and south sides of the trunks of trees in exposed positions. The north being known, of course any other point of the compass is easily found.

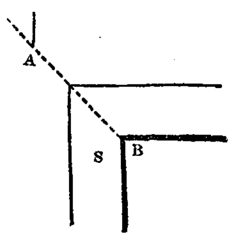
By whatever means the meridian line be determined, the angle which it makes with one side of the object to be set down in a map or plan, must be ascertained and noted, so that not only the true form, but also the true position of such object may be given.

TO ASCERTAIN THE HEIGHT OF A BUILDING, WHEN THE BASE OF THE BUILDING IS ACCESSIBLE.

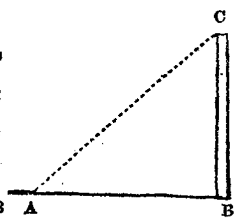
First Method, by shadows.—If the sun or moon be shining, set up perpendicularly and near the edge of the shadow S of the building B a staff A, of known length, and where its shadow ends, set up another staff *a* of any length, measure the distance A *a* between them, and note it, then leaving the staves standing, go to the base of the building B and turning your back upon it, place yourself on a line with A *a* as at *b*, and measure from thence to the edge *b′*, of the shadow S of the building, then says as the length A *a* is to the height of the staff A, so is *b b′* to the height of the building B.



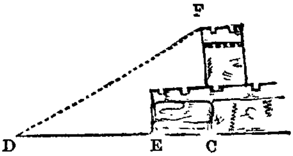
It may be observed that the line *b b′* is parallel to a line joining the angle of the building and the angle of its shadow; if then you be near such angle the operation is more expeditious. Thus, set up the staff A in the line of these angles, measure its shadow without placing any other staff, and going forward at once, measure from the angle of the shadow to the angle of the building.



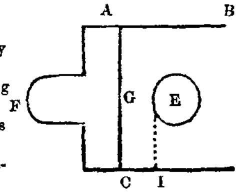
N. B.—This method requires that the ground on which the shadow of the staff and that of the building fall, be in the same plane. We may also observe further, that for the application of this method it is not sufficient that the base of the building be accessible, it must be the horizontal projection of the point or line casting the shadow that must be accessible. Thus, if the shadow proceed from a wall, such as A B from B C, then B, being the horizontal projection of C, the height of B C may be esti-



mated by its shadow; but if the shadow proceed from F, it is evident the height of F cannot be determined by measuring to the base of the building, as from D to E; for to have the length of the shadow cast by the object F, the length E C must be added to D E. This length may sometimes be obtained, though it is often

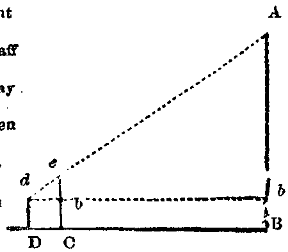


impossible, and in such case the height of the object cannot be estimated by its shadow. Thus, if A B C D represent the outer wall of a building, and E a tower in its centre, if the direction of the shadow of this tower be perpendicular to the face A C of the lower and outer wall, then having measured the length of the shadow F G, and of the staff as before directed, place yourself in a line with the shaded face of the tower, and mark whereabouts on the outer wall C D, the visual ray along the face of the tower falls, as at I, and add the length C I to the length of the shadow F G.



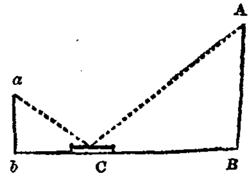
In any other position of the shadow it would be necessary to raise perpendiculars and take several measures, during which the length of the shadows would be changing and thus falsify the results of the operation. The height of a pyramid may be taken when the shadow is perpendicular to one of its faces, by adding half the length of the face to the length of the measured shadow before workng the proportion.

Second Method, by sticks.—When, for want of the sun, there is no shadow, the height of an object as A B may be taken thus. At a convenient distance from the base B of the object A B set up a staff C, and behind it a shorter one D, so as their tops *d c* may be in a line with A. Measure D C, D *d*, and D B, then say as D C is to C *c*—D *d*, or what is the same *thing*, as *d c*′ is *c*′ *c* so is D B or *d b* to a fourth time, to which must be added D *d* or B *b* for the height required.



N. B.—Here, as in the case of shadows the horizontal projection of the point A must be accessible, or in a situation to be estimated, otherwise this method cannot be employed.

Third Method, by reflection.—If the traveller have a looking glass or a broken piece of one, let him place it as horizontally as possible on the ground as at C, then walk backwards till he sees the top of the object A B reflected in the glass. Now knowing the height of his eye from the ground, let him say, as his distance at *b* is from the point in C, where the image is reflected, is to *b a*, the height of his eye, so is the distance C B, which he must measure, to the height B A.



If the traveller have no glass, any other reflecting object will do, as a little water in a black cup or japanned tray, &c., or a natural pool of water. In the latter case, the observer must move till he bring the reflected object near the edge of the pool, marking the spot by a stick, to which he can measure. Observe also that in all cases of reflection from liquids, there must be no wind.

N. B. The same observations regarding the necessity of measuring to the horizontal projection of the point A or ascertaining it, holds good here as for the former methods.

4th. *Method, by a falling Body.*—From the top of a wall or tower whose height is required, let fall a stone counting exactly by a stop watch or otherwise, the number of seconds it takes to reach the bottom, then say, as 1 is to the square of the time, so is 16 to the height required. Thus, suppose the stone took four seconds in falling, then 1 : 16, (the square of the time), as 16 : 256. When the object whose height is to be measured is such, that its whole height cannot be thus estimated at once, it may perhaps be done by successive stages, when of course the several heights must be added together. Care must be taken not to *throw* the stone ; but just to open the fingers or hand and let it fall by its own weight.

5th. *Method, by actual measurement with a line having a weight at bottom.*—When the base of the building is inaccessible the length of the line to the horizontal projection of the point or line whose height is required may be ascertained by any of the previous modes of measuring inaccessible distances.

TO MEASURE TIME.

Short intervals of time may be measured by a pendulum vibrating seconds. For this purpose suspend a musket or pistol ball, or a stone, by a string, in such wise as from the centre of the ball or stone to the point of suspension, the length may be what is required for vibrating seconds according to the given latitude of the place. For this lengtht we give the following table.

Degrees of Latitude.	Length of Pendulum.	Degrees of Latitude.	Length of Pendulum.
	Inches.		Inches.
0	39.027	50	39.126
5	39.029	55	39.142
10	39.032	60	39.158
15	39.036	65	39.168
20	39.044	70	39.177
25	39.057	75	39.185
30	39.070	80	39.191
35	39.084	85	39.195
40	39.097	90	39.197
45	39.111		

Or, if the traveller has learnt to count seconds regularly, he may measure time by counting.

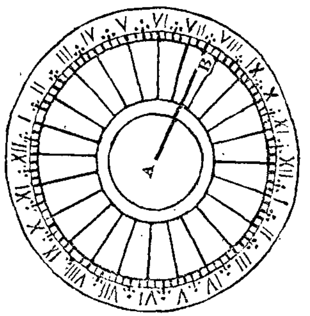
Time may also be counted by the pulsations, which, for a man in health, are usually 75 in a minute.

Hours may be measured by the running of sand or dropping of water, as we shall presently explain.

TO CONSTRUCT A MAKE-SHIFT SUN-DIAL.

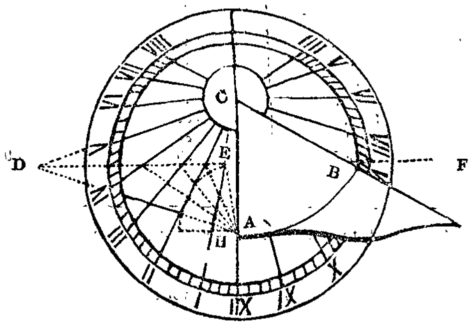
Supposing the traveller's watch to have got broken, or to be lost, he will find it very advantageous to be able to construct a sun-dial. There are a great variety of dials, we shall only mention the two simplest.

Draw on a card, or on a flat board, or on a piece of paper pasted to a board, or on a piece of sheet copper or lead, or on a piece of slate, a tile, or any flat surface that may be easily moved, three concentric circles as in the figure; the outer being a few inches in diameter if the dial is to be stationery, and smaller if it be required to be portable. Divide these into twenty-four equal parts for the hours, and each of these parts into four for the quarters Make the top and bottom the twelve o'clock lines; the right and left the six o'clock lines; and from the twelve at top, go round with the other numbers from left to right as in the figure. Now, fix up in the middle, and perpendicularly with the plane of the dial, a wire or thin wooden rod, and your dial is made. It must now be set; this is done by raising the plane of the dial as many degrees as form the compliment to the height of the pole; thus, if



the latitude of the place be 35 degrees, the compliment will be 55 degrees; or in other words, tilt up the dial so that the stile or wire many make an angle with the horizon equal to the elevation of the pole. At the same time, the twelve o'clock lines must be exactly on the plane of the meridian. This dial, which is called an equinoxial dial, in order to be universally applicable, must be marked on both sides, and the stile made to go through, otherwise it will only serve in the northern hemisphere, from the 22nd of March, to the 21st of September.

The next dial we shall mention is the horizontal dial, and is thus constructed. Draw the concentric circles as before directed, and through the centre E of this circle a line C A for the twelve o'clock line. Choose a point C on the line C A, and a little above the centre E of the concentric circles, and through this point draw a line perpendicular to



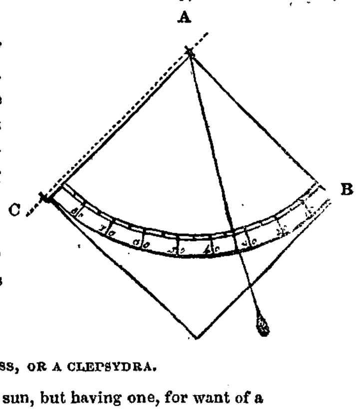
C A and this will be the six o'clock lines; now draw through the centre E a line D E F perpendicular to C A. This done, draw from the point C a line C B, making with C A an

angle equal to the height of the pole or latitude of the place. Or open your compasses to the chord of 60 degrees and describe with this as a radius the arc A. B. Then take the chord of the latitude and set it off from A to B, and draw the line C B for the stile, of which you thus obtain the true form. Set one leg of your compasses in E, and take the nearest distance to the line C B or stile's height, and turning the compass, mark with this distance, the point H on the line C A. On H as a centre draw the quadrant G E, and divide it into six equal parts, and each part into four for the quarters. Lay a ruler to H and to those equal parts in the arch severally, and where the ruler cuts the line D E F, the points are those through which the hour lines must pass. Then lay the ruler to the point C, and to those marks on the line D E F, and draw the hour lines. Set off the same distances on the line D E F from E to F, and draw the morning hour lines. Those before six in the morning and after six in the evening are drawn by containing the same hour lines beyond the point C.

To set this dial truly, the plane of the dial must be horizontal and the stile fixed upon it in a vertical plane, and the line C A must be in the meridian. For the horizontal setting of the plane, and for the angle of the stile, a quadrant may be used. It is evident that no dial can be constructed if the latitude of the place be not know n, we must also remember of the dial, *non nisi cœlesti radio.*

TO CONSTRUCT A MAKE-SHIFT QUADRANT.

From a point A on a flat board, or other thin but inflexible body, draw a line A B, and from this same point A another line perpendicular to A B, (by folding paper, if you have no better means). From A as a centre, describe the arc B C, which divide into 90 parts for degrees; suspend a weight by a string from the point A and your quadrant is made. If you stick two bits of card at the extremities of the edge C A, (taking care that that this edge be parallel to A C,) and make holes in them, for sights, your quadrant will be very useful in taking angles of elevation or depression.



TO MAKE A SAND-GLASS, OR A CLEPSYDRA.

The dial is, of course, useless without the sun, but having one, for want of a watch, the traveller can profit by the presence of the sun, to construct a make-shift hour-glass. Take fine washed sand, and when quite dry, put it into a bottle, cover the neck of the bottle with a piece of bladder, in which make a small hole sufficient for the sand to fall gently through; observing now the indication of the dial, reverse the bottle over some receiver, and let the sand run out for an hour exactly, then stop it by reversing the bottle. Now put the sand run out into a phial that will just contain it, and close the neck by the same or some other piece of bladder, having a hole of exactly the same size, and the running out of this sand will measure one hour exactly. If it be required, however, to measure a longer time by this means another bottle similar to that containing the sand should be reversed on it, neck to neck, and then fastened so that the bladder, or paper, or other covering, with the hole may serve as a diaphragm between them, so that the whole may be rapidly turned as in a common hour-glass.

The running of sand, it must be observed, is a much better measure of time than the dropping of water, for of the former, equal quantities run out in equal times, whatever be the height of the column of sand above, whereas in water, the rapidity of the running decreases as the pressure becomes less by a diminution in the height of the column. Nevertheless, as it may be more convenient in some cases to use a Clepsydra or water measure, it may be made in this way—

To construct a Clepsydra.—Take a vessel containing a sufficient quantity of water to serve for twelve or twenty-four hours, and make a small hole in the bottom of it, so that the water may fall in drops, place under this vessel another to receive the water, and after the water has flowed for half an hour by the dial, mark the height to which the water has risen in the lower vessel, do the same for the next half hour, and so on, and let these marks be numbered ½, 1, 1½, 2, &c. The upper vessel, in the beginning of the operation, that is, every time it is filled, must be filled to the same height exactly. Observe also to place the Clepsydra out of the sun's direct rays, and out of the wind, so as to have as little error as possible from evaporation.

TO KNOW THE HOUR OF THE DAY OR NIGHT, HAVING NEITHER DIAL NOR WATCH NOR ANGULAR INSTRUMENT.

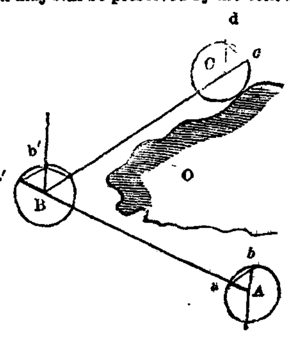
We know of no way of effecting this but by the knowledge of certain vegetable or other natural phenomena. Thus certain flowers open and close at stated hours, but these must be known, and only one at a time perhaps can be found in any one locality, and very often not even one.

TO FIND ONE'S WAY WITHOUT COMPASS.

Over a plain, by day.—Find the meridian line by one of the methods we have indicated; draw a large circle on the ground, and divide it into sixteen or thirty-two parts, as may be requisite; set up a staff in the direction you want to go, and observe what objects, such as tufts of grass, stones, trees, &c., lie in the exact line, and direct your course by them, as already explained. If no natural objects exist, set up staves, or place stones or men in the required direction. *By night*, mark the line by fires or by men with lights.

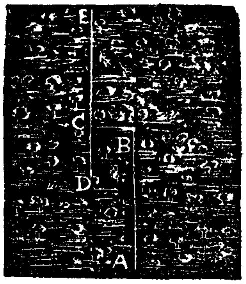
If any impassible object should occur, the direction may still be preserved by the following process:—

Having arrived at A, near the obstacle, plant a staff, and round it, as a centre, trace a circle of a given radius; then direct a line towards B, and measure the chord *a b*; arrived at B, where the object is cleared, set a staff in B, and round it trace a circle with the same radius as was used at A. On this circle measure from the continuation of the line A B, a chord *a′ b′*, equal to *a b*, and setting up a staff at *b′*, the line *B b′* will be in the same direction as A *b*. If the point B is very far out of the direct line A *b*, you may get nearer the continuation of that line, by striking off in the line B *c*, after measuring the chord *b′ c*. Arrived at C describe the circle as before, and from the continuation of C, mark off the chord *c′ d*. and the line C *d*. will be the direction in which to proceed.



It is strongly recommended in traversing extensive plains where there are no objects to serve as land marks, to set up such, as you proceed, and at distances visible the one from the other, for then, if it be impossible to proceed, the shortest way back may be easily traced.

Through a wood.—To proceed in a given direction through a wood is no easy matter, and the difficulty increases with the thickness of the wood. The only way is to set up marks in the direction as far as they can be seen, that is to say, wherever in the line any two may be seen from a third; and when any trees intervene, proceed thus :—



Suppose A B to be the direction interrupted by the tree at B; look to the right and left where you can see farthest. Suppose it to be on the left at C, three steps from B; set up a mark there and one behind it at D, also at three paces from the line A B, then proceed in the direction D C on to E, or till some other interruption, when the same process must be repeated. Note always how many paces have been taken to the right or left, and cancelling them as often as possible by taking alternately on either side, as far as it can be done. This procees is exceedingly slow, but there is no better that we know of, when deprived of a compass. If the traveller have a watch, he may know his direction at noon-day by the shadows, but this will only serve him as a rectification of his route. Little can be learned in a thick wood of the points of the compass, by observing the trunks of the trees, for they are too sheltered from the effects of prevailing winds to afford any indications, an experienced eye, however, may discern a general inclination of the tops of the trees, occasioned by the prevailing winds, and this sometimes affords a good clue to following a particular course through a forest.

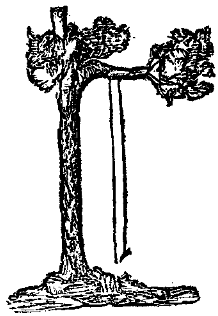
In going into a wood, it is recommended either to break branches off the underwood, or twist them, or make some other marks by which you may retrace your steps.

In a cavern, or intricate subterranean passage.—The grand object of solicitude on entering a cavern or subterranean passage is to be able to find the way out again. For this purpose a clue of strong cord, and of sufficient length should be provided. When, after entering, you begin to lose the daylight, then fasten one end of your line firmly to some large stone or otherwise, in such manner that it may not slip, and unwind as you proceed; but as the line may by some accident get broken, or be maliciously detached, so as to render it useless as a means of extrication, other marks should be made. Thus marks of this form ∠ may be made on the walls of the cavern or passage by the smoke of the candles or torches, the point showing the direction in which to proceed *on returning*, remembering also to place the marks so that one may always be seen from another; or three stones may be placed in a line on the ground, every here and there; or, if the soil be soft and no stones are to be found, scratch a line on the ground. At the top and bottom of every precipitous decent which you have to pass, a distinct mark should also be made, and also at the angles of every turn. It need hardly be recommended to provide matches of some sort or other, or flint and steel, &c., for obtaining a light.

TO CLIMB TREES.

It is often necessary for travellers to climb trees, either for looking round, or to pass the night in security from wild beasts, or for concealment, &c. Hence the following instructions my be acceptable. If the trees have no branches, such as palm trees, they may be climbed with comparative ease, by the following process.—Take a strip of linen or two towels, or streng handkerchiefs tied together, and form a loop at each end for the feet to pass tight into without going through ; or for want of such material make a rope of grass or straw in the same way. The length should be such as to embrace a little more than half of the diameter of the trunk to be climbed, (palm trees are seldom of great girth). Now, being at the foot of the tree, fix the feet tight into the loops, and opening the legs a little, embrace the tree as high up as you can; raise you legs, then pressing the cord against the tree with your feet, stand, as it were, in your stirrups, and raise your body and arms higher; hold fast again by the arms, open the legs again, and raise them a stage higher, and so on to the top. The descent is effected in the same way, reversing of course, the order of the movements. The ruggedness of the bark and the weight of the body pressing diagonally across the trunk of the tree, prevent the rope from slipping. Any thing, provided it be strong enough, is better than a *round* rope, which does not hold so fast. A little practice will soon render perfectly easy this mode of climbing.

Trees having branches, but of which the lowest is of considerable height, may be ascended thus.—Having a strong rope, at least twice as long as the branch to be reached is high, keep one end in the hand, and by means of a stone tied to the other end, throw this over the branch; or if it be too high, and you have the means, fasten a long twine to an arrow, and shoot it over the branch, than fastening one end of your rope to this twine, draw it over the branch. Now fasten one end of it firmly so as not to slip, a strong stick, about two feet long, with a notch in the middle. Seat yourself across this stick, so as to have the rope come up from between your legs in front of you ; now seize the other end of the rope above your head, and draw yourself up. This mode, though extremely simple, requires a little practice, as by pulling too hard, or leaning *back*, the *legs are tilted* up and the climber comes to the ground.



TO CLIMB OR DESCEND PRECIPICES, &c.

The mode just indicated may be sometimes employed for ascending and descending precipices, if they be studded, as is often the case, with projecting trees. The decent particularly, may often be rendered easily practicable by this means, when it would otherwise be impossible, and escape from confinement may sometimes be effected in this way. In all cases, the rope should be of sufficient *strength*, and the object round which it is *thrown*, and against which it rubs, must not be angular and sharp Rounded and weatherworn, but solid rock, will do, but angular or splintery rocks will not.

TO PASS A ROPE OVER AN ELEVATED OR TO A DISTANT OBJECT.

It not unfrequently happens that an object over, or to which, the traveller would pass a rope, is too high or too distant for him to throw it. In this case he must employ his ingenuity. Thus a stone may be thrown a great way by means of a sling, than which, nothing is easier to construct. Let then, a long twine be coiled up on *the* ground, having one end fastened to the rope to be passed, and the other end made fast to the stone thrown by the sling. Or without a sling, fasten a stone to one end of the twine, and turning it a few times, so as to communicate a sufficient centrifugal force, hurl it from you. If the object be vertical and the base accessible, you will get back the stone end, which will come down by its own weight, if you let out the coil. If the object be distant and inaccessible, some other person must be at the place to sieze the twine, and by its means pull the rope over. We need hardly say that thicker ropes may successively be bent on, and passed over if needful. An arrow shot from a bow may be also used to pass a twine to the top of a precipice or tower, across a stream, a small river, &c. A kite, if the wind be favourable, answers very well, and may be immediately made with a newspaper, or a square of *glazed* linen, &c., and two cross reeds, cane, or slips of wood. When we say that in order to employ a kite, the wind should be favourable, we do not mean that it is required to blow exactly in the direction we want to send the kite, for by means of two belly-bands, at right angles to each other, the kite may be so braced as to go many points from the wind.

TO JUMP WIDE DITCHES.

Very wide ditches or small streams, may sometimes be passed by using a long pole, this is held in the hands and near the top, the right hand uppermost. A short run is then taken, and upon coming near the brink, the lower end of the pole is directed to the middle of the ditch, while he who holds it firmly, springs at the same instant upwards and forwards, by which he is carried over in an arc of a circle, of which the pole is the radius. To be dexterous at this feat requires some practice. The Dutch are great adepts at this.

TO SEEK FOR FORDS.

Fords must always be sought in the widest part of a river, or in the diagonal line that joins the salient angle of one side of the stream, to the salient angle of the other side, and not from the salient angle of one side, to the opposite re-entering angle. Fords for persons on foot, should not exceed three feet, and for horses four feet, for camels five feet. These are the extreme depths, and if the current be strong, one foot should be deducted from these depths. When a large caravan has to pass a ford, it is sometimes found to be practicable only for the first that go over ; for these stir up the bottom, and the sand so moved is carried away, and the ford deepened, so as to be no longer passable.

TO PASS RIVERS.

The obstruction of a river is always a serious impediment to the progress of travellers, whether they be wandering alone, or be in a large or small party. And here we cannot help observing how very necessary it is that every traveller should be a good swimmer. But though the traveller may be able to swim, it may be of importance to him to secure his papers, his watch, or instruments, his gun and powder, and even his clothes from wet. He must therefore, construct a little raft of branches, or reeds, or anything floatable he can get, and on this erect securely a little stage, on which to put his clothes, papers, &c., and by means of twisted twigs or otherwise, for want of a rope, drag his raft after him while swimming over. When there is a party they are probably provided with many objects which may help them in the construction of a raft to carry all across. In swimming a river with a horse, the better plan is to lie in the water, and holding tight by the lower part of the mane with the left hand, allow the horse to drag you along, keeping the body stretched out straight, and assisting yourself with the movement of the right hand and arm. The cow-herd of the Nile crosses this stream, seated on a bundle of straw and dragged across by his swimming cow, of which he holds the tail. Sometimes this river is crossed on a raft of inverted earthen pots, or on an inflated goat's hide. In tropical countries, where sharks or crocodiles, or other dangerous animals inhabit the water, the crossing on a raft should always be preferred, if practicable, to swimming. Crossing astride on a rounded log is always hazardous for one who cannot swim, for it is very apt to roll. This inconvenience is avoided by fastening two logs together, in a parallel direction. It may be observed that as the specific gravity of the human body is not very different from that of water, a very little is required to bear the body up. A string of small faggots or rushes, fastened round the body under the arms, is quite sufficient.

OF SIGNALS BY SIGHT OR SOUND, NIGHT AND DAY.

It is often necessary to make signals; this may be done in a variety of ways and applied to a variety of purposes. Travellers are sometimes so circumstanced, as to have occasion to communicate resolutions in presence of their enemies, which it would be unsafe to do by word of mouth, lest they should be understood. Preconcerted signals should therefore be agreed upon, of a kind easily understood by the party, and which shall create no suspicion, as particular positions of the fingers, the hands, the arms, the feet, and legs. These positions may be taken with apparent unconcern, and as if accidental, scratching or rubbing some particular part of the face or body with one or the other hand, with one or other finger, and in all cases there must be an answer signal to show that the one made has been understood. Signals to convey intelligence at a distant, may be made by sight or sound; with regard to sight for day signals, men may be placed at such a distance as to see each other's movements distinctly, and then, by the positions of the arms, convey intelligence very quickl to a distance so much the greater as the number of men is greater. Each arm may be placed in four different positions \ — / | Thus you have *eight* signals, and by using both arms together, a combination of sixteen more may be obtained. These twenty-four signals are sufficient for communicating every thing important; it being understood that such a telegraph is only established for a particular purpose, none but the first and last person need understand the signals, the intermediate individuals being only repeaters; or, in this case, mere machines. A similar system may be adopted at night by means of lanterns, with this advantage, that as the lights may be seen at a great distance, fewer men are required, or, what is the same thing, the same number of men can convey the intelligence much further. Be it observed, however, that as the position of the arms cannot be distinguished at night, it will not do to apply the system of the same signals with a lantern in each hand, for at night, all but five of the twenty-four arm signals would be confounded. It is therefore necessary with lanterns to have a bar of wood fixed to an upright pole, in such a way that the bar may revolve upon its centre in a verticle plane; now four different positions may be given to this bar, and by a combination of four lamps, forty-seven signals may be made. The plan might also be adopted in the day time by suspending in the same way, balls of grass, or bundles of dark twigs, &c. As for the lanterns, the number required would be greater than travellers usually have with them, and generally speaking, there are few occasions where such a telegraph is required: mostly a single signal is all that is required for some special purpose, and this will be different according to the distance, and whether it be day or night. A black kite, or a kite with a dark-coloured handkerchief at the tail, may be set up for a day signal, and a kite with a lantern at the tail for a night signal. The writer once set up a kite in a dark night with two port fires spliced into one, and a slow match fixed to the tail; when at a great height it took fire, and burned twenty minutes like a most brilliant meteor, which was noticed by many persons several miles off. Rockets are easily made, and are a good night signal, but it is necessary to keep a good look out for them, or they may be unseen. The same may be said of the kite, but then it burns much longer. In all cases, we repeat, the signal must be answered. For shorter distances, the firing of muskets or pistols may be used, or the ringing of a bell, &c. While speaking of signals, we cannot help reminding the reader of a signal once employed with success in—we forget what battle—we think the battle of Fleurus, of mechanically turning the sails of a windmill in a direction contrary to the natural one. It was of course preconcerted, and escaped the notice of all but the parties concerned. We cannot close this article on signals, which many may, perhaps, think superfluous, without recommending all travellers to be provided with a small shrill whistle or a horn, by which signals of recognition or assembly may be given in the dark, or in wandering through woods or over mountains.

TO SEEK FOR FRESH WATER, AND TO OBTAIN IT.

There is nothing, perhaps, more essential to the traveller than to procure potable water. In cultivated plains, water is, of course, always to be had, and in mountain districts it may generally be procured by looking for; though all kinds of mountains are not alike in this particular. Thus, in primitive soils or granite rocks, &c., there will be found many, but small, springs, and their waters pure, limpid, and wholesome. In secondary limestone countries, on the contrary, springs will be more rarely met with, but those which exist will be found to be very abundant, and their waters, though limpid, less pure and wholesome, by reason of a portion of dissolved lime, and, probably, other mineral matter with which calcareous formations sometimes abound. In stratified rocks, springs should be looked for on the side towards which the strata dip; but it is chiefly in barren, sandy tracts, that the want of water is most keenly felt, and that this essential article is most difficultly obtained. In such places, water must be sought wherever there is an appearance of vegetation, though this does not always prove the existance of water, as certain plants require no more moisture than what is supplied to them by the circumambient air. At other times, however, though no water be visible, it may be found where there is vegetation by digging. We need hardly say that it is more likely to be met with in hollows than elsewhere, and at a less depth below the soil at the edges of a plain, than nearer its centre. Water, though found, is not always drinkable. In such case it may sometimes be distilled by a simple adaptation of pots, so as to form an alembic, or with a single pot, by stretching over it a cloth to imbibe the steam, and wringing this out. The quantity thus procured will, of course, not be great, but a few mouthfuls of drinkable water is all that is required to sustain the failing strength of the nearly-exhausted traveller. Very pure water may sometimes be obtained by collecting the dew in a large oil skin or waxed cloth, stretched out for the purpose on the ground, and somewhat raised at the corners, so as to have a concave surface. Rain water may be caught in the same way; or, what is still better for rain water, stretch a large permeable cloth, but rather loosely, by the four corners, fastening them to four poles; place a stone or other heavy body in the centre of the cloth, which will draw this centre downwards in a point; below this centre place a vessel to receive the water. All the rain which falls on the cloth will run down to the centre and fall thence in a stream into the receiver. An umbrella reversed will catch water enough into a vessel to satisfy one or more persons according to the duration of the shower.

TO CLARIFY FOUL OR TURBID WATER.

The great impurity of the water frequently met with by travellers, is one of the most distressing circumstances to which they are exposed. When water is salt or bitter, or rendered disagreeable by any soluble substances it may contain, there is no other way of rendering it palatable than by distillation, a process which, in some cases, may be resorted to, though very rarely, because the process is slow, and even in its simplest form, that of a pot and a cloth, as we have already stated, or of a tea kettle and a bottle, cannot always be performed for want of even such apparatus. Impurities, mechanically suspended, may be in part got rid of by filtration through linen, and this will do very well sometimes, but when a rather numerous party, or caravan, is encamped for some hours or days near a muddy pool, the following method for having clear water may be adopted.

Take a cask or a box, perforate the bottom and the sides, to the height of three or four inches, with a great number of holes of about a quarter of an inch diameter. Place in the bottom a layer of straw, or grass, or moss, or twigs, or tow, or any thing of like kind, so as to cover all the holes of the sides and bottom without stopping them up; then throw in a layer of sand, if any can be had clean near the spot, if not, it must be cleansed by washing. Over the sand place another layer of straw, &c., and keep all down with sticks and stones. Place the cask or box thus prepared in a pool within two or three inches of the upper edge, and to this height the water will rise in the box, clarified by its passage through the sand, and any quantity taken out is almost immediately replaced. Care must be taken that the bottom of the cask or box do not rest no the muddy bottom of the pool or river, for this would close the holes. If the party be very large, several boxes may be thus prepared. The holes made in the boxes will not unfit them for the carriage of many objects, and they may be repeatedly used for the purpose just stated. Or place in the muddy water a close-textured bag, keeping it stretched open by means of hoops or cross sticks, and fixing it in its place by stakes.

A small piece of alum thrown into troubled water will clarify a very large jar of it in a very short time, as is well known in India, where it is a common practice. Some fetid waters are much improved by being boiled before they are drank.

TO KINDLE A FIRE.

To obtain a fire is often as necessary to the traveller as to obtain water, and is sometimes as difficult. A fire may be kindled by a variety of means, as with instantaneous light matches of various sorts; by means of flint and steel, with tinder and a common sulphur match; by igniting gunpowder; by the use of a common lens, or a metallic reflector; by percussion, compression, and friction; by chemical combustion, &c.

Of the instantaneous light matches, whether Lucifers or Congreves, nothing need be said but that they are, particularly the latter, invaluable to the traveller; he should, therefore, be always provided with them. They must be kept very dry or they will not ignite; care must also be taken in travelling, so to pack them that they be subjected to no friction, otherwise they may take fire and do much damage. The tinder used with flint and steel, is prepared by burning old rags and smothering them before they are burnt to an ash; but unless sulphur matches are at hand, or sulphur to make them with, it is needless to make tinder. Flint and steel may be used with a piece of *amadou*,* as is well known to all smokers. As most travellers are armed, the use of a little gunpowder is, perhaps, the readiest way to obtain a fire, if he have no instantaneous light matches. When the sun is out and powerful, a lens or a reflector may be used with advantage in kindling a fire; it may be remarked that the darker the colour of the substance to be ignited by this means, the readier it takes fire. It is said that a blacksmith can make a piece of iron red hot by hammering it on his anvil; but, allowing the fact, the traveller has neither the blacksmith's dexterity at this feat, nor, generally, the instruments at hand. The air-syringe is a well-known toy; if a piece of *amadou* be placed under the piston of this instrument it will ignite. Friction, it is well known, produces heat, and savages are in the habit of kindling fires by this means. Two pieces of hard dry wood are rubbed together till they emit sparks or flame; or the point of a piece of hard dry wood is thrust into a hole purposely made in another piece of dry wood, and the former is then made to revolve quickly by rolling between the hands; dry leaves and other easily combustible matters are heaped round the point of friction to take fire readily. A great many chemical combinations extremely simple produce instantaneous combustion; but simple as they are, the traveller seldom carries with him the requisite ingredients.

TO ASCERTAIN THE BREADTH, DEPTH, AND SLOPE OF THE BED OF A RIVER.

By the bed of a river we mean that part of its channel which is habitually under water. The breadth of this bed is, properly speaking, the breadth of the river, though this is sometimes taken from bank to bank which often exceeds the ordinary width of the stream. The *breadth* of the bed then, may be taken by any of the methods we have already pointed out.

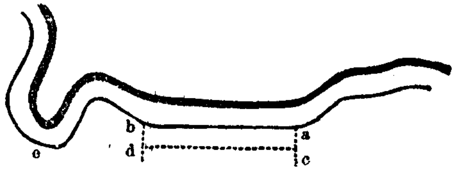
The *depth* of the bed must be taken by soundings right across, at short intervals—say every hundred yards. These soundings will show, at the same time, the *slope* of the bed which is, be it remarked, a very different thing from the slope of the surface of the stream. This latter may be taken by means of any convenient and portable level, setting it up always close to the water's edge.

TO ASCERTAIN THE VELOCITY OF A RIVER.

It is necessary to observe that the velocity at the surface is different from that of the mass; but as the former must be known before the latter can be computed, we shall first indicate the different means by which the former may be ascertained.

Surface Velocity of a River.—1st. By means of the common log or its substitute, as indicated at the article *log* in section INSTRUMENTS.†

2dly. By the following method. Choose as straight a part of the river as possible.



* *Amadou* is a species of fungus called *Boletus Igniarius*. This is beaten into flat pieces, then dried, then steeped in a solution of nitre and dried.

† The log, from the very small portion of it which rises out of the water, will be found particularly convenient whenever you can have a boat or raft anchored in the stream.

At *a* plant a stick in the ground, and, retiring half a dozen paces back, plant another stick at *c* in such manner that the line *a c* may be as perpendicular as possible to the direction of the current, and that from two or three paces behind *c*, the middle of the stream may be easily seen. From *a* measure along the bank as many times 51 feet (strictly 50 feet 11 inches,) as may be convenient, and place another stick, say at *b*, and behind this a fourth stick *d*, making *b d*, like *a c*, perpendicular to the course of the stream. The distance of *c* from *a*, and of *d* from *b* is quite arbitrary, nor need it be alike at the two stations ; a little more or less is of no consequence, so that the lines they form be perpendicular to the line of the current and parallel to each other, and that the middle of the stream may be seen from behind the hindmost.

This done, if you have an assistant let him go a little above the station *a*, and throw into the *middle of the stream*, if this be possible,* a ball of wood so balanced by lead as to float just above the surface ; or, for want of this, any piece of wood, bark, or other thing which will float ; remembering only that the less it rises above the surface of the water the better, for even in a calm its motion is impeded by the resistance of the air, and if there be wind, it tends alike, from whatever quarter it blows, to give an enormous result.† While your assistant is going about this, station yourself behind *d*, then take out your watch and be ready. Your assistant having thrown in the float, runs down to his place behind *c*, to wait for its passage : when he sees it coming near he must raise up his arm at full stretch, on seeing which you stop the seconds hand of your stop watch, keeping your nail on the catch. The moment the float passes the line *c b*, the assistant drops his hand, and at the same instant you touch the catch and let go the seconds hand of your watch, keeping your nail at the catch ready to stop the watch again ; you observe, in your turn, the passage of the float past *b d*, when you stop the watch, and count the seconds elapsed during the passage of the float from *a* to *b*. Now multiply 30 by the number of times you have taken 51 feet in your line from *a* to *b*, and divide by the number of seconds elapsed, and the quotient will be the velocity of the stream, expressed in nautical miles to the hour. Example, suppose you had measured 255 feet from *a* to *b*, or 5 times 51 feet, and the seconds elapsed, as marked by the stop watch, had been 40. Then—

$$\frac{30 \times 5}{40} = 3\tfrac{3}{4} \text{ geographical miles per hour.}$$

Velocity of the Mass of Water.—The surface velocity being obtained by any of the methods above stated, the velocity of the mass of moving water may be found with sufficient accuracy for all practical purposes by the following rule :—

From the square root of the velocity at the surface take 1, square the remainder, ad

* When a river is wide, it is no easy matter to throw any thing exactly into the middle of the stream, or to see it floating there, if small. In this case, if a bend can be found at no great distance above, as at *e*, the float should be there thrown in, as at such places the mid-current, or *fil de l'eau*, as the French term it, hugs or approaches the re-entering bank. In all cases it must be stated whether the rapidity observed be that at the middle of the stream or not, for the difference is very great between that in the middle and that near the banks ; the latter being incomparably slower, and so much the more so as the banks are more shelving.

† The best kind of float is, perhaps, that which was used by General Destrem on the Neva, but it requires conveniences which a traveller cannot always command. It consists of a cylindrical disc of cork, one inch thick and one foot in diameter, and lined with sheet lead, so as its upper surface may just be even with the surface of the water ; from the centre of this disc rises a slight copper stem surmounted by a little ball of cork, painted white. This may be seen at a distance, is little affected by the wind, and the small thickness of the disc prevents its motion being affected by the less rapidity of the deeper fillets of the stream.—See *Journal des Voies de Communications*, No. 2. St. Petersburgh, 1826.

this square to the velocity at the surface, and take half the sum, so that if S be the velocity at the surface, and Y that of the mass, the formula will stand thus—

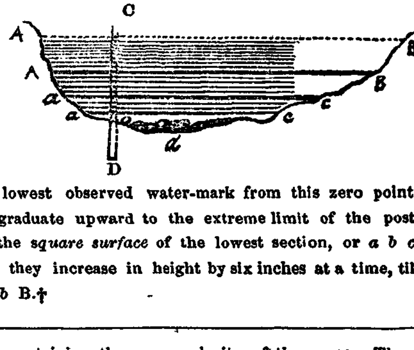
$$Y=\frac{(\sqrt{S}-1)^2+S}{2}.*$$

TO FIND THE QUANTITY OF WATER DISCHARGED BY A RIVER, AT A GIVEN POINT IN A GIVEN TIME.

In order to ascertain the quantity of water discharged by a river, at any given point of its course in a given time, it is only necessary to multiply the section at the particular place by the rapidity of the mass at the same place. Having already detailed the operation by which the rapidity of the mass is found, it remains to explain how the section of the river is to be obtained.

Having chosen a convenient spot for the purpose, drive down into the bed of the river a squared post, which must be sufficiently long to rise above the greatest height to which the water ever rises. Form this into a scale, beginning at, or even below, the lowest observed water-mark, and indicating every rise of six inches, by white lines on a black ground, or black lines on a white ground with corresponding number, at every foot.

This done, measure, with the greatest possible accuracy, the transverse section of the river passing through the post, and formed by a vertical plane, perpendicular to the direction of the stream, the superior limit of which section must be a horizontal line passing through the top of the post. Lay this section carefully down on paper, by scale, and as large as possible.



Having done this, let fall, as in the figure, the line C D, perpendicular to A B, the superior limit of the section, and at a height O from the bottom of the bed, mark the zero point somewhat below the lowest observed water-mark from this zero point, taking six inches from your scale, graduate upward to the extreme limit of the post. Now measure as nearly as possible the *square surface* of the lowest section, or *a b c*, and successively all the sections, as they increase in height by six inches at a time, till you arrive at the greatest section, A *b* B.†

* There are other formulæ for ascertaining the mean velocity of the mass. Thus, knowing the slope and the section of the bed, proceed thus, *a* being the section of the channel, *p* the periphery of the channel, *l* the length of the course in which the slope *h* has been observed, and *x* the mean velocity sought, say

$$x=90{,}9\frac{\sqrt{ah.}}{pl.}$$

This formula is by Etelwein, and is consigned in the memoirs of the Academy of Berlin. Whatever formula be adopted, however, nothing but an approximation to truth can possibly be obtained. Those, however, who wish, for particular purposes, to calculate with the greatest possible accuracy, may consult Bellidor, Prony, and other engineers.

† The lines A B and *a c* in the figure, are supposed to represent the ordinary high and low water marks.

These areas of the different sections must now be entered in the second olumn of a table like the following:—

Height of water at the post.	Areas of sections in square feet.	Velocity; feet in a second.	Discharge of water in cubic feet in a second.	Remarks.
ft in.	...	..	..	
0 — 6	..	..	...	
1 — 0	..	...	...	
1 — 6	...	...	...	
2 — 0	...	...	..	
2 — 6	...	...	...	
3 — 0	..	...	...	
3 — 6	...	...	..	
&c.	...	..	...	
	..	...	...	

Every thing being thus arranged, the velocity of the mass must be observed at all the different heights, as occasion offers, and the results placed in the third column, when the multiplication of the numbers of the second and third column will furnish the result to be consigned in the fourth.

A circumstance which it is very important to observe is, that the velocity, and consequently the discharge, is not always the same for the same height of water. Thus, in the vicinity of the embouchure into large lakes, or inland seas without tides, the direction of the wind, by impeding the flowing off of the waters, causes them to rise, and sometimes even drives them back to overflowing, as is the case with the Neva, at St. Petersburg. Sometimes the increased rapidity and volume of water of a large recipient swells up the water of an affluent. Care must be taken to notice these circumstances, so as not to confound such accidental rise with that occasioned by an increase in the quantity of water flowing down.

Now, supposing the stream to flow equably, it is evident that, by multiplying the numbers of the fourth column by sixty, the product will be the quantity of water which flows off in a minute, and this again by sixty, the discharge of an hour; this again by twenty-four, the daily discharge, and so on.

But as few rivers have this regularity, it is best to observe at least three times a day, from the medium of which observations will be calculated the discharge of the day. When once the discharge at all the different heights of section shall have been obtained, it will be sufficient just to remark the height of the water, and then insert the corresponding discharge in the morning, at noon, and in the evening of each day, as in the following table, the mean of which will be the mean discharge for that day. Thus—

DISCHARGE OF THE WATER OF———, MONTH OF———.

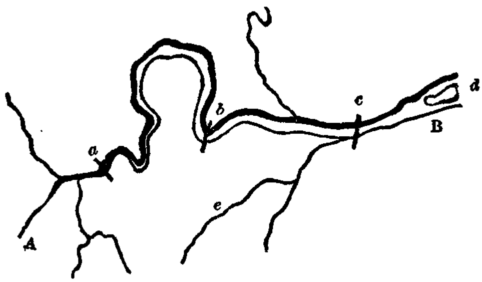
Date.	Observed discharge in cubic feet.			Mean daily discharge.	Remarks.
	Morning.	Noon.	Evening.		
1	...	..	...	...	
2	...	..	..	...	
3	...	...	..	..	
4	..	...	...	...	
&c.	..	...	...	...	

The addition of the means will give the whole discharge for the month.

It is evident, that by this plan, an approximate estimation of the discharge of the river at any particular place, so long as the bed remains surcharged, may be obtained by the second, the minute, the hour, the day, the month, or the year, and for any number of years, &c.

TO ASCERTAIN THE QUANTITY OF SOLID MATTER HELD IN SUSPENSION BY RUNNING WATER.

To judge of the solid matter held in suspension by running water, and thus conveyed from one place to be eventually deposited in another, would be a very easy task, if the particles were all of equal size, and the stream equally rapid in all parts, for then it would be sufficient to take up, from the immediate surface, a given measure of the troubled water, and separating the solid particles by filtration or by subsidence, measure the residuum. But two causes contribute to render the result of such a method erroneous, the difference in the size and weight of the particles of suspended matter, and the different velocities of the stream at different depths, at different distances from the banks, and in different parts of the river's course. The fact, therefore, is, that the proportion of matter carried along by the water is different at different places, and at different depths. The most rapid part of the current being a little below the surface, and in the deeper part of the stream, it is also there where the greater proportion of suspended matter will be found; but this will be different in different parts of the river's course. Thus it is impossible to say from one, or even a few experiments, made in different places, that the river, generally speaking, carries along such or such a proportion of detrital matter; for from the separate data no medium can be taken; each case is a fact in itself, unconnected with every other. Thus in the river A B, experiments made at the points *a*, *b*, *c*, will give different results; say at *a*, 1-100th; at *b*, 1-500th, and at *c*, 1-350th.



Now we must neither take the sum of these quantities nor the mean. The water at *a* is very thick and troubled, coming immediately from the torrents near the source; but the bends of the river between *a* and *b*, are such that the rapidity of the stream is greatly impeded, so that at *b* the water contains only 1-500th of sedimentary matter. If no fresh detritus were stirred up or brought into the river, a still smaller proportion would be formed at *c*; but either because the soil from *b* to *c* is of easy erosion in the floods, or because the stream *e* bring in a quantity of mud or sand, the water at *c* is found to bear along 1-350th part of detrital matter, the greater part of which is deposited at the bank *d*.

In estimating, therefore, the quantity of sedimentary matter carried along by streams, with a view to form some idea of the progress of alluvial deposits (the only object for which such estimate is made), the experiment should invariably be made as near as possible to the spot at which the alluvial deposit is an object of interest. If it had so happened that a lake had intervened between that part of the Yellow River of China, when Sir George Staunton made his experiments, and the sea, so far from bringing into the Yellow Sea forty-eight millions of cubic feet of earthy matter, that river might not have brought in any; or if, without a lake, the course had been long or very winding, the quantity might have been less; or if, in that length of course, other turbid waters were received, the quantity would have been greater.

Mr. Lyall, in treating of this subject, proposes taking the weight of the sedimentary matter obtained in the experiment, and then, from the difference of the specific gravity between the water and the sedimentary matter, deducing the bulk of the latter; but the readier manner is to compare the bulks at once.

Thus, take from different places, in a line across a proper part of the stream, a given measure of the turbid water, and having allowed it to subside, draw off the clear water, and dry the precipitate. In the case of a very fine clay, which requires a long time to settle completely, the last water must be driven off by artificial heat. Measure the dried mass, and compare its bulk with that of the turbid water taken up. Any cylindrical vessel will do for the experiment, by merely dividing it into equal parts, or by measuring the height of the liquid with a rule or stick divided into equal parts—say tenths of an inch,—and subsequently putting the dried precipitate into same vessel, and observing its height with the same rule or stick. The dried precipitate must of course be brought to as horizontal a surface as possible in the vessel, before the rule be stuck into it, and the rule must be as thin as possible, in order not to displace any notable quantity either of water or sediment.

It will be found that the quantity urged along in the deep part of the current, is greater than that carried forward in the more shallow parts; the latter will also be finer, the medium of these in the same cross section must be taken; and when the absolute quantity of turbid water which passes the place in a given time is known, the quantity of solid matter carried into the sea or into a lake or other recipient, to be there deposited, is easily computed, with an approximation to truth, sufficient for the purposes intended.

TO TAKE THE TEMPERATURE OF SPRINGS.

The traveller should never pass a spring without taking its temperature, if this be possible. We recommend his plunging the whole instrument into the water and holding it there till it has taken the temperature, then draw it out sufficiently to read off; after which dip it in again, and repeat the operation three times at least, and if there be any difference in the reading, take the mean of the three observations. Wipe the instrument carefully before putting it back into its case. The temperature of springs should be taken as close as possible to the very point where they issue from the earth. The temperature of the air in the shade, must be taken at the same time. The object of plunging the whole instrument in the water is to save time, and have greater accuracy. Care must be taken however, not to plunge suddenly a thermometer which is very warm into an ice cold spring. In taking the temperature of mineral springs, the thermometer should be put into a glass tube, otherwise the metal mounting may be corroded;* but when a tube is used, longer time is, of course, required to get the temperature.

In taking the temperature of springs it is necessary to note their position and aspect, and the nature of the rock or soil whence they issue.

TO TAKE THE TEMPERATURE OF THE SOIL.

The temperature of the soil at what may be regarded as its surface is easily observed. Surround the bulb of your thermometer with some non-conducting substance; put it into a strong wooden box, but which may be readily opened, and bury it at depths of 3, 6, 9, 12, &c., feet in the soil. A rope should be fastened to the box, with its extremity above ground, to serve as a guide for digging the box up again. The instrument should be left in the ground twelve hours, and the time it is taken up should be indicated, and, with the temperature marked by the buried instrument, should be noted that of the air at the time of burying and of taking up the instrument out of the ground. This operation, simple as it is, cannot always be performed by the traveller for want of time or other reasons; but those who remain any time in the same place, should examine as far as they can, the temperature of different soils at different depths, in different seasons, and in different localities. The depth to which soil freezes is particularly interesting; but in order to ascertain this, the soil must be dug and examined, not only by placing a thermometer in the soil so dug, but by examining it with a magnifier in order to discern the interspersed spiculæ of ice. When the temperature of a soil likely to freeze is to be observed, bottles filled with spirit should be buried in boxes, stuffed with some bad conducting substance, and the necks of the bottles, being of a size to admit the thermometer, this latter should be immediately plunged into the liquor when the bottle is drawn up, and quickly read off.

The temperature of sand is taken by simply sticking the naked thermometer into it and observing its indication; but we recommend wrapping a fold of paper over that part of the instrument which is plunged into sand or soil, to prevent the scratching of the glass.

TO TAKE THE TEMPERATURE OF THE GASES RISING FROM VOLCANOES.

The thermometer should, as in the case of mineral springs, be protected by a glass tube; and when it is required to ascertain the temperature of the hot chasms or fissures of volcanoes, or the temperature of thermal springs, the bulb of the instrument must be surrounded with bad conductors.

TO OBSERVE THE COLOUR OF WATER.

M. Arago recommends that the colour of sea water, as also that of lakes and rivers be observed by means of a large hollow prism, whose refracting angle is 45°. To observe with this instrument, let the refraction angle dip into the water, the prism being held horizontally, and with one face of the angle (that turned from the spectator) being vertical, in which case the other face will of course be inclined 45° to the horizon. The instrument being thus disposed, the light which traverses horizontally, just below the

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* Thermometers graduated on the glass stem, or having a glass scale are the best fo such cases.

surface of the water, will strike the vertical side of the prism, will penetrate it, and reach the face turned towards the observer, whence it will be reflected vertically, so that on looking down upon the inclined face, the colour of the water will be seen.

We give this method as being the only one with which we are acquainted that seems philosophical, but we cannot help observing, that even if this method were calculated satisfactorily to solve the intricate question of the colour of water, it could but seldom be employed conveniently for the observer, and perhaps never in those cases where the singularity of tint renders its examination the more desirable.

Where no insturment is used, the traveller must be content to observe the tint of the water as it appears to him, taking notice of the nature and colour of the bottom, the height of the sun, the angle under which he views the water, the state of its surface, as smooth or agitated, the state of the sky, &c. Having done all this, two objects are still necessary to be attended to; the precise determination of the colour the water presents, and the cause of this colour, if it can be ascertaind.

As for the former of these objects, we know of no better way than by a comparison with a very complete chromatic scale of tints, which no traveller should be without, although, unfortunately, science has not yet discovered a means of making chromatic scales comparable at all times and in all places.

As for the cause of the tints which water presents, it is difficult to determine satisfactorily, unless when the water contains foreign substances, which, though often exceedingly small, may be detected by taking up a portion of the water and examining it with a good microscope.

TO COLLECT THE GASES FROM VOLCANOES, SPRINGS, &c.

This is an operation which the casual traveller can hardly have time or opportunity to perform. As it is, however, desirable to ascertain precisely the nature of the gases given out by volcanoes, springs, &c., we will point out a mode by which this may be effected.

Fill a bottle with water and invert it into a basin having some water in it and a slip of wood laid across with a notch cut out to receive the neck of the bottle. Insert one end of a double bent tube* having this form into the nozzle of a funnel by means of a cork or otherwise, so that gas may not escape at the juncture. Slip the other end of the bent tube into the neck of the bottle. Having thus arranged your pneumatic trough, fasten all firmly, so that nothing may move, and set the apparatus with the inverted funnel over the evolving gas. If there be any inconvenience or danger attending a too near approach, fix the whole to a ring, at the end of a pole, like the ring and handle of a landing net, and hold the apparatus over the gas till the bottle be full, which it will be when all the water is expelled. Then remove the tube, and cork your bottle under water. The water used must not be thrown away, but bottled for examination, as it may have imbibed some principles from the gas which passed through it.

A portable apparatus for collecting the gas might be easily imagined, and would be found very useful on many occasions.

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* A flexible tube might, on many occasions, supply the place of a glass tube with advantage; and such a one might be made to screw on to the end of a funnel.

TO TAKE THE LENGTH, BREADTH, CIRCUMFERENCE, AND SURFACE OF LAKES.

If square, the side will of course be both length and breadth; if oblong, the longest side will be the length, and the shortest the breadth; if round, take the diameter; if oval, take the two diameters; if the shape be triangular, take the length of one of the sides if they are nearly similar, and of the base of the triangle, and of one of the other sides, if the triangle be a short or long isosceles; when the lake is of a long, narrow, and winding form, it may be well to take two lengths; that of the lake itself must be measured along a line traced in the general direction of the lake, and as equidistant as possible from either side, and the other distance must be from the extreme points in a straight line, whether it pass over the land or not. For this kind of lake, and generally for such as are irregularly wide, the greatest, the last, and the general medium breadth should be taken. All breadths must invariably be taken perpendicularly to the line of length. In the case of extraordinary forms and irregularity, various dimensions should be taken, and the directions in which these are taken must be well defined.

Lengths and breadths actually taken on the water, and not estimated between points obtained by intersection or otherwise, may be measured by ascertaining the rate of rowing, and finding how long it takes to row from end to end of the lake, and across it.

The length and breadth once obtained, if the form be at all regular, the perimeter is easily found by calculation; in other cases actual admeasurement must be had recourse to.

Whenever a sufficient number of points at the circumference can be obtained by intersection, these may be united by lines, which being measured and a proper allowance over and above being made, the circumference will be ascertained with sufficient accuracy for the ordinary purposes of geography; but if this plan cannot be followed, then the circumference may be found by the time required to walk or ride round the lake, making due allowance whenever the various sinuosities are not closely followed.

The surface of a lake is easily found when its dimensions and form are known. Thus, if it be circular, or nearly so, multiply the circumference by a quarter of the diameter; if it be oval, multiply the transverse and conjugate diameters together, and the product by 7854; for a square, multiply the side by itself; for oblong, the long side by the short; for triangular, the perpendicular by half the base; and for all irregular figures divide them into triangles, and taking the surface of each of them, add them together.

It is interesting to know the surface of lakes in order to ascertain the probable evaporation from them, which has great influence on the climate of the surrounding country.

OBSERVATIONS AT SEA.

The following extract from the instructions of the United States Government on the subject of deep sea surveying are worthy of careful attention; they are taken from the Washington Observatory Reports for 1849:—

Programme of the Instructions issued o Lieut. Commanding J. C. Walsh, of the U. S. Schooner "Taney," by the Secretary of the Navy, October 4th, 1849.

The object of the service upon which the "Taney" has been detailed, is to make observations upon the winds and currents of the sea, and to collect other facts in connection with the "wind and current charts" of Lieut. Maury, and which are of practical importance to the safe navigation of the seas, or to the study of the phenomena of the ocean. This is an important service. It is a service which requires patient and laborious observations from the officers entrusted with it.

A faithful record of every phenomenon observed, with a full statement of all the circumstances as to time, place, &c., connected with it, is of great importance.

It is expected, therefore, that you and the officers of the "Taney," will bestow upon the duty which has been assigned yourself and them, because of a peculiar fitness therefor, the utmost diligence and the most assiduous attention.

The subjects of observation which will command your particular attention, are:—

1st. The force and direction of the wind, the hourly state of the weather and all the meteorological conditions connected therewith, as thermal, dynamical, barometrical, and the like.

2d. The force and set of currents, their depth and width, their temperature and the position of their edges or limits.

3d. Hourly observations upon the temperature of the surface water.

4th. Frequent observations upon the temperature of the ocean at various depths.

5th. Deep-sea soundings.

6th. Vigias and all dangers about which there are doubts either as to existence or position.

7th. Transparency and saltness, or the specific gravity of sea-water, in the different parts of the ocean.

You will determine the specific gravity of the water either by one of the hydrometers or the specific gravity bottle furnished for the purpose.

You will keep an abstract of your log, as per form. * It is believed that the

* We have not deemed it necessany to give the form.

form itself is sufficiently explicit as to what is wanted for the abstract, a copy of which you will send to Lieut. Maury, as often as you have an opportunity, returning the original to him when you arrive in the United States.

You will make it a rule, the better to ascertain the rate of currents and fix their limits, to determine by observation the variation of the compass and your position in the forenoon, in the afternoon, and at night, as well as at noon whenever the weather will permit; and after allowing for lee-way, heave of the sea, variation of the compass and false steerage, you will call the difference between the place of the vessel as established by observation, and as established by *dead reckoning*, current, and so enter it in the abstract.

You will also try in calms, and as often as convenient, both for surface and under currents, in the usual way, by lowering boats, letting down weights, &c.

For longitude by chronometer at night, the planets, or the largest of the fixed stars are the best objects to be observed when the horizon is good. The Mer. Alt. of the moon may be used for latitude at night, or in the fore or afternoon according to its age.

Note in its proper column, not only the portion of cloudy sky, 10 being entirely overcast, and 0 clear; but state also the direction or directions in which the clouds are moving, with the kinds of clouds, as Nimb., Cum., Cirrus, Stratus, &c.

In taking temperature of surface water, a fresh bucket should be drawn up each time, the thermometer plunged into it immediately, held there for several minutes, and *read while the bulb is in the water*.

For the purpose of ascertaining the existence of under currents, you will sound at intervals, at the least, of every 30 miles, with 100 fathoms line, if there be as much depth, attaching to the line two thermometers, one near the lead and the other 30 fathoms from it. In case you have no thermometers suitable, or should lose them, then you will attach two hollow non-conducting cylinders with valves opening upward, in the place of the thermometers, haul the line up briskly, and try quickly the temperature of the water brought up in the cylinders.

In case you should find an under current, you will endeavour to ascertain its limits and set with all the accuracy possible. For rate and direction, a block of wood, or a berrega loaded just to sinking, and suspended at any required depth by a small float just sufficient to keep it from sinking further, will perhaps be the best means.

The determination of the rate and set of under currents is an operation which is so modified by the weather and other circumstances, that is must of necessity be left, in a great measure, to the judgement and mental resources of the operators. The officers of the "Taney" will, perhaps, have abundant opportunity to display their ingenuity with regard to the subject. The lead used in sounding for temperatures should be painted white, and the distance at which it disappears going down and re-appears coming up should be entered in fathoms in the transparency column.

The "Taney" will be provided with the means of sounding at great depths. It is desirable to reach the bottom at every attempt, for the depth of the ocean is an important element towards a perfect understanding of the tides, their laws of motion, the course and form of the tidal wave, and the like.

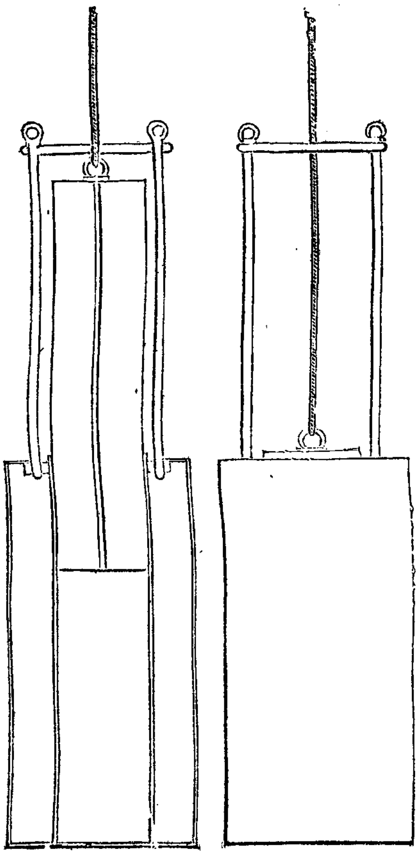
At the distance of every two hundred miles across the ocean, soundings must be made all the way both going and returning with the view to reach the bottom and determine the depth of the sea. The "Taney" has been provided with the necessary apparatus therefor. In each case the lead must be armed, the specimens of the bottom which it may bring up must be preserved in a bottle with a label attached showing the date, place, and the depth. The time selected for these soundings should be calm weather, when the sea is smooth and when there is a likelihood of its so continuing for several hours at least. In hauling up the sounding line from great depths, care should be taken to prevent the lead from having too great an upward motion, lest by turning around it should twist the line in two. Therefore in hauling it up frequent pauses should be made to allow the line to untwist. It is desirable also to have specimens of water from the gratest depths.

In going across the Atlantic and in looking after the vigias and doubtful dangers to which your attention will also be called, it will be most convenient for you to take up your position for deep sea-sounding in the calm region known as the "horse latitudes," which in the month of October will be found between the parallels of 24° and 35° N. according to longitude; you will see the limits of this calm belt sufficiently marked and developed on series B of Maury's wind and current chart, with copies of which the "Taney" will be supplied.

A series of accurate barometrical observations in this belt of calms will be of exceeding interest and value. It is one of the nodes in the general system of the atmospherical circulation of the earth. Here the winds from the polar meet in the upper regions those from the equatorial calms, and they so nearly balance each other as to produce almost a perpetual calm. We may then look under this meeting of opposing winds for an accumulation of atmosphere, and consequently for an increased barometrical pressure, and from this increase of pressure, accurately determined, may be derived an expression to show the total amount or value of those physical forces which are exerted to put and keep the trade winds in motion. You will, therefore, be diligent with the barometer in those regions and in all others, taking care when it is mounted on board to note in the abstract log its distance from the level of the sea.

Instead of the method of obtaining specimens of water, either with the view of determining its temperature or its other qualities, the following is recorded as having the advantage of of extreme simplicity on its side :—

The following instrument for obtaining specimens of water from great depths requires no explanation. It consists of a cylinder of common tin plate with a double wall, the outer and inner plates of which are an inch or so apart, and filled up with dammer, pitch, sealing-wax, or some other bad conductor. Inside is a solid piston of wood, with a slight groove on one side. A cross bar and side-links allow this to be pulled out to about three quarters of its length. The piston being forced home, the whole is lowered to the required depth in the water : the piston line being pulled, withdraws the piston, and of course the water at this particular depth finds its way through the groove and takes the place of the piston itself. The whole is now quickly withdrawn : the piston pulled out altogether, and the water examined. This I have tried at depths of thirty and forty feet, and found it to answer perfectly.



Cylinder for drawing water from considerable depths under the surface of the sea.

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000.)	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
10	10·0	10·0	0·089	1·11	0·00	1·000	550·1	560·0	569·8	579·6	589·4	599·2	609·0
	9·8	8·3	0·084	1·05	0·06	0·946	550·2	560·1	569·9	579·7	589·5	599·3	609·1
	9·6	6·6	0·079	0·98	0·13	0·883	550·2	560·1	569·9	579·7	589·5	599·3	609·1
	9·4	4·9	0·074	0·92	0·19	0·829	550·2	560·1	569·9	579·7	589·5	599·3	609·1
	9·2	3·2	0·069	0·86	0·25	0·775	550·3	560·2	570·0	579·8	589·6	599·4	609·2
	9·0	1·5	0·065	0·81	0·30	0·730	550·3	560·3	570·0	579·8	589·6	599·4	609·3
11	11·0	11·0	0·093	1·15	0·00	1·000	548·9	558·7	568·5	578·3	588·1	597·9	607·7
	10·8	9·3	0·087	1·08	0·07	0·939	548·9	558·7	568·5	578·3	588·1	597·9	607·7
	10·6	7·6	0·082	1·02	0·13	0·887	549·0	558·8	568·6	578·4	588·2	598·0	607·8
	10·4	5·9	0·077	0·96	0·19	0·835	549·0	558·8	568·6	578·4	588·2	598·0	607·8
	10·2	4·2	0·072	0·90	0·25	0·783	549·0	558·8	568·6	578·4	588·2	598·0	607·8
	10·0	2·5	0·067	0·84	0·31	0·731	549·1	558·9	568·7	578·6	588·3	598·1	607·9
	9·8	0·8	0·063	0·78	0·37	0·679	549·1	558·9	568·7	578·6	588·3	598·1	607·9
12	12·0	12·0	0·096	1·19	0·00	1·000	547·7	557·5	567·2	577·0	586·8	596·6	606·4
	11·8	10·3	0·090	1·12	0·07	0·942	547·7	557·5	567·2	577·0	586·8	596·6	606·4
	11·6	8·6	0·085	1·05	0·14	0·883	547·8	557·6	567·3	577·1	586·9	596·7	606·5
	11·4	6·9	0·080	0·99	0·20	0·832	547·8	557·6	567·3	577·1	586·9	596·7	606·5
	11·2	5·2	0·075	0·93	0·26	0·782	547·8	557·6	567·3	577·1	586·9	596·7	606·5
	11·0	3·5	0·070	0·87	0·32	0·731	547·9	557·7	567·4	577·2	587·0	596·8	606·6
	10·8	1·8	0·066	0·81	0·38	0·681	547·9	557·7	567·4	577·2	587·0	596·8	606·6
	10·6	0·1	0·061	0·76	0·43	0·639	547·9	557·7	567·4	577·2	587·0	596·8	606·6
13	13·0	13·0	0·100	1·24	0·00	1·000	546·5	556·3	566·0	575·8	585·5	595·3	605·0
	12·8	11·3	0·094	1·16	0·08	0·936	546·5	556·3	566·0	575·8	585·5	595·3	605·0
	12·6	9·6	0·088	1·08	0·16	0·871	546·6	556·4	566·1	575·9	585·6	595·4	605·1
	12·4	7·9	0·083	1·02	0·22	0·823	546·7	556·5	566·2	576·0	585·7	595·5	605·2
	12·2	6·2	0·077	0·97	0·27	0·783	546·7	556·5	566·2	576·0	585·7	595·5	605·2
	12·0	4·5	0·073	0·91	0·33	0·734	546·7	556·5	566·2	576·0	585·7	595·5	605·2
	11·8	2·8	0·068	0·84	0·40	0·678	546·8	556·6	566·3	576·1	585·8	595·6	605·3
	11·6	1·1	0·064	0·79	0·45	0·637	546·8	556·6	566·3	576·1	585·8	595·6	605·3
14	14·0	14·0	0·104	1·28	0·00	1·000	545·3	555·0	564·7	574·4	584·2	594·0	603·7
	13·8	12·3	0·097	1·20	0·08	0·938	545·3	555·0	564·7	574·4	584·2	594·0	603·7
	13·6	10·6	0·091	1·12	0·16	0·875	545·4	555·1	564·8	574·5	584·3	594·1	603·8
	13·4	8·9	0·086	1·06	0·22	0·828	545·4	555·1	564·8	574·5	584·3	594·1	603·8
	13·2	7·2	0·080	1·00	0·28	0·782	545·4	555·1	564·8	574·5	584·3	594·1	603·8
	13·0	5·5	0·075	0·93	0·35	0·727	545·5	555·2	564·9	574·6	584·4	594·2	603·9
	12·8	3·8	0·071	0·87	0·41	0·680	545·5	555·2	564·9	574·6	584·4	594·2	603·9
	12·6	2·1	0·066	0·82	0·46	0·641	545·6	555·3	565·0	574·7	584·5	594·2	603·9
15	15·0	15·0	0·108	1·32	0·00	1·000	544·0	553·8	563·5	573·2	582·9	592·6	602·3
	14·8	13·3	0·101	1·24	0·08	0·940	544·0	553·8	563·5	573·2	582·9	592·6	602·3
	14·6	11·6	0·095	1·16	0·16	0·879	544·1	553·9	563·6	573·3	583·0	592·7	602·4
	14·4	9·9	0·089	1·10	0·22	0·833	544·1	553·9	563·6	573·3	583·0	592·7	602·4
	14·2	8·2	0·083	1·04	0·28	0·788	544·2	554·0	563·7	573·4	583·1	592·8	602·5
	14·0	6·5	0·078	0·97	0·35	0·735	544·2	554·0	563·7	573·4	583·1	592·8	602·5
	13·8	4·8	0·073	0·90	0·42	0·682	544·2	554·0	563·7	573·4	583·1	592·8	602·5
	13·6	3·1	0·069	0·85	0·47	0·644	544·3	554·1	563·8	573·5	583·2	592·9	602·6
16	16·0	16·0	0·112	1·37	0·00	1·000	542·8	552·5	562·2	571·9	581·6	591·3	601·0
	15·8	14·3	0·105	1·29	0·08	0·942	542·9	552·6	562·3	572·0	581·7	591·4	601·1
	15·6	12·6	0·098	1·21	0·16	0·883	542·9	552·6	562·3	572·0	581·7	591·4	601·1
	15·4	10·9	0·092	1·14	0·23	0·832	543·0	552·7	562·4	572·1	581·8	591·5	601·2
	15·2	9·2	0·087	1·07	0·30	0·781	543·0	552·7	562·4	572·1	581·8	591·5	601·2
	15·0	7·5	0·081	1·00	0·37	0·730	543·0	552·7	562·4	572·1	581·8	591·5	601·2
	14·8	5·8	0·076	0·94	0·43	0·686	543·1	552·8	562·5	572·1	581·9	591·6	601·3
	14·6	4·1	0·072	0·88	0·49	0·643	543·1	552·8	562·5	572·1	581·9	591·6	601·3

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
			in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
17°	17°0	17·0°	0·116	1·41	0·00	1·000	541·3	551·0	560·8	570·5	580·1	589·8	599·4
	16·8	15·3	0·109	1·33	0·08	0·943	541·3	551·0	560·8	570·5	580·1	589·8	599·4
	16·6	13·6	0·102	1·25	0·16	0·887	541·4	551·1	560·9	570·6	580·2	589·9	599·5
	16·4	11·9	0·096	1·17	0·24	0·830	541·4	551·1	560·9	570·6	580·2	589·9	599·5
	16·2	10·2	0·090	1·10	0·31	0·780	541·5	551·2	561·0	570·7	580·3	590·0	599·6
	16·0	8·5	0·084	1·03	0·38	0·730	541·5	551·2	561·0	570·7	580·3	590·0	599·6
	15·8	6·8	0·079	0·97	0·44	0·688	541·5	551·2	561·0	570·7	580·3	590·0	599·6
	15·6	5·1	0·074	0·91	0·50	0·646	541·6	551·3	561·1	570·8	580·4	590·1	599·7
18	18·0	18·0	0·120	1·47	0·00	1·000	540·5	550·2	559·8	569·5	579·1	588·8	598·4
	17·8	16·3	0·113	1·38	0·09	0·939	540·5	550·2	559·8	569·5	579·1	588·8	598·4
	17·6	14·6	0·106	1·29	0·18	0·878	540·6	550·3	559·9	569·6	579·2	588·9	598·5
	17·4	12·9	0·099	1·21	0·26	0·824	540·6	550·3	559·9	569·6	579·2	588·9	598·5
	17·2	11·2	0·093	1·14	0·33	0·776	540·7	550·4	560·0	569·7	579·3	589·0	598·6
	17·0	9·5	0·088	1·07	0·40	0·728	540·7	550·4	560·0	569·7	579·3	589·0	598·6
	16·8	7·8	0·082	1·01	0·46	0·688	540·7	550·5	560·1	569·8	579·3	589·0	598·6
	16·6	6·1	0·077	0·95	0·52	0·647	540·8	550·6	560·2	569·9	579·4	589·1	598·7
19	19·0	19·0	0·125	1·52	0·00	1·000	539·3	548·9	558·5	568·2	577·8	587·5	597·1
	18·8	17·3	0·117	1·43	0·09	0·941	539·3	548·9	558·5	568·2	577·8	587·5	597·1
	18·6	15·6	0·110	1·34	0·18	0·882	539·4	549·0	558·6	568·3	577·9	587·6	597·2
	18·4	13·9	0·103	1·26	0·26	0·829	539·4	549·0	558·6	568·3	577·9	587·6	597·2
	18·2	12·2	0·097	1·18	0·34	0·776	539·5	549·1	558·7	568·4	578·0	587·7	597·3
	18·0	10·5	0·091	1·11	0·41	0·730	539·5	549·1	558·7	568·4	578·0	587·7	597·3
	17·8	8·8	0·085	1·04	0·48	0·684	539·6	549·2	558·8	568·5	578·1	587·8	597·4
	17·6	7·1	0·080	0·98	0·54	0·645	539·6	549·2	558·8	568·5	578·1	587·8	597·4
20	20·0	20·0	0·129	1·58	0·00	1·000	538·1	547·7	557·3	566·9	576·5	586·1	595·7
	19·8	18·3	0·121	1·48	0·10	0·937	538·2	547·8	557·4	567·0	576·6	586·2	595·8
	19·6	16·6	0·114	1·38	0·20	0·874	538·3	547·9	557·5	567·1	576·7	586·3	595·9
	19·4	14·9	0·107	1·30	0·28	0·823	538·3	547·9	557·5	567·1	576·7	586·3	595·9
	19·2	13·2	0·101	1·23	0·35	0·779	538·3	547·9	557·5	567·1	576·7	586·3	595·9
	19·0	11·5	0·094	1·15	0·43	0·728	538·4	548·0	557·6	567·2	576·8	586·4	596·0
	18·8	9·8	0·089	1·08	0·50	0·684	538·4	548·0	557·6	567·2	576·8	586·4	596·0
	18·6	8·1	0·083	1·01	0·57	0·639	538·5	548·1	557·7	567·3	576·9	586·5	596·1
	18·4	6·4	0·078	0·95	0·63	0·601	538·5	548·1	557·7	567·3	576·9	586·5	596·1
21	21·0	21·0	0·134	1·63	0·00	1·000	537·0	546·6	556·1	565·7	575·3	584·9	594·5
	20·8	19·3	0·126	1·53	0·10	0·939	537·0	546·6	556·1	565·7	575·3	584·9	594·5
	20·6	17·6	0·118	1·44	0·19	0·884	537·1	546·7	556·2	565·8	575·4	585·0	594·6
	20·4	15·9	0·111	1·36	0·27	0·835	537·1	546·7	556·2	565·8	575·4	585·0	594·6
	20·2	14·2	0·104	1·28	0·35	0·785	537·2	546·8	556·3	565·9	575·5	585·1	594·7
	20·0	12·5	0·098	1·20	0·43	0·736	537·2	546·8	556·3	565·9	575·5	585·1	594·7
	19·8	10·8	0·092	1·12	0·51	0·687	537·3	546·9	556·4	566·0	575·6	585·2	594·8
	19·6	9·1	0·086	1·05	0·58	0·644	537·3	546·9	556·4	566·0	575·6	585·2	594·8
	19·4	7·4	0·081	0·99	0·64	0·607	537·3	546·9	556·4	566·0	575·6	585·2	594·8
22	22·0	22·0	0·139	1·69	0·00	1·000	535·7	545·3	554·9	564·5	574·0	583·6	593·1
	21·8	20·3	0·131	1·59	0·10	0·941	535·8	545·4	555·0	564·6	574·1	583·7	593·2
	21·6	18·6	0·123	1·49	0·20	0·882	535·8	545·4	555·0	564·6	574·1	583·7	593·2
	21·4	16·9	0·115	1·40	0·29	0·828	535·9	545·5	555·1	564·7	574·2	583·8	593·3
	21·2	15·2	0·108	1·31	0·38	0·775	535·9	545·5	555·1	564·7	574·2	583·8	593·3
	21·0	13·5	0·102	1·23	0·46	0·728	536·0	545·6	555·2	564·8	574·3	583·9	593·4
	20·8	11·8	0·096	1·16	0·53	0·686	536·0	545·6	555·2	564·8	574·3	583·9	593·4
	20·6	10·1	0·090	1·09	0·60	0·645	536·1	545·7	555·3	564·9	574·4	584·0	593·5
	20·4	8·4	0·084	1·02	0·67	0·604	536·1	545·7	555·3	564·9	574·4	584·0	593·5
	20·2	6·7	0·079	0·96	0·73	0·568	536·1	545·7	555·3	564·9	574·4	584·0	593·5

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
23	23·0	23·0	0·144	1·75	0·00	1·000	534·6	544·2	553·7	563·3	572·8	582·4	591·9
	22·8	21·3	0·136	1·65	0·10	0·943	534·6	544·2	553·7	563·3	572·8	582·4	591·9
	22·6	19·6	0·127	1·55	0·20	0·886	534·7	544·3	553·8	563·4	572·9	582·5	592·0
	22·4	17·9	0·120	1·45	0·30	0·829	534·7	544·3	553·8	563·4	572·9	582·5	592·0
	22·2	16·2	0·112	1·36	0·39	0·777	534·8	544·4	553·9	563·5	573·0	582·6	592·1
	22·0	14·5	0·106	1·28	0·47	0·731	534·8	544·4	553·9	563·5	573·0	582·6	592·1
	21·8	12·8	0·099	1·21	0·54	0·691	534·9	544·5	554·0	563·6	573·1	582·7	592·2
	21·6	11·1	0·093	1·13	0·62	0·646	534·9	544·5	554·0	563·6	573·1	582·7	592·2
	21·4	9·4	0·087	1·06	0·69	0·606	535·0	544·6	554·1	563·7	573·2	582·8	592·3
	21·2	7·7	0·082	1·00	0·75	0·571	535·0	544·6	554·1	563·7	573·2	582·8	592·3
24	24·0	24·0	0·150	1·81	0·00	1·000	533·4	542·9	552·4	562.0	571·5	581·1	590·6
	23·8	22·5	0·142	1·72	0·09	0·951	533·5	543·0	552·5	562·1	571·6	581·2	590·7
	23·6	21·1	0·135	1·63	0·18	0·901	533·5	543·1	552·5	562·1	571·6	581·2	590·7
	23·4	19·6	0·127	1·55	0·26	0·856	533·6	543·2	552·6	562·2	571·7	581·3	590·8
	23·2	18·2	0·121	1·46	0·35	0·807	533·6	543·2	552·6	562·2	571·7	581·3	590·8
	23·0	16·7	0·115	1·38	0·43	0·762	533·7	543·3	552·7	562·3	571·8	581·4	590·9
	22·8	15·2	0·108	1·31	0·50	0·724	533·7	543·3	552·7	562·3	571·8	581·4	590·9
	22·6	13·8	0·103	1·24	0·57	0·685	533·7	543·3	552·7	562·3	571·8	581·4	590·9
	22·4	12·3	0·097	1·18	0·63	0·652	533·8	543·4	552·8	562·4	571·9	581·5	591·0
	22·2	10·8	0·091	1·12	0·69	0·634	533·8	543·4	552·8	562·4	571·9	581·5	591·0
25	25·0	25·0	0·155	1·87	0·00	1·000	532·3	541·8	551·3	560·8	570·3	579·8	589·3
	24·8	23·7	0·148	1·78	0·09	0·952	532·3	541·8	551·3	560·8	570·3	579·8	589·3
	24·6	22·4	0·141	1·70	0·17	0·909	532·4	541·9	551·4	560·9	570·4	579·9	589·4
	24·4	21·2	0·135	1·62	0·25	0·867	532·4	541·9	551·4	560·9	570·4	579·9	589·4
	24·2	19·9	0·129	1·55	0·32	0·829	532·4	541·9	551·4	560·9	570·4	579·9	589·4
	24·0	18·6	0·123	1·48	0·49	0·791	532·5	542·0	551·5	561·0	570·5	580·0	589·5
	23·8	17·3	0·117	1·41	0·46	0·754	532·5	542·0	551·5	561·0	570·5	580·0	589·5
	23·6	16·0	0·112	1·34	0·53	0·717	532·6	542·1	551·6	561·1	570·6	580·1	589·6
	23·4	14·8	0·107	1·28	0·59	0·685	532·6	542·1	551·6	561·1	570·6	580·1	589·6
	23·2	13·5	0·102	1·22	0·65	0·653	532·6	542·1	551·6	561·1	570·6	580·1	589·6
26	26·0	26·0	0·161	1·93	0·00	1·000	531·1	540·6	550·0	559·5	569·0	578·5	588·0
	25·8	24·8	0·154	1·85	0·08	0·959	531·2	540·7	550·1	559·6	569·1	578·6	588·1
	25·6	23·6	0·147	1·78	0·15	0·923	531·2	540·7	550·1	559·6	569·1	578·6	588·1
	25·4	22·3	0·141	1·70	0·23	0·881	531·2	540·7	550·1	559·6	569·1	578·6	588·1
	25·2	21·2	0·136	1·62	0·31	0·839	531·3	540·8	550·2	559·7	569·2	578·7	588·2
	25·0	19·9	0·129	1·55	0·38	0·804	531·3	540·8	550·2	559·7	569·2	578·7	588·2
	24·8	18·7	0·123	1·48	0·45	0·767	531·4	540·9	550·3	559·8	569·3	578·8	588·3
	24·6	17·5	0·118	1·41	0·52	0·731	531·4	540·9	550·3	559·8	569·3	578·8	588·3
	24·4	16·2	0·112	1·35	0·58	0·700	531·4	540·9	550·3	559·8	569·3	578·8	588·3
	24·2	15·0	0·108	1·29	0·64	0·668	531·5	541·0	550·4	559·9	569·4	578·9	588·4
27	27·0	27·0	0·167	2·00	0·00	1·000	529·9	539·4	548·9	558·4	567·8	577·3	586·7
	26·7	25·2	0·156	1·88	0·12	0·940	529·9	539·4	548·9	558·4	567·8	577·4	586·8
	26·4	23·3	0·146	1·76	0·24	0·880	530·0	539·5	549·0	558·5	567·9	577·5	586·9
	26·1	21·5	0·137	1·64	0·36	0·820	530·1	539·6	549·1	558·6	568·0	577·6	587·0
	25·8	19·7	0·128	1·53	0·47	0·765	530·1	539·6	549·1	558·6	568·0	577·6	587·0
	25·5	17·8	0·119	1·43	0·57	0·715	530·2	539·7	549·2	558·7	568·1	577·7	587·1
	25·2	16·0	0·112	1·34	0·66	0·670	530·3	539·8	549·3	558·8	568·2	577·8	587·2
	24·9	14·2	0·104	1·26	0·74	0·630	530·3	539·8	549·3	558·8	568·2	577·8	587·2
	24·6	12·4	0·098	1·17	0·83	0·585	530·4	539·9	549·4	558·9	568·3	577·9	587·3
	24·3	10·5	0·091	1·09	0·91	0·545	530·5	540·0	549·5	559·0	568·3	577·9	587·3

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. =1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
28	28·0	28·0	0·173	2·07	0·00	1·000	528·7	538·1	547·6	557·0	566·5	575·9	585·4
	27·7	26·3	0·163	1·95	0·12	0·942	528·8	538·2	547·7	557·1	566·6	576·0	585·5
	27·4	24·6	0·153	1·84	0·23	0·889	528·9	538·3	547·8	557·2	566·7	576·1	585·6
	27·1	22·9	0·144	1·73	0·34	0·836	528·9	538·3	547·8	557·2	566·7	576·1	585·6
	26·8	21·2	0·135	1·62	0·45	0·783	529·0	538·4	547·9	557·3	566·8	576·2	585·7
	26·5	19·4	0·126	1·52	0·55	0·734	529·1	538·5	548·0	557·4	566·9	576·3	585·8
	26·2	17·7	0·119	1·42	0·65	0·686	529·1	538·5	548·0	567·4	566·9	576·3	585·8
	25·9	16·0	0·112	1·34	0·73	0·648	529·2	538·6	548·1	557·5	567·0	576·4	585·9
	25·6	14·3	0·105	1·26	0·82	0·604	529·2	538·6	548·1	557·5	567·0	576·4	585·9
	25·3	12·6	0·098	1·18	0·89	0·571	529·2	538·6	548·1	557·5	567·0	576·4	585.9
29	29·0	29·0	0·179	2·14	0·00	1·000	527·6	537·0	546·5	555·9	565·3	574·7	584·1
	28·7	27·5	0·170	2·03	0·11	0·949	527·7	537·1	546·6	556·0	565·4	574·8	584·2
	28·4	26·0	0·161	1·92	0·22	0·898	527·7	537·1	546·6	556·0	565·4	574·8	584·2
	28·1	24·5	0·152	1·82	0·32	0·851	527·8	537·2	546·7	556·1	565·5	574·9	584·3
	27·8	23·0	0·144	1·73	0·41	0·809	527·8	537·2	546·7	556·1	565·5	574·9	584·3
	27·5	21·5	0·137	1·64	0·50	0·766	527·9	537·3	546·7	556·2	565·6	575·0	584·5
	27·2	20·0	0·129	1·55	0·59	0·725	528·0	537·4	546·8	556·2	565·7	575·1	584·6
	26·9	18·5	0·122	1·47	0·67	0·687	528·0	537·4	546·8	556·3	565·7	575·2	584·6
	26·6	17·0	0·116	1·38	0·76	0·645	528·1	537·5	546·9	556·4	565·8	575·3	584·7
	26·3	15·5	0·110	1·30	0·84	0·617	528·1	537·5	546·9	556·4	565·8	575·3	584·7
30	30·0	30·0	0·186	2·21	0·00	1·000	526·5	535·9	545·3	554·7	564·1	573·5	582·9
	29·7	28·6	0·177	2·10	0·11	0·951	526·5	535·9	545·3	554·7	564·1	573·5	582·9
	29·4	27·2	0·168	2·00	0·21	0·905	526·6	536·0	545·4	554·8	564·2	573·6	583·0
	29·1	25·9	0·160	1·91	0·30	0·864	526·7	536·1	545·5	554·9	564·3	573·7	583·1
	28·8	24·5	0·152	1·82	0·39	0·824	526·7	536·1	545·5	554·9	564·3	573·7	583·1
	28·5	23·1	0·145	1·73	0·48	0·783	526·8	536·2	545·6	555·0	564·4	573·8	583·2
	28·2	21·7	0·138	1·64	0·57	0·742	526·8	536·2	545·6	555·0	564·4	573·8	583·2
	27·9	20·3	0·131	1·56	0·65	0·706	526·9	536·3	545·7	555·1	564·5	573·9	583·3
	27·6	19·0	0·125	1·49	0·72	0·674	526·9	536·3	545·7	555·1	564·5	573·9	583·3
	27·3	17·6	0·118	1·42	0·79	0·643	527·0	536·4	545·8	555·2	564·6	574·0	583·4
31	31·0	31·0	0·192	2·29	0·00	1·000	525·4	534·7	544·1	553·5	562·9	572·3	581·7
	30·7	29·9	0·185	2·20	0·09	0·961	525·4	534·7	544·1	553·5	562·9	572·3	581·7
	30·4	28·8	0·178	2·12	0·17	0·926	525·5	534·8	544·2	553·6	363·0	572·4	581·8
	30·1	27·7	0·171	2·04	0·25	0·891	525·5	534·8	544·2	553·6	563·0	572·4	581·8
	29·8	26·6	0·164	1·95	0·34	0·852	525·6	534·9	544·3	553·7	563·1	572·5	581·9
	29·5	25·5	0·158	1·87	0·42	0·817	525·6	534·9	544·3	553·7	563·1	572·5	581·9
	29·2	24·4	0·152	1·80	0·49	0·786	225·6	534·9	544·3	553·7	563·1	572·5	581·9
	28·9	23·4	0·146	1·73	0·56	0·756	525·7	535·0	544·4	553·8	563·2	572·6	582·0
	28·6	22·3	0·141	1·67	0·62	0·729	525·7	535·0	544·4	553·8	563·2	572·6	582·0
	28·3	21·2	0·135	1·60	0·69	0·699	525·7	535·0	544·4	553·8	563·2	572·6	582·0
32	32·0	32·0	0·199	2·37	0·00	1·000	524·2	533·5	542·9	552·3	561·6	570·9	580·3
	31·6	30·8	0·191	2·27	0·10	0·958	524·3	533·6	543·0	552·4	561·7	571·0	580·4
	31·2	29·5	0·182	2·17	0·20	0·916	524·4	533·7	543·1	552·5	561·8	571·1	580·5
	30·8	28·3	0·175	2·07	0·30	0·874	524·4	533·7	543·1	552·5	661·8	571·1	580·6
	30·4	27·0	0·167	1·98	0·39	0·836	524·5	533·8	543·2	552·6	561·9	571·2	580·6
	30·0	25·8	0·160	1·90	0·47	0·802	524·5	533·8	243·2	552·6	561·9	571·2	580·6
	29·6	24·6	0·153	1·82	0·55	0·768	524·6	533·9	543·3	552·7	562·0	571·3	580·7
	29·2	23·3	0·146	1·74	0·63	0·735	524·6	533·9	543·3	552·7	562·0	571·3	580·7
	28·8	22·1	0·140	1·67	0·70	0·705	524·6	533 9	543·3	552·7	562·0	571·3	580·7
	28·4	20·8	0·133	1·60	0·77	0·675	524·7	534·0	543·4	552·8	562·1	571·4	580·8

Reading of Thermometer. Dry.	Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn.=1·000.)	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
33	33·0	33·0	0·207	2·45	0·00	1·000	523·0	532·3	541·7	551·1	560·4	569·7	579·1
	32·5	31·6	0·197	2·33	0·12	0·951	523·1	532·5	541·8	551·2	560·5	569·8	579·2
	32·0	30·2	0·187	2·22	0·23	0·906	523·2	532·6	541·9	551·3	560·6	569·9	579·3
	31·5	28·8	0·178	2·11	0·34	0·862	523·3	532·7	542·0	551·4	560·7	570·0	579·4
	31·0	27·4	0·169	2·01	0·44	0·821	523·3	532·7	542·0	551·4	560·7	570·0	579·4
	30·5	26·0	0·161	1·91	0·54	0·780	523·4	532·8	542·1	551·5	560·8	570·1	579·5
	30·0	24·6	0·153	1·82	0·63	0·743	523·4	532·8	542·1	551·5	560·8	570·1	579·5
	29·5	23·2	0·145	1·74	0·71	0·711	523·5	532·9	542·2	551·6	560·9	570·2	579·6
	29·0	21·8	0·138	1·65	0·80	0·674	523·5	532·9	542·2	551·6	560·9	570·2	579·6
	28·5	20·4	0·131	1·57	0·88	0·641	523·6	533·0	542·3	551·7	561·0	570·3	579·7
34	34·0	34·0	0·214	2·53	0·00	1·000	521·9	531·2	540·6	549·9	559·2	568·5	577·8
	33·5	32·7	0·204	2·42	0·11	0·957	522·0	531·4	540·7	550·0	559·3	568·6	577.9
	33·0	31·4	0·195	2·31	0·22	0·913	522·0	531·4	540·7	550·0	559·3	568·6	577·9
	32·5	30·1	0·186	2·21	0·32	0·874	522·1	531·5	540·8	550·1	559·4	568·7	578·0
	32·0	28·8	0·178	2·11	0·42	0·834	522·1	531·5	540·8	550·1	559·4	568·7	578·0
	31·5	27·5	0·170	2·01	0·52	0·795	522·2	531·6	540·9	550·2	559·5	568·8	578·1
	31·0	26·2	0·162	1·91	0·62	0·755	522·3	531·7	541·0	550·3	559·6	568·9	578·2
	30·5	24·9	0·155	1·83	0·70	0·724	522·3	531·7	541·0	550·3	559·6	568·9	578·2
	30·0	23·6	0·147	1·75	0·78	0·692	522·4	531·8	541·1	550·4	559·7	569·0	578·3
	29·5	22·3	0·141	1·67	0·86	0·660	522·4	531·8	541·1	550·4	559·7	569·0	578·3
	29·0	21·0	0·134	1·59	0·94	0·629	522·5	531·9	541·2	550·5	559·8	569·1	578·4
35	35	35·0	0·222	2·62	0·00	1·000	520·8	530·1	539·4	548·7	558·0	567·3	576·6
	34	32·5	0·203	2·40	0·22	0·916	520·9	530·2	539·5	548·8	558·1	567·4	576·7
	33	30·0	0·186	2·19	0·43	0·836	521·0	530·3	539·6	548·9	558·3	567·5	576·8
	32	27·5	0·170	2·00	0·62	0·764	521·1	530·4	539·7	549·0	558·4	567·6	576·9
	31	25·0	0·155	1·83	0·79	0·698	521·2	530·5	539·8	549·1	558·5	567·7	577·0
	30	22·5	0·142	1·68	0·94	0·641	521·3	530·6	539·9	549·2	558·6	567·8	577·1
	29	20·0	0·129	1·53	1·09	0·584	521·3	530·7	540·0	549·3	558·6	567·9	577·2
	28	17·5	0·117	1·39	1·23	0·531	521·4	530·8	540·1	549·4	558·7	568·0	577·3
	27	15·0	0·108	1·27	1·35	0·485	521·5	530·9	540·2	549·5	558·7	568·1	577·4
36	36	36·0	0·230	2·71	0·00	1·000	519·7	529·0	538·3	547·5	556·8	566·1	575·4
	35	33·5	0·210	2·48	0·23	0·915	519·8	529·1	538·4	547·6	556·9	566·2	575·5
	34	31·0	0·192	2·27	0·44	0·838	519·9	529·2	538·5	547·7	557·0	566·3	575·6
	33	28·5	0·176	2·07	0·64	0·764	520·0	529·3	538·6	547·8	557·1	566·4	575·7
	32	26·0	0·161	1·89	0·82	0·698	520·1	529·4	538·7	547·9	557·2	566·5	575·8
	31	23·5	0·147	1·74	0·97	0·642	520·2	529·5	538·8	548·0	557·3	566·6	575·9
	30	21·0	0·134	1·58	1·13	0·583	520·3	529·6	538·9	548·1	557·4	566·7	576·0
	29	18·5	0·122	1·45	1·26	0·538	520·4	529·7	539·0	548·2	557·5	566·8	576·1
	28	16·0	0·112	1·32	1·39	0·487	520·5	529·8	539·1	548·3	557·6	566·9	576·2
37	37	37·0	0·238	2·80	0·00	1·000	518·6	527·8	537·1	546·3	555·6	564·8	574·1
	36	34·5	0·218	2·56	0·24	0·914	518·7	527·9	537·2	546·4	555·7	564·9	574·2
	35	32·0	0·199	2·35	0·45	0·839	518·8	528·0	537·3	546·5	555·8	565·0	574·3
	34	29·5	0·182	2·14	0·66	0·764	518·9	528·1	537·4	546·6	555·9	565·1	574·4
	33	27·0	0·167	1·96	0·84	0·700	519·0	528·2	537·5	546·7	556·0	565·2	574·5
	32	24·5	0·152	1·79	1·01	0·640	519·1	528·3	537·6	546·8	556·1	565·3	574·6
	31	22·0	0·139	1·64	1·16	0·586	519·2	528·4	537·7	546·9	556·2	565·4	574·7
	30	19·5	0·127	1·50	1·30	0·536	519·3	528·5	537·8	547·1	556·3	565·5	574·8
	29	17·0	0·116	1·37	1·43	0·489	519·4	528·6	537·9	547·2	556·4	565·6	574·9
38	38	38·0	0·246	2·89	0·00	1·000	517·4	526·6	535·9	545·1	554·4	563·6	572·9
	37	35·5	0·226	2·65	0·24	0·917	517·5	526·7	536·0	545·2	554·5	563·7	573·0
	36	33·0	0·207	2·43	0·46	0·841	517·6	526·8	536·1	545·3	554·6	563·8	573·1
	35	30·5	0·189	2·22	0·67	0·768	517·7	526·9	536·2	545·4	554·7	563·9	573·2
	34	28·0	0·173	2·03	0·86	0·703	517·8	527·0	536·3	545·5	554·8	564·0	573·3
	33	25·5	0·158	1·85	1·04	0·640	517·9	527·1	536·4	545·6	554·9	564·1	573·4
	32	23·0	0·144	1·70	1·19	0·588	518·0	527·2	536·5	545·7	555·0	564·2	573·5
	31	20·5	0·132	1·54	1·35	0·533	518·1	527·3	536·6	545·8	555·1	564·3	573·6
	30	18·0	0·120	1·39	1·50	0·481	518·2	527·4	536·7	545·9	555·2	564·4	573·7

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
39	39	39·0	0·255	2·99	0·00	1·000	516·3	525·5	534·7	543·9	553·2	562·4	571·6
	38	[illegible]	0·234	2·74	0·25	0·917	516·4	525·6	534·8	544·0	553·3	562·5	571·7
	37	34·0	0·214	2·51	0·48	0·840	516·5	525·7	534·9	544·1	553·4	562·6	571·8
	36	31·5	0·196	2·30	0·69	0·769	516·6	525·8	535·0	544·2	553·5	562·7	571·9
	35	29·0	0·179	2·10	0·89	0·703	516·7	525·9	535·1	544·3	553·6	562·8	572·1
	34	26·5	0·164	1·91	1·08	0·639	516·8	526·0	535·2	544·4	553·7	562·9	572·2
	33	24·0	0·150	1·76	1·23	0·589	516·9	526·1	535·3	544·5	553·8	563·0	572·3
	32	21·5	0·137	1·60	1·39	0·535	517·0	526·2	535·4	544·6	553·9	563·1	572·4
	31	19·0	0·125	1·46	1·53	0·488	517·1	526·3	535·6	544·8	554·1	563·3	572·6
	30	16·5	0·114	1·32	1·67	0·442	517·2	526·4	535·7	544·9	554·2	563·4	572·7
40	40	40·0	0·264	3·09	0·00	1·000	515·2	524·4	533·6	542·8	552·0	561·2	570·4
	39	37·8	0·245	2·86	0·23	0·926	515·3	524·5	533·7	542·9	552·1	561·3	570·5
	38	35·6	0·227	2·65	0·44	0·858	515·4	524·6	533·8	543·0	552·2	561·4	570·6
	37	33·4	0·210	2·45	0·64	0·793	575·5	524·7	533·9	543·1	552·3	561·5	570·7
	36	31·2	0·194	2·27	0·82	0·734	515·6	524·8	534·0	543·2	552·4	561·6	570·8
	35	29·0	0·179	2·09	1·00	0·676	515·7	524·9	534·1	543·3	552·5	561·7	570·9
	34	26·8	0·165	1·94	1·15	0·628	515·8	525·0	534·2	543·4	552·6	561·8	571·0
	33	24·6	0·153	1·79	1·30	0·579	515·9	525·1	534·3	543·5	552·7	561·9	571·1
	32	22·4	0·141	1·65	1·44	0·534	516·0	525·2	534·4	543·6	552·8	562·0	571·2
	31	20·2	0·130	1·53	1·56	0·495	516·1	525·3	534·5	543·7	552·9	562·1	571·3
	30	18·0	0·120	1·42	1·67	0·459	516·1	526·3	534·5	543·8	553·0	562·2	571·4
41	41	41·0	0·274	3·19	0·00	1·000	514·1	523·3	532·5	541·6	550·8	560·0	569·2
	40	38·8	0·253	2·96	0·23	0·928	514·2	523·4	532·6	541·7	550·9	560·1	569·3
	39	36·6	0·235	2·74	0·45	0·859	514·3	523·5	532·7	541·8	551·0	560·2	569·4
	38	34·4	0·217	2·54	0·65	0·796	514·4	523·6	532·8	541·9	551·1	560·3	569·5
	37	32·2	0·201	2·35	0·84	0·737	514·5	523·7	532·9	542·0	551·2	560·4	569·6
	36	30·0	0·186	2·16	1·03	0·677	514·6	523·8	533·0	542·1	551·3	560·5	569·7
	35	27·8	0·172	2·01	1·18	0·630	514·7	523·9	533·1	542·2	551·4	560·6	569·8
	34	25·6	0·158	1·85	1·34	0·580	514·8	524·0	533·2	542·3	551·5	560·7	569·9
	33	23·4	0·146	1·71	1·48	0·536	514·9	524·1	533·3	542·4	551·6	560·8	570·0
	32	21·2	0·135	1·58	1·61	0·495	514·9	524·1	533·3	542·5	551·7	560·9	570·1
	31	19·0	0·125	1·46	1·73	0·458	515·0	524·2	533·4	542·6	551·8	561·0	570·2
42	42	42·0	0·283	[illegible]	0·00	1·000	513·0	522·2	531·3	540·5	549·6	558·8	567·9
	41	39·8	0·263	[illegible]	0·24	0·927	513·1	522·3	531·4	540·6	549·7	558·9	568·0
	40	37·6	0·243	[illegible]	0·47	0·858	513·2	522·4	531·5	540·7	349·9	559·0	568·1
	39	35·4	0·225	2·65	0·67	0·797	513·3	522·5	531·6	540·8	550·0	559·1	568·2
	38	33·2	0·208	2·43	0·87	0·736	513·4	522·6	531·7	540·9	550·1	559·2	568·3
	37	31·0	0·192	2·24	1·06	0·679	513·5	522·7	531·8	541·0	550·2	559·3	568·4
	36	28·8	0·178	2·06	1·22	0·631	213·6	522·8	531·9	541·1	550·3	559·4	568·5
	35	26·6	0·164	1·91	1·39	0·579	513·7	522·9	532·0	541·2	550·4	559·5	568·6
	34	24·4	0·152	1·77	1·53	0·536	513·8	523·0	532·1	541·3	550·5	559·6	568·7
	33	22·2	0·140	1·63	1·67	0·494	513·9	523·1	532·2	541·4	550·6	559·7	568·8
	32	20·0	0·129	1·51	1·79	0·458	513·9	523·1	532·3	541·5	550·6	559·8	569·0
43	43	43·0	0·293	3·41	0·00	1·000	511·8	520·9	530·1	539·3	548·4	557·5	566·7
	42	40·8	[illegible]	[illegible]	0·25	0·927	511·9	521·0	530·2	539·4	548·6	557·7	566·9
	41	38·6	0·252	2·95	0·48	0·859	512·0	521·1	530·3	539·5	548·7	557·8	567·0
	40	36·4	0·233	2·71	0·70	0·795	512·1	521·2	530·4	539·6	648·8	557·9	567·1
	39	34·2	0·216	2·51	0·90	0·736	512·2	521·3	[illegible]	539·7	548·9	558·0	567·2
	38	32·0	[illegible]	2·32	1·09	0·680	512·3	521·4	230·7	539·8	549·0	558·1	567·3
	37	29·8	[illegible]	2·15	1·26	0·630	512·4	521·5	530·8	539·9	549·1	558·2	567·4
	36	27·6	0·170	1·98	1·43	0·581	512·5	521·6	530·9	540·0	549·2	558·3	567·5
	35	25·4	0·157	1·82	1·59	0·534	512·6	521·7	531·0	540·1	549·3	558·4	567·6
	34	23·2	0·145	1·69	1·72	0·495	512·7	521·8	531·1	540·2	549·4	558·5	567·7
	33	21·0	0·134	1·56	1·85	0·458	512·9	522·0	531·2	540·3	549·5	558·6	567·8

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. =1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in 29·5	in. 30·0	in. 30·5	ni 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
44	44	44·0	0·304	3·52	0·00	1·000	510·8	519·9	529·0	538·1	547·3	556·4	565·5
	43	41·8	0·282	3·27	0·25	0·929	510·9	520.0	529·1	538·2	547·5	556·5	565·7
	42	39·6	0·261	3·02	0·50	0·858	511·0	520.1	529·2	538·3	547·6	556·6	565·8
	41	37·4	0·241	2·80	0·72	0·796	511·1	520·2	529·3	538·4	547·7	556·7	565·9
	40	35·2	0·223	2·60	0·92	0·739	511·2	520·3	529·4	538·5	547·8	556·8	566·0
	39	33·0	0·207	2·40	1·12	0·682	511·3	520·4	529·5	538·6	547·9	556·9	566·1
	38	30·8	0·191	2·22	1·30	0·631	511·4	520·5	529·6	538·7	548·0	557·0	566·2
	37	28·6	0·177	2·05	1·47	0·582	511·5	520·6	529·7	538·8	548·1	557·1	566·3
	36	26·4	0·163	1·89	1·63	0·537	511·6	520·7	529·8	538·9	548·2	557·2	566·4
	35	24·2	0·151	1·75	1·77	0·497	511·7	520·8	529·9	539·0	548·3	557·3	566·5
	34	22·0	0·139	1·62	1·90	0·460	511·7	520·8	530·0	539·1	548·3	557·4	566·6
45	45	45·0	0·315	3·64	0·00	1·000	509·7	518·8	527·9	537.0	546·1	555·2	564·3
	44	42·9	0·292	3·39	0·25	0·931	509·8	518·9	528·0	537·1	546·3	555·3	564·5
	43	40·8	0·272	3·14	0·50	0·863	509·9	519·0	528·1	537·2	546·4	555·4	594·6
	42	38·7	0·253	2·92	0·72	0·802	510·0	519·1	528·2	537·3	546·5	555·5	564·7
	41	36·6	0·235	2·70	0·94	0·742	510·1	519·2	528·3	537·4	546·6	555·6	564·8
	40	34·5	0·218	2·52	1·12	0·692	510·2	519·3	528·4	537·5	546·7	555·7	564·9
	39	32·4	0·202	2·34	1·30	0·643	510·3	519·4	528·5	537·6	546·8	555·8	565·0
	38	30·3	0·188	2·16	1·48	0·593	510·4	519·5	528·6	537·7	546·9	555·9	565·1
	37	28·2	0·174	2·01	1·63	0 552	510·5	519·6	528·7	837·8	547·0	556·0	565·2
	36	26·1	0·161	1·87	1·77	0·514	510·6	519·7	528·8	537·9	547·1	556·1	565·3
	35	24·0	0·150	1·73	1·91	0·475	510·7	519·8	528·9	538·0	547·2	556·3	565·4
46	46	46·0	0·326	3·76	0·00	1·000	508·6	517·7	526·7	535·8	544·9	554·0	563·1
	45	43·9	0·303	3·50	0·26	0·931	508·7	517 8	526·8	535·9	545·0	554·1	563·2
	44	41·8	0·282	3·25	0·51	0·864	508·8	517·9	526·9	536·0	545·1	554·2	563·3
	43	39·7	0·262	3·02	0·74	0·803	508·9	518·0	527·0	536·1	545·2	554·3	563·4
	42	37·6	0·243	2·80	0·96	0·745	509·0	518·1	527·2	536·3	545·4	554·5	563·6
	41	35·5	0·226	2·61	1·15	0·694	509·1	518·2	527·3	536·4	545·5	554·6	563·7
	40	33·4	0·210	2·42	1·34	0·643	509·2	518·3	527·4	536·5	545·6	554·7	563·8
	39	31·3	0 194	2·24	1·52	0·596	509·3	518·4	527·5	536·6	545·7	554·8	563·9
	38	29·2	0·181	2·08	1·68	0·553	509·4	518·5	527·6	536·7	545·8	554·9	564·0
	37	27·1	0·167	1·93	1·83	0·514	509·5	518·6	527·7	536·8	545·9	555·0	564·1
	36	25·0	0·155	1·79	1·97	0 476	509·5	518·6	527·7	536·8	545·9	555·0	564·1
47	47	47·0	0·337	3·88	0·00	1·000	507·5	516·5	525·6	534·7	543·8	552·8	561·9
	46	44·9	0·313	3·62	0·26	0·933	507·6	516·6	525·7	534·8	543·9	552·9	562·0
	45	42·8	0·291	3·36	0·52	0·866	507·8	516·7	525·9	535·0	544·1	553·1	562·2
	44	40·7	0·271	3·12	0·76	0·804	507·9	516·8	526·0	535·1	544·2	553·2	562·3
	43	38·6	0·252	2·90	0·98	0·747	508·0	516·9	526·1	535·2	544·3	553·3	562·4
	42	36·5	0·234	2·70	1·18	0·696	508·1	517·0	526·2	535·3	544·4	553·4	562·5
	41	34·4	0·217	2·51	1·37	0·647	508·2	517·1	526·3	535·4	544·5	553·5	562·6
	40	32·3	0·201	2·32	1·56	0·598	508·3	517·2	526·4	535·5	544·6	553·6	562·7
	39	30·2	0·187	2·16	1·72	0·557	508·4	517·3	526·5	535·6	544·7	553·7	562·8
	38	28·1	0·173	2·00	1·88	0·515	508·5	517·4	526·6	535·7	544·8	553·8	562·9
	37	26·0	0·161	1·85	2·03	0·477	508·5	517·6	526·7	535.8	544·9	554·0	563·1
48	48	48·0	0·349	4·01	0·00	1·000	506·4	515·4	524·5	533·5	542·6	551·6	560·7
	47	45·9	0·324	3·73	0·28	0·930	506·5	515·5	524·6	533·7	542·8	551·8	560·9
	46	43·8	0·302	3·47	0·54	0·865	506·6	515·6	524·7	533·8	542·9	551·9	561·0
	45	41·7	0·281	3·23	0·78	0·805	506·7	515·7	524·8	533·9	543·0	552·0	561·1
	44	39·6	0·261	3·00	1·01	0·748	506·8	515·8	524·9	534·0	543·1	552·1	561·2
	43	37·5	0·242	2·79	1·22	0·696	506·9	515·9	525·0	534·1	543·2	552·2	561·3
	42	35·4	0·225	2·60	1·41	0·648	507·0	516·0	525·1	534·2	543·3	552·3	561·4
	41	33·3	0·209	2·40	1·61	0·598	507·1	516·1	525·2	534·4	543·5	552·5	561·5
	40	31·2	0·194	2·24	1·77	0·558	507·2	516·2	525·3	534·5	543·5	552·5	561·6
	39	29·1	0·180	2·07	1·94	0·516	507·3	516·3	525·4	534·6	543·6	552·6	561·6
	38	27·0	0·167	1·92	2·09	0·479	507·4	516·4	525·5	534·7	543·6	552·7	561·7
	37	24·9	0·155	1·77	2·24	0·441	507·4	516·4	525·6	534·7	543·7	552·8	561·8

Reading of Dry.	Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
49	49	49·0	0·361	4·14	0·00	1·000	505·3	514·3	523·3	532·3	541·4	550·4	559·4
	48	46·9	0·336	3·85	0·29	0·930	505·4	514·4	523·4	532·4	541·5	550·5	559·5
	47	44·8	0·312	3·59	0·55	0·867	505·6	514·6	523·6	532·6	541·7	550·7	559·7
	46	42·7	0·290	3·34	0·80	0·807	505·7	514·7	523·7	532·7	541·8	550·8	559·8
	45	40·6	0·270	3·10	1·04	0·749	505·9	514·9	523·8	532·9	542·0	551·0	560·0
	44	38·5	0·251	2·88	1·26	0·696	506·0	515·0	523·9	533·0	542·1	551·1	560·1
	43	36·4	0·233	2·68	1·46	0·647	506·1	515·1	524·0	533·1	542·2	551·2	560·2
	42	34·3	0·216	2·49	1·65	0·601	506·2	515·2	524·1	533·2	542·3	551·3	560·3
	41	32·2	0·201	2·32	1·82	0·360	506·3	515·3	524·2	533·3	542·4	551·4	560·4
	40	30·1	0·186	2·14	2·00	0·517	506·3	515·3	524·3	533·4	542·5	551·5	560·5
	39	28·0	0·173	1·99	2·15	0·481	506·4	515·4	524·4	533·5	542·6	551·6	560·6
	38	25·9	0·160	1·84	2·30	0·444	506·4	515·4	524·4	533·5	542·6	551·6	560·6
50	50	50·0	0·373	4·28	0·00	1·000	504·1	513·1	522·1	531·1	540·2	549·2	558·2
	49	48·0	0·349	3·99	0·29	0·932	504·2	513·2	522·2	531·2	540·3	549·3	558·3
	48	46·0	0·326	3·73	0·55	0·871	504·4	513·4	522·4	531·4	540·5	549·5	558·5
	47	44·0	0·304	3·48	0·80	0·813	504·5	513·5	522·5	531·5	540·6	549·6	558·6
	46	42·0	0·283	3·25	1·03	0·759	504·6	513·6	522·6	531·6	540·7	549·7	558·7
	45	40·0	0·264	3·03	1·25	0·708	504·8	513·8	522·8	531·8	540·9	549·9	558·9
	44	38·0	0·246	2·82	1·46	0·659	504·9	513·9	522·9	532·0	541·0	550·0	559·0
	43	36·0	0·230	2·63	1·65	0·614	505·1	514·1	523·1	522·1	541·2	550·2	559·2
	42	34·0	0·214	2·45	1·83	0·572	505·2	514·2	523·2	532·2	541·3	550·3	559·3
	41	32·0	0·199	2·28	2·00	0·533	505·3	514·3	523·3	532·3	541·4	550·4	559·4
	40	30·0	0·186	2·12	2·16	0·495	505·4	514·4	523·4	532·4	541·5	550·5	559·5
	39	28·0	0·173	1·97	2·31	0·460	505·5	514·5	523·5	532·5	541·6	550·6	559·6
51	51	51·0	0·386	4·42	0·00	1·000	503·1	512·1	521·1	530·0	539·0	548·0	557·0
	50	49·0	0·361	4·12	0·30	0·932	503·2	512·2	521·2	530·1	539·1	548·1	557·1
	49	47·0	0·337	3·85	0·57	0·871	503·3	512·3	521·3	530·3	539·3	548·3	557·3
	48	45·0	0·315	3·60	0·82	0·814	503·4	512·4	521·4	530·4	539·4	548·4	557·4
	47	43·0	0·293	3·36	1·06	0·760	503·5	512·5	521·5	530·5	539·5	548·5	557·5
	46	41·0	0·274	3·13	1·29	0·708	503·7	512·7	521·7	530·7	539·7	548·7	557·7
	45	39·0	0·255	2·92	1·50	0·661	503·8	512·8	521·8	530·8	539·8	548·8	557·8
	44	37·0	0·238	2·72	1·70	0·615	503·9	512·9	521·9	530·9	539·9	548·9	557·9
	43	35·0	0·222	2·54	1·88	0·575	504·0	513·0	522·0	531·0	540·0	549·0	558·0
	42	33·0	0·207	2·36	2·06	0·534	504·1	513·1	522·1	531·1	540·1	549·1	558·1
	41	31·0	0·192	2·20	2·22	0·498	504·2	513·2	522·2	531·2	540·3	549·3	558·3
	40	29·0	0·179	2·05	2·37	0·464	504·3	513·3	522·3	531·3	540·4	549·4	558·4
52	52	52·0	0·400	4·56	0·00	1·000	502·1	511·0	520·0	528·9	537·9	546·8	555·8
	51	50·0	0·373	4·26	0·30	0·934	502·2	511·1	520·1	529·0	538·0	546·9	555·9
	50	48·0	0·349	3·98	0·58	0·873	502·4	511·3	520·3	529·2	538·2	547·1	556·1
	49	46·0	0·326	3·72	0·84	0·816	502·5	511.4	520·4	529·3	538·3	547·2	556·2
	48	44·0	0·304	3·47	1·09	0·761	502·6	511·5	520·5	529·4	538·4	547·3	556·3
	47	42·0	0·283	3·23	1·33	0·709	502·8	511·7	520·7	529·6	538·6	547·5	556·5
	46	40·0	0·264	3·02	1·54	0·662	502·9	511·8	520·8	529·7	538·7	547·6	556·6
	45	38·0	0·246	2·81	1·75	0·616	502·9	511·9	520·9	529·8	538·8	547·8	556·8
	44	36·0	0·230	2·63	1·93	0·577	503·1	512·0	521·0	529·9	539·0	548·0	557·0
	43	34·0	0·214	2·44	2·12	0·535	503·2	512·1	521·1	530·0	539·1	548·1	557·1
	42	32·0	0·199	2·28	2·28	0·500	503·3	512·3	521·3	530·2	539·2	548·2	557·2
	41	30·0	0·186	2·13	2·43	0·467	503·4	512·4	521·4	530·3	539·3	548·3	557·3
53	53	53·0	0·414	4·71	0·00	1·000	500·9	509·8	518·8	527·7	536·7	545·6	554·6
	52	51·0	0·386	4·40	0·31	0·934	501·1	510·0	519·0	527·9	536·9	545·8	554·8
	51	49·0	0·361	4·11	0·60	0·873	501·2	510·1	519·1	528·0	537·0	545·9	554·9
	50	47·0	0·337	3·84	0·87	0·815	501·4	510·3	519·3	528·2	537·2	546·1	555·1
	49	45·0	0·315	3·58	1·13	0·760	501·5	510·4	519·4	528·3	537·3	546·2	555·2
	48	43·0	0·293	3·34	1·37	0·709	501·6	510·5	519·5	528·4	537·4	546·3	555·3
	47	41·0	0·274	3·12	1·59	0·662	501·7	510·6	519·6	528·5	537·5	546·4	555·4
	46	39·0	0·255	2·91	1·80	0·618	501·8	510·7	519·7	528·6	537·6	546·5	555·5
	45	37·0	0·238	2·71	2·00	0·575	502·0	510·9	519·9	528·8	537·8	546·7	555·7
	44	35·0	0·222	2·53	2·18	0·537	502·1	511·0	520·0	528·9	537·9	546·8	555·8
	43	33·0	0·207	2·35	2·36	0·499	502·1	511·0	520·0	528·9	538·0	546·9	555·9
	42	31·0	0·192	2·18	2·53	0·463	502·2	511·1	520·1	529·0	538·1	547·0	556·0

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
54	54	54·0	0·428	4·83	0·00	1·000	499·9	508·8	517·8	526·7	535·6	544·5	553·5
	53	52·0	0·400	4·51	0·32	0·934	500·0	508·9	517·9	526·8	535·7	544·6	553·6
	52	50·0	0·373	4·25	0·61	0·875	500·2	509·1	518·1	527·0	535·9	544·8	553·8
	51	48·0	0·349	3·96	0·90	0·815	500·3	509·2	518·2	527·1	536·0	544·9	553·9
	50	46·0	0·326	3·70	1·16	0·761	500·4	509·3	518·3	527·2	536·1	545·0	554·0
	49	44·0	0·304	3·45	1·41	0·709	500·6	509·5	518·5	527·4	536·3	545·2	544·2
	48	42·0	0·283	3·23	1·63	0·665	500·7	509·6	518·6	527·5	536·4	545·3	554·3
	47	40·0	0·264	3·01	1·85	0·619	500·8	509·7	518·7	527·6	536·5	545·4	554·4
	46	38·0	0·246	2·80	2·06	0·576	500·9	509·8	518·8	527·7	536·7	545·6	554·6
	45	36·0	0·230	2·61	2·25	0·537	501·0	509·9	518·9	527·8	536·8	545·7	554·7
	44	34·0	0·214	2·43	2·43	0·500	501·1	510·0	519·0	527·9	536·9	545·8	554·8
	43	32·0	0·199	2·27	2·59	0·467	501·2	510·1	519·1	528·0	537·0	545·9	554·9
	42	30·0	0·186	2·10	2·76	0·432	501·3	510·2	519·2	528·1	537·1	546·0	555·0
	41	28·0	0·173	1·96	2·90	0·403	501·4	510·3	519·3	528·2	537·2	546·1	555·1
	40	26·0	0·161	1·82	3·04	0·375	501·5	510·4	519·4	528·3	537·3	546·2	555·2
55	55	55·0	0·442	5·02	0·00	1·000	498·8	507·7	516·6	525·5	534·4	543·3	552·2
	54	53·3	0·418	4·74	0·28	0·944	499·0	507·9	516·8	525·7	534·6	543·5	552·4
	53	51·6	0·394	4·46	0·56	0·888	499·1	508·0	516·9	525·8	534·7	543·6	552·5
	52	49·9	0·372	4·23	0·79	0·843	499·3	508·2	517·1	526·0	534·9	543·8	552·7
	51	48·2	0·351	3·98	1·04	0·793	499·4	508·3	517·2	526·1	535·0	543·9	552·8
	50	46·5	0·331	3·76	1·26	0·749	499·5	508·4	517·3	526·2	535·1	544·0	552·9
	49	44·8	0·312	3·55	1·47	0·707	499·7	508·6	517·5	526·3	535·3	544·2	553·1
	48	43·1	0·295	3·34	1·68	0·665	499·8	508·7	517·6	526·5	535·4	544·3	553·3
	47	41·4	0·278	3·14	1·88	0·626	499·8	508·7	517·6	526·6	535·5	544·4	553·4
	46	39·7	0·262	2·97	2·05	0·591	499·9	508·8	517·7	526·7	535·6	544·5	553·5
	45	38·0	0·246	2·79	2·23	0·556	500·0	508·9	517·9	526·8	535·7	544·6	553·6
	44	36·3	0·232	2·64	2·38	0·526	500·1	509·0	518·0	526·9	535·8	544·7	553·7
	43	34·6	0·219	2·47	2·55	0·492	500·2	509·1	518·1	527·0	535·9	544·8	553·8
	42	32·9	0·206	2·32	2·70	0·46[illegible]	500·3	509·2	518·2	527·1	536·0	544·9	553·9
	41	31·2	0·194	2·20	2·82	0·438	500·4	509·3	518·3	527·1	536·0	544·9	554·0
	40	29·5	0·182	2·07	2·95	0·412	500·5	509·3	518·4	527·2	536·1	545·0	554·1
	39	27·8	0·172	1·95	3·07	0·388	500·6	509·4	518·5	527·3	536·2	545·1	554·2
	38	26.1	0·161	1·83	3·19	0·365	500·7	509·5	513·6	527·4	536·2	545·1	554·2
56	56	56·0	0·458	5·18	0·00	1·000	497·7	506·6	515·5	524·4	533·2	542·1	551·0
	55	54·3	0·432	4·89	0·29	0·944	497·9	506·8	515·7	524·6	533·4	542·3	551·2
	54	52·6	0·408	4·61	0·57	0·890	498·0	506·9	515·8	524·7	533·5	542·4	551·3
	53	50·9	0·385	4·37	0·81	0·844	498·2	507·1	516·0	524·9	533·7	542·6	551·5
	52	49·2	0·363	4·11	1·07	0·793	498·3	507·2	516·1	525·0	533·8	542·7	551·6
	51	47·5	0·343	3·87	1·31	0·747	498·4	507·3	516·2	525·1	533·9	542·8	551·7
	50	45·8	0·323	3·66	1·52	0·706	498·6	507·5	516·4	525·3	534·1	543·0	551·9
	49	44·1	0·305	3·45	1·73	0·666	498·6	507·5	516·4	525·3	534·2	543·1	552·0
	48	42.4	0·287	3·25	1·93	0·627	498·7	507·6	516·5	525·4	534·3	543·2	552·1
	47	40·7	0·271	3·07	2·11	0·593	498·8	507·7	516·6	525·5	534·4	543·3	552·2
	46	39·0	0·255	2·89	2·29	0·558	498·9	507·8	516·7	525·6	534·5	543·4	552·3
	45	37·3	0·240	2·73	2·45	0·527	499·0	507·9	516·8	525·7	534·6	543·5	552·4
	44	35·6	0·227	2·56	2·62	0·494	499·1	508·0	516·9	525·8	534·7	543·6	552·5
	43	33·9	0·213	2·41	2·77	0·465	499·2	508·1	517·0	525·9	534·8	543·7	552·6
	42	32·2	0·201	2·27	2·91	0·438	499·3	508·2	517·1	526·0	534·9	543·8	552·7
	41	30·5	0·189	2·14	3·04	0·413	499·4	508.3	517·2	526·1	535·0	543·9	552·8
	40	28·8	0·178	2·01	3·17	0·388	499·5	508·4	517·3	526·2	535·1	544·1	552·9
	39	27·1	0·167	1·89	3·29	0·365	499·5	508·4	517·3	526·2	535·1	544·1	552·9

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000.)	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
57	57	57·0	0·473	5·34	0·00	1·000	496·6	505·5	514·4	523·2	532·1	540·9	549·8
	56	55·3	0·447	5·05	0·29	0·946	496·8	505·7	514·6	523·4	532·3	541·1	550·0
	55	53·6	0·422	4·76	0·58	0·891	496·9	505·8	514·7	523·5	532·4	541·2	550·1
	54	51·9	0·398	4·50	0·84	0·843	497·1	506·0	514·9	523·7	532·6	541·4	550·3
	53	50·2	0·376	4·25	1·09	0·796	497·2	506·1	515·0	523·8	532 7	541·5	550·4
	52	48·5	0·355	4·00	1·34	0·749	497·3	506·2	515·1	523·9	532·8	541·6	550·5
	51	46·8	0·335	3·78	1·56	0·709	497·5	506·4	515·3	524·1	533·0	541·8	550·7
	50	45·1	0·316	3·56	1·78	0·667	497·6	506·5	515·4	424·2	533·1	541·9	550·8
	49	43·4	0·298	3·36	1·98	0·629	497·7	506·6	515·5	524·3	533·2	542·0	550·9
	48	41·7	0·281	3·17	2·17	0·594	497·8	506·7	515·6	524·4	533·3	542·1	551·0
	47	40·0	0·264	2·99	2·35	0·560	497·9	506·8	515·7	524·5	533·4	542·2	551·2
	46	38·3	0·249	2·81	2·53	0·526	498·0	506·9	515·8	524·6	533·5	542·3	551·3
	45	36·6	0·235	2·65	2·69	0·496	498·1	507·0	515·9	524·7	533·6	542·4	551·4
	44	34·9	0·221	2·50	2·84	0·468	498·2	507·1	516·0	524·8	533·7	542·5	551·5
	43	33·2	0·208	2·35	2·99	0·440	498·3	507·2	516·1	524·9	533·8	542·6	551·6
	42	31·5	0·196	2·21	3·13	0·414	498·3	507·2	516·1	524·9	533·8	542·6	551·6
	41	29·8	0·184	2·08	3·26	0·390	498·4	507·3	516·2	525·1	533·9	542·7	551·7
	40	28·1	0·173	1·96	3·38	0·367	498·5	507·4	516·3	525·2	534·0	542·8	551·8
58	58	58·0	0·489	5·51	0·00	1·000	495·5	504·3	513·2	522·0	530·9	539·7	548·6
	57	56·3	0·462	5·21	0·30	0·946	495·7	504·5	513·4	522·2	531·1	539·9	548·8
	56	54·6	0·437	4·92	0·59	0·893	495·8	504·6	513·5	522·3	531·2	540·0	548·9
	55	52·9	0·412	4·64	0·87	0·842	496·0	504·8	513·7	522·5	531·4	540·2	549·1
	54	51·2	0·389	4·39	1·12	0·797	496·1	504·9	513·8	522·7	531·6	540·4	549·3
	53	49·5	0·367	4·14	1·37	0·751	496·2	505·1	513·9	522·8	531·7	540·5	549·4
	52	47·8	0·346	3·90	1·61	0·708	496·4	505·2	514·1	523·0	531·9	550·7	549·6
	51	46·1	0·327	3·68	1·83	0·668	496·5	505·3	514·2	523·1	532·0	540·8	549·7
	50	44·4	0·308	3·48	2·03	0·632	496·6	505·4	514·3	523·2	532·1	540·9	549·8
	49	42·7	0·290	3·28	2·23	0·595	496·7	505·5	514·4	523·3	532·2	541·0	549.9
	48	41·0	0·274	3·08	2·43	0·559	496·8	505·6	514·5	523·4	532·3	541·1	550·0
	47	39·3	0·258	2·91	2·60	0·528	496·9	505·7	514·6	523·5	532·4	541·2	550·1
	46	37·6	0·243	2·74	2·77	0·497	497·0	505·8	514·7	523·6	532·5	541·3	550·2
	45	35·9	0·229	2·58	2·93	0·469	497·1	505·9	514·8	523·7	532·6	541·4	550·3
	44	34·2	0·216	2·43	3·08	0·441	497·2	506·0	514·9	523·8	532·7	541·5	550·4
	43	32·5	0·203	2·29	3·22	0·416	497·3	506·1	515·1	523·9	532·8	541·6	550·5
	42	30·8	0·191	2·15	3·36	0·392	497·4	506·2	515·2	524·1	532·9	541·7	550·6
	41	29.1	0·180	2·03	3·48	0·368	497·5	506·3	515·3	524·2	533·0	541·8	550·7
	40	27·4	0·169	1·91	3·60	0·347	497·6	506·3	515·3	524·2	533·0	541·8	550·7
59	59	59·0	0·506	5·69	0·00	1·000	494·5	503·3	512·2	521·0	529·8	538·6	547·5
	58	57·3	0·478	5·37	0·32	0·944	494·6	503·4	512·3	521·1	529·9	538·7	547·6
	57	55·6	0·452	5·08	0·61	0·893	494·7	503·5	512·4	521·2	530·0	538·8	547·7
	56	53·9	0·426	4·79	0·90	0·842	494·8	503·6	512·5	521·3	530·1	538·9	547·8
	55	52·2	0·402	4·53	1·16	0·796	494·9	503·7	512·6	521·4	530·3	539·1	548·0
	54	50·5	0·380	4·28	1·41	0·752	495·1	503·9	512·8	521·6	530 5	539·3	548·2
	53	48·8	0·358	4·03	1·66	0·708	495·3	504·1	513·0	521·8	530·7	539·5	548·4
	52	47·1	0·338	3·80	1·89	0·668	495·4	504·2	513·1	521·9	530·8	539·6	548·5
	51	45·4	0·319	3·60	2·09	0·633	495·5	504·3	513·2	522·0	530·9	539·7	548·6
	50	43·7	0·301	3·39	2·30	0·596	495·7	504·5	513·4	522·2	531·1	539·9	548·8
	49	42·0	0·283	3·19	2·50	0·561	495·8	504·6	513·4	522·3	531·2	540·0	548·9
	48	40·3	0·267	3·01	2·68	0·528	495·9	504·7	513·5	522·4	531·3	540·1	549·0
	47	38·6	0·252	2·84	2·85	0·499	496·0	504·8	513·6	522·5	531·4	540·2	549·1
	46	36·9	0·237	2·67	3·02	0·469	496·1	504·9	513·7	522·6	531·5	540·3	549·2
	45	35·2	0·223	2·51	3·18	0·441	496·2	505·0	513·8	522·7	531·6	540·4	549·3
	44	33·5	0·210	2·37	3·32	0·417	496·3	505·1	513·9	522·8	531·7	540·5	549·4
	43	31·8	0·198	2·23	3·46	0·392	496·4	505·2	514·1	522·9	531·8	540·6	549·5
	42	30·1	0·186	2·09	3·60	0·367	496·5	505·3	514·2	523·0	531·9	540·7	549·6
	41	28·4	0·175	1·97	3·72	0·346	496·6	505·4	514·3	523·1	532·0	540·8	549·7
	40	26·7	0·165	1·85	3·84	0·325	496·6	505·4	514·3	523·1	532·0	540·8	549·7

Reading of Dry.	Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
60	60	60·0	0·523	5·87	0·00	1·000	493·4	502·2	511·0	519·8	528·6	537·4	546·2
	59	58·3	0·494	5·54	0·33	0·944	493·6	502·4	511·2	520·0	528·8	537·6	546·4
	58	56·6	0·467	5·29	0·63	0·893	493·7	502·5	511·3	520·1	528·9	537·7	546·5
	57	54·9	0·441	4·95	0·92	0·843	493·8	502·6	511·4	520·2	529·0	537·8	546·6
	56	53·2	0·416	4·68	1·19	0·797	494·0	502·8	511·6	520·4	529·2	538·0	546·8
	55	51·5	0·393	4·41	1·46	0·751	494·2	503·0	511·8	520·6	529·4	538·2	547·0
	54	49·8	0·371	4·17	1·70	0·710	494·4	503·2	512·0	520·8	529·6	538·4	547·2
	53	48·1	0·350	3·92	1·95	0·668	494·5	503·3	512·1	520·9	529·7	538·5	547·4
	52	46·4	0·330	3·70	2·17	0·630	494·7	503·4	512·3	521·1	529·9	538·7	547·6
	51	44·7	0·311	3·49	2·38	0·595	494·8	503·5	512·4	521·2	530·0	538·8	547·7
	50	43·0	0·293	3·29	2·58	0·561	494·8	503·6	512·5	521·3	530·1	538·9	547·8
	49	41·3	0·277	3·10	2·77	0·528	494·9	503·7	512·6	521·4	530·2	539·0	547·9
	48	39·6	0·261	2·93	2·94	0·499	495·0	503·8	512·7	521·5	530·3	539·1	548·0
	47	37·9	0·246	2·75	3·12	0·468	495·1	503·9	512·8	521·6	530·4	539·2	548·1
	46	36·2	0·231	2·60	3·27	0·443	495·2	504·0	512·9	521·7	530·5	539·3	548·2
	45	34·5	0·218	2·45	3·42	0·417	495·3	504·1	513·0	521·8	530·6	539·4	548·3
	44	32·8	0·205	2·31	3·56	0·394	495·4	504·2	513·1	521·9	530·7	539·5	548·4
	43	31·1	0·193	2·17	3·70	0·370	495·5	504·3	513·2	522·0	530·8	539·6	548·5
	42	29·4	0·182	2·04	3·83	0·348	495·6	504·4	513·3	522·1	530·9	539·7	548·6
	41	27·7	0·171	1·92	3·95	0·327	495·6	504·4	513·3	522·1	530·9	539·7	548·7
61	61	61·0	0·541	6·06	0·00	1·000	492·3	501·1	509·9	518·7	527·5	536·3	545·1
	60	59·3	0·511	5·72	0·34	0·944	492·5	501·3	510·1	518·9	527·7	536·5	545·3
	59	57·6	0·483	5·40	0·66	0·891	492·6	501·4	510·2	519·0	527·8	536·6	545·4
	58	55·9	0·456	5·11	0·95	0·843	492·8	501·6	510·4	519·2	528·0	536·8	545·6
	57	54·2	0·431	4·83	1·23	0·797	493·0	501·8	510·6	519·4	528·2	537·0	545·8
	56	52·5	0·407	4·55	1·51	0·751	493·1	501·9	510·7	519·5	528·3	537·1	545·9
	55	50·8	0·383	4·30	1·76	0·710	493·3	502·1	510·9	519·7	528·5	537·3	546·1
	54	49·1	0·362	4·05	2·01	0·668	493·4	502·2	511·0	519·8	528·6	537·4	546·2
	53	47·4	0·342	3·83	2·23	0·632	493·5	502·3	511·1	519·9	528·7	537·5	546·3
	52	45·7	0·322	3·61	2·45	0·596	493·6	502·4	511·2	520·0	528·8	537·6	546·4
	51	44·0	0·304	3·40	2·66	0·561	493·8	502·6	511·4	520·2	529·0	537·8	546·6
	50	42·3	0·286	3·21	2·85	0·530	493·9	502·7	511·5	520·3	529·1	537·9	546·7
	49	40·6	0·270	3·02	3·04	0·498	494·0	502·8	511·6	520·4	529·2	538·0	546·8
	48	38·9	0·254	2·85	3·21	0·470	494·1	502·9	511·7	520·5	529·3	538·1	546·9
	47	37·2	0·240	2·69	3·37	0·444	494·2	503·0	511·8	520·6	529·4	538·2	547·0
	46	35·5	0·226	2·53	3·53	0·417	494·3	503·1	511·9	520·7	529·5	538·3	547·1
	45	33·8	0·213	2·38	3·68	0·393	494·4	503·2	512·0	520·8	529·6	538·4	547·2
	44	32·1	0·200	2·24	3·82	0·370	494·5	503·3	512·1	520·9	529·7	538·5	547·3
	43	30·4	0·188	2·11	3·96	0·348	494·6	503·4	512·2	521·0	529·8	538·6	547·4
	42	28·7	0·177	1·99	4·07	0·328	494·7	503·5	512·3	521·1	529·9	538·7	547·5
	41	27·0	0·167	1·87	4·19	0·309	494·7	503·5	512·3	521·1	529·9	538·7	547·5
62	62	62·0	0·559	6·25	0·00	1·000	491·2	499·9	508·7	517·5	526·3	535·1	543·9
	61	60·3	0·528	5·91	0·34	0·946	491·4	500·1	508·9	517·7	526·5	535·3	544·1
	60	58·6	0·499	5·58	0·67	0·893	491·5	500·2	509·0	517·8	326·6	535·4	544·2
	59	56·9	0·472	5·27	0·98	0·843	491·7	500·4	509·2	518·0	526·8	535·6	544·4
	58	55·2	0·445	4·99	1·26	0·798	491·9	500·6	509·4	518·2	527·0	535·8	544·6
	57	53·5	0·421	4·70	1·55	0·752	492·0	500·7	509·5	518·3	527·1	535·9	544·7
	56	51·8	0·397	4·44	1·81	0·710	492·1	500·7	509·5	518·4	527·3	536·1	544·9
	55	50·1	0·375	4·19	2·06	0·670	492·2	500·9	509·7	518·5	527·4	536·2	545·0
	54	48·4	0·354	3·95	2·30	0·632	492·4	501·1	509·9	518·7	527·6	536·4	545·2
	53	46·7	0·333	3·72	2·53	0·595	492·5	501·3	510·1	518·9	527·7	536·5	545·3
	52	45·0	0·315	3·52	2·73	0·563	492·7	501·5	510·3	519·1	527·9	536·7	545·5
	51	43·3	0·297	3·31	2·94	0·530	492·8	501·6	510·4	519·2	528·0	536·8	545·6
	50	41·6	0·280	3·13	3·12	0·501	492·9	501·7	510·5	519·3	528·1	536·9	545·7
	49	39·9	0·263	2·95	3·30	0·472	493·0	501·8	510·6	519·4	528·2	537·0	545·8
	48	38·2	0·248	2·77	3·48	0·443	493·1	501·9	510·7	519·5	628·3	537·1	545·9
	47	36·5	0·234	2·61	3·64	0·418	493·2	502·0	510·8	519·6	528·4	537·2	546·0
	46	34·8	0·220	2·47	3·78	0·395	493·3	502·1	210·9	519·7	528·5	537·3	546·1
	45	33·1	0·207	2·32	3·93	0·371	493·3	502·1	511·0	519·7	528·6	537·3	546·1
	44	31·4	0·195	2·18	4·07	0·349	493·4	502·2	511·0	519·8	528·6	537·4	546·2
	43	29·7	0·184	2·06	4·19	0·330	493·4	502·2	511·1	519·8	528·6	537·4	546·2
	42	28·0	0·173	1·94	4·31	0·311	493·5	502·3	511·2	519·9	528·7	537·5	546·3
	41	26·3	0·163	1·83	4·42	0·293	493·6	502·4	511·3	520·0	528·8	537·6	546·4

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. =1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
63	63	63·0	0·578	6·45	0·00	1·000	490·2	498·9	507·7	516·4	525·2	533·9	542·7
	62	61·3	0·546	6·10	0·35	0·946	490·4	499·1	507·9	516·6	525·4	534·1	542·9
	61	59·6	0·516	5·76	0·69	0·893	490·5	499·2	508·0	516·7	525·5	534·2	543·0
	60	57·9	0·488	5·44	1·01	0·843	490·7	499·4	508·2	516·9	525·7	534·4	543·2
	59	56·2	0·461	5·15	1·30	0·798	490·9	499·6	508·4	517·1	525·9	534·6	543·4
	58	54·5	0·435	4·86	1·59	0·753	491·0	499·7	508·5	517·2	526·0	534·7	543·5
	57	52·8	0·411	4·59	1·86	0·712	491·1	499·8	508·6	517·3	526·2	534·9	543·7
	56	51·1	0·388	4·33	2·12	0·671	491·2	499·9	508·7	517·4	526·3	535·0	543·8
	55	49·4	0·366	4·09	2·36	0·634	491·3	500·0	508·8	517·5	526·4	535·1	543·9
	54	47·7	0·345	3·85	2·60	0·597	491·5	500·2	509·0	517·7	526·6	535·3	544·1
	53	46·0	0·326	3·63	2·82	0·563	491·7	500·4	509·2	518·0	526·8	535·5	544·3
	52	44·3	0·307	3·43	3·02	0·532	491·8	500·5	509·3	518.1	526·9	535·6	544·4
	51	42·6	0·289	3·24	3·21	0·502	491·9	500·6	509·4	518·2	527·0	535·7	544·5
	50	40·9	0·273	3·05	3·40	0·473	492·0	500·7	509·5	518·3	527·1	535·8	544·6
	49	39·2	0·257	2·87	3·58	0·445	492·1	500·8	509·6	518·4	527·2	535·9	544·7
	48	37·5	0·242	2·71	3·74	0·420	492·2	500·9	509·7	518·5	527·3	536·0	544·8
	47	35·8	0·228	2·56	3·89	0·397	492·3	501·0	509·8	518·6	527·4	536·1	544·9
	46	34·1	0·215	2·41	4·04	0·374	492·4	501·1	509·9	518·7	527·5	536·2	545·0
	45	32·4	0·202	2·26	4·19	0·351	492·5	501·2	510·0	518·8	527·6	536·3	545·1
	44	30·7	0·190	2·13	4·32	0·330	492·5	501·2	510·0	518·8	527·6	536·3	545·1
	43	29·0	0.179	2·00	4·45	0·310	492·6	501·3	510·1	518·9	527·7	536·4	545·2
	42	27·3	0·168	1·87	4·58	0·290	492·7	501·4	510·2	519·0	527·8	536·5	545·3
64	64	64·0	0·597	6·65	0·00	1·000	489·1	497·8	506·6	515·3	524·0	532·7	541·5
	63	62·3	0·565	6·29	0·36	0·946	489·3	498·0	506·8	515·5	524·2	532·9	541·7
	62	60·6	0·534	5·94	0·71	0·893	489·5	498·2	507·0	515·7	524·4	533·1	541·9
	61	58·9	0·504	5·61	1·04	0·843	489·7	498·4	507·2	515·9	524·6	533·3	542·1
	60	57·2	0·476	5·31	1·34	0·798	489·9	498·6	507·4	516·1	524·8	533·5	542·3
	59	55·5	0·450	5·01	1·64	0·753	490·0	498·7	507·5	516·2	524·9	533·6	542·4
	58	53·8	0·425	4·73	1·92	0·711	490·1	498·8	507·6	516·3	525·1	533·8	542·6
	57	52·1	0·401	4·47	2·18	0·672	490·2	498·9	507·7	516·4	525·2	533·9	542·7
	56	50·4	0·379	4·23	2·42	0·636	490·4	499·1	507·9	516·6	525·4	534·1	542·9
	55	48·7	0·357	3·98	2·67	0·598	490·5	499·2	508·0	516·7	525·5	534·2	543·0
	54	47·0	0·337	3·75	2·90	0·564	490·7	499·4	508·2	516·9	525·7	534·4	543·2
	53	45·3	0·318	3·55	3·10	0·534	490·8	499·5	508·3	517·0	525·8	534·5	543·3
	52	43·6	0·300	3·34	3·31	0·502	490·9	499·6	508·4	517·1	525·9	534·6	543·4
	51	41·9	0·282	3·15	3·50	0·473	491·0	499·7	508·5	517·2	526·0	534·7	543·5
	50	40·2	0·266	2·96	3·69	0·445	491·2	499·9	508·7	517·4	526·1	534·9	543·7
	49	38·5	0·251	2·79	3·86	0·419	491·3	500·0	508·8	517·5	526·2	535·0	543·8
	48	36·8	0·236	2·63	4·02	0·396	491·4	500·1	508·9	517·6	526·3	535·1	543·9
	47	35·1	0·223	2·47	4·18	0·372	491·5	500·2	509·0	517·7	526·4	535·2	544·0
	46	33·4	0·210	2·33	4·32	0·351	491·6	500·3	509·1	517·8	526·5	535·3	544·1
	45	31·7	0·197	2·19	4·46	0·330	491·7	500·4	509·2	517·9	526·6	535·4	544·2
	44	30·0	0·186	2·06	4·59	0·310	491·7	500·4	509·2	517·9	526·6	535·4	544·2
	43	28·3	0·175	1·94	4·71	0·292	491·8	500·5	509·3	518·0	526·7	535·5	544·3
	42	26·6	0·164	1·83	4·82	0·275	491·9	500·6	509·4	518·1	526·8	535·6	544·4
65	65	65·0	0·617	6·87	0·00	1·000	488·1	496·8	505·5	514·2	522·9	531·6	540·3
	64	63·4	0·586	6·51	0·36	0·947	488·3	497·0	505·7	514·4	523·1	531·8	540·5
	63	61·8	0·555	6·17	0·70	0·895	488·5	497·2	505·9	514·6	523·3	532·0	540·7
	62	60·2	0·527	5·85	1·02	0·851	488·7	497·4	506·1	514·8	523·5	532·2	540·9
	61	58·6	0·499	5·55	1·32	0·808	488·9	497·6	506·3	515·0	523·7	532·4	541·1
	60	57·0	0·473	5·25	1·62	0·765	489·0	497·7	506·5	515·2	523·9	532·6	541·3
	59	55·4	0·449	4·98	1·89	0·725	489·1	497·8	506·6	515·3	524·0	532·7	541·5
	58	53·8	0·425	4·72	2·15	0·687	489·3	498·0	506·8	515·5	524·2	532·9	541·7
	57	52·2	0·402	4·47	2·40	0·651	489·4	498·1	506·9	515·6	524·3	533·0	541·8
	56	50·6	0·381	4·23	2·64	0·616	489·6	498·3	507·1	515·8	524·5	533·2	542·0
	55	49·0	0·361	4·01	2·86	0·584	489·7	498·4	507·2	515·9	524·6	533·3	542·1
	54	47·4	0·342	3·79	3·08	0·552	489·8	498·5	507·3	516·0	524·7	533·4	542·2
	53	45·8	0·323	3·60	3·27	0·524	489·9	498·6	507·4	516·1	524·8	533·5	542·3

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
65	53	45·8	0·323	3·60	3·27	0·524	489·9	498·6	507·4	516·1	524·8	533·5	542·3
	52	44·2	0·306	3·39	3·48	0·493	490·0	498·7	507·5	516·2	524·9	533·6	542·4
	51	42·6	0·289	3·22	3·65	0·469	490·1	498·8	507·6	516·3	525·0	533·7	542·5
	50	41·0	0·274	3·04	3·83	0·442	490·2	498·9	507·7	516·4	525·1	533·8	542·6
	49	39·4	0·259	2·87	4·00	0·418	490·3	499·0	507·8	516·5	525·2	533·9	542·7
	48	37·8	0·245	2·72	4·15	0·396	490·3	499·0	507·8	516·5	525·2	533·9	542·7
	47	36·2	0·231	2·57	4·30	0·374	490·4	499·1	507·9	516·6	525·3	534·0	542·8
	46	34·6	0·219	2·43	4·44	0·354	490·5	499·2	508·0	516·7	525·4	534·1	542·9
	45	33·0	0·207	2·31	4·56	0·336	490·6	499·3	508·1	516·8	525·5	534·2	543·0
	44	31·4	0·195	2·17	4·70	0·316	490·7	499·4	508·2	516·9	525·6	534·3	543·1
	43	29·8	0·184	2·05	4·82	0·299	490·7	499·4	508·2	516·9	525·6	534·3	543·1
	42	28·2	0·174	1·94	4·93	0·283	490·8	499·5	508·3	517·0	525·7	534·4	543·2
66	66	66·0	0·638	7·08	0·00	1·000	487·0	495·7	504·4	513·1	521·8	530·5	539·2
	65	64·4	0·605	6·72	0·36	0·949	487·2	495·9	504·6	513·3	522·0	530·7	539·4
	64	62·8	0·574	6·35	0·73	0·897	487·3	496·0	504·7	513·4	522·1	530·8	539·5
	63	61·2	0·544	6·04	1·04	0·853	487·5	496·2	504·9	513·6	522·3	531·0	539·7
	62	59·6	0·516	5·72	1·36	0·808	487·7	496·4	505·1	513·8	522·5	531·2	539·9
	61	58·0	0·489	5·42	1·66	0·766	487·9	496·6	505·3	514·0	522·7	531·4	540·1
	60	56·4	0·464	5·14	1·94	0·726	488·0	496·7	505·4	514·1	522·8	531·5	540·2
	59	54·8	0·440	4·88	2·20	0·689	488·1	496·8	505·5	514·2	523·0	531·7	540·4
	58	53·2	0·416	4·62	2·46	0·652	488·2	496·9	505·6	514·3	523·1	531·8	540·5
	57	51·6	0·394	4·37	2·71	0·619	488·4	497·1	505·8	514·5	523·3	532·0	540·7
	56	50·0	0·373	4·15	2·93	0·586	488·5	497·2	505·9	514·6	523·4	532·1	540·8
	55	48·4	0·354	3·92	3·16	0·553	488·6	497·3	506·1	514·8	523·5	532·2	541·0
	54	46·8	0·335	3·72	3·36	0·525	488·8	497·5	506·3	515·0	523·7	532·4	541·2
	53	45·2	0·317	3·51	3·57	0·496	488·9	497·6	506·4	515·1	523·8	532·5	541·3
	52	43·6	0·300	3·33	3·75	0·470	489·0	497·7	506·5	515·2	523·9	532·6	541·4
	51	42·0	0·283	3·14	3·94	0·443	489·1	497·8	506·6	515·6	524·0	532·7	541·5
	50	40·4	0·268	2·97	4·11	0·419	489·2	497·9	506·7	515·4	524·1	532·8	541·6
	49	38·8	0·253	2·81	4·27	0·397	489·3	498·0	506·8	515·5	524·2	532·9	541·7
	48	37·2	0·240	2·66	4·42	0·376	489·4	498·1	506·9	515·6	524·3	533·0	541·8
	47	35·6	0·227	2·51	4·57	0·355	489·4	498·1	506·9	515·6	524·3	533·0	541·8
	46	34·0	0·214	2·37	4·71	0·335	489·5	498·2	507·0	515·7	524·4	533·1	541·9
	45	32·4	0·202	2·24	4·84	0·316	489·6	498·3	507·1	515·8	524·5	533·2	542·0
	44	30·8	0·191	2·12	4·96	0·299	489·7	498·4	507·2	515·9	524·6	533·3	542·1
	43	29·2	0·180	2·00	5·08	0·283	489·7	498·4	507·2	515·9	524·6	533·3	542·1
67	67	67·0	0·659	7·30	0·00	1·000	485·9	494·6	503·3	512·0	520·6	529·3	538·0
	66	65·4	0·626	6·93	0·37	0·949	486·1	494·8	503·5	512·2	520·8	529·5	538·2
	65	63·8	0·593	6·55	0·75	0·897	486·3	495·0	503·7	512·4	521·0	529·7	538·4
	64	62·2	0·563	6·23	1·07	0·853	486·5	495·2	503·9	512·6	521·2	529·9	538·6
	63	60·6	0·534	5·91	1·39	0·810	486·7	495·4	504·1	512·8	521·4	530·1	538·8
	62	59·0	0·506	5·60	1·70	0·767	486·8	495·5	504·2	512·9	521·6	530·3	539·0
	61	57·4	0·480	5·31	1·99	0·728	486·9	495·6	504·3	513·0	521·7	530·4	539·1
	60	55·8	0·455	5·04	2·26	0·691	487·1	495·8	504·5	513·2	521·9	530·6	539·3
	59	54·2	0·431	4·77	2·53	0·653	487·2	495·9	504·6	513·3	522·0	530·7	539·4
	58	52·6	0·408	4·52	2·78	0·619	487·3	496·0	504·7	513·4	522·1	530·8	539·5
	57	51·0	0·386	4·28	3·02	0·586	487·5	496·2	504·9	513·6	522·3	531·0	539·7
	56	49·4	0·366	4·05	3·25	0·555	487·6	496·3	505·0	513·7	522·4	531·1	539·8
	55	47·8	0·346	3·83	3·47	0·524	487·8	496·5	505·1	513·8	522·6	531·2	539·9
	54	46·2	0·328	3·62	3·68	0·496	487·9	496·6	505·2	513·9	522·7	531·3	540·0
	53	44·6	0·310	3·43	3·87	0·470	488·0	496·7	505·3	514·0	522·8	531·4	540·1
	52	43·0	0·293	3·25	4·05	0·445	488·1	[illegible]	505·4	514·1	522·9	531·5	540·2
	51	41·4	0·278	3·08	4·22	0·422	488·2	496·9	505·5	514·2	523·0	531·6	540·3
	50	39·8	0·263	2·91	4·39	0·399	488·4	497·1	505·7	514·4	523·1	531·8	540·5
	49	38·2	0·248	2·75	4·55	0·377	488·5	497·2	505·8	514·5	523·2	531·9	540·6
	48	36·6	0·235	2·60	4·70	0·356	488·6	497·3	505·9	514·6	523·3	532·0	540·7

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000.)	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
67	48	36·6	0·235	2·60	4·70	0·356	488·6	497·3	505·9	514·6	523·3	532·0	540·7
	47	35·0	0·222	2·46	4·84	0·337	488·7	497·4	505·9	514·7	523·4	532·1	540·8
	46	33·4	0·210	2·32	4·98	0·318	488·7	497·4	506·0	514·7	523·4	532·1	540·8
	45	31·8	0·198	2·19	5·11	0·301	488·8	497·5	506·1	514·8	523·5	532·2	540·9
	44	30·2	0·187	2·07	5·23	0·284	488·9	497·6	506·2	514·9	523·6	532·3	541·0
68	68	68·0	0·681	7·53	0·00	1·000	484·9	493·5	502·2	510·8	519·5	528·1	536·8
	67	66·4	0·646	7·15	0·38	0·949	485·1	493·8	502·5	511·1	519·7	528·4	537·1
	66	64·8	0·613	6·77	0·76	0·899	485·3	494·0	502·6	511·2	519·9	528·6	537·3
	65	63·2	0·582	6·43	1·10	0·854	485·5	494·2	502·8	511·4	520·1	528·8	537·5
	64	61·6	0·552	6·10	1·43	0·810	485·7	494·4	503·0	511·6	520·3	529·0	537·7
	63	60·0	0·523	5·78	1·75	0·768	485·8	494·5	503·1	511·8	520·5	529·2	537·9
	62	58·4	0·496	5·47	2·06	0·726	485·9	494·6	503·3	512·0	520·7	529·4	538·1
	61	56·8	0·470	5·20	2·33	0·691	486·0	494·7	503·4	512·1	520·8	529·5	538·3
	60	55·2	0·445	4·93	2·60	0·655	486·2	494·9	503·6	512·3	521·0	529·7	538·5
	59	53·6	0·422	4·67	2·86	0·620	486·3	495·0	503·7	512·4	521·1	529·8	538·6
	58	52·0	0·400	4·42	3·11	0·587	486·4	495·1	503·8	512·5	521·2	529·9	538·6
	57	50·4	0·379	4·19	3·34	0·556	486·6	495·3	504·0	512·7	521·4	530·1	538·8
	56	48·8	0·358	3·96	3·57	0·526	486·7	495·4	504·1	512·8	521·5	530·2	538·9
	55	47·2	0·339	3·75	3·78	0·498	486·8	495·5	504·2	512·9	521·6	530·3	539·0
	54	45·6	0·321	3·54	3·99	0·470	486·9	495·6	504·3	513·0	521·7	530·4	539·1
	53	44·0	0·304	3·35	4·18	0·445	487·0	495·7	504·4	513·1	521·8	530·5	539·2
	52	42·4	0·287	3·17	4·36	0·421	487·1	495·8	504·5	513·2	521·9	530·6	539·3
	51	40·8	0·272	3·00	4·53	0·399	487·2	495·9	504·6	513·3	522·0	530·7	539·4
	50	39·2	0·257	2·84	4·69	0·377	487·3	496·0	504·7	513·4	522·1	530·8	539·5
	49	37·6	0·243	2·68	4·85	0·356	487·4	496·1	504·8	513·5	522·2	530·9	539·6
	48	36·0	0·230	2·54	4·99	0·337	487·5	496·2	504·9	513·6	522·3	531·0	539·7
	47	34·4	0·217	2·40	5·13	0·319	487·6	496·3	505·0	513·7	522·4	531·1	539·8
	46	32·8	0·205	2·27	5·26	0·302	487·6	496·3	505·0	513·7	522·4	531·1	539·8
	45	31·2	0·194	2·15	5·38	0·286	487·7	496·4	505·1	513·8	522·5	531·2	539·9
	44	29·6	0·183	2·04	5·49	0·271	487·8	496·5	505·2	513·9	522·6	531·3	540·0
69	69	69·0	0·704	7·76	0·00	1·000	483·8	492·4	501·1	509·7	518·3	527·0	535·6
	68	67·4	0·668	7·37	0·39	0·950	484·0	492·6	501·3	509·9	518·5	527·2	535·8
	67	65·8	0·634	7·00	0·76	0·902	484·2	492·8	501·5	510·1	518·7	527·4	536·0
	66	64·2	0·601	6·63	1·13	0·854	484·4	493·0	501·7	510·3	518·9	527·6	536·2
	65	62·6	0·570	6·29	1·47	0·810	484·6	493·2	501·9	510·5	519·1	527·8	536·4
	64	61·0	0·541	5·97	1·79	0·769	484·8	493·4	502·1	510·7	519·3	528·0	536·6
	63	59·4	0·513	5·65	2·11	0·728	485·0	493·6	502·3	510·9	519·5	528·2	536·8
	62	57·8	0·486	5·37	2·39	0·695	485·1	493·7	502·4	511·0	519·6	528·3	536·9
	61	56·2	0·461	5·09	2·67	0·657	485·1	493·7	502·6	511·2	519·8	528·5	537·1
	60	54·6	0·437	4·82	2·94	0·621	485·2	493·9	502·7	511·3	519·9	528·6	537·3
	59	53·0	0·414	4·57	3·19	0·589	485·4	494·1	502·8	511·5	520·1	528·8	537·5
	58	51·4	0·392	4·33	3·43	0·558	485·5	494·2	502·9	511·6	520 2	528·9	537·6
	57	49·8	0·371	4·09	3·67	0·527	485·7	494·4	503·1	511·8	520·4	529·1	537·8
	56	48·2	0·351	3·87	3·89	0·499	485·8	494·5	503·2	511·9	520·5	529·2	537·9
	55	46·6	0·332	3·66	4·10	0·472	485·9	494·6	503·3	512·0	520·6	529·3	538·0
	54	45·0	0·315	3·47	4·29	0·447	486·0	494·7	503·4	512·1	520·7	529·4	538·1
	53	43·4	0·298	3·29	4·47	0·424	486·1	494·8	503·5	512·2	520·8	529·5	538·2
	52	41·8	0·282	3·11	4·65	0·401	486·2	494·9	503·6	512·3	520·9	529·6	538·3
	51	40·2	0·266	2·94	4·82	0·379	486·3	495·0	503·7	512·4	521·0	529·7	538·4
	50	38·6	0·252	2·78	4·98	0·358	486·4	495·1	503·8	512·5	521·1	529·8	538·5
	49	37·0	0·238	2·63	5·13	0·339	486·5	495·2	503·9	512·6	521·2	529·9	538·6
	48	35·4	0·225	2·49	5·27	0·321	486·6	495·3	504·0	512·7	521·3	530·0	538·7
	47	33·8	0·213	2·34	5·42	0·302	486·7	495·4	504·1	512·8	521·4	530·1	538·8
	46	32·2	0·201	2·20	5·56	0·284	486·8	495·5	504·2	512·9	521·5	530·2	538·9
	45	30·6	0·190	2·06	5·70	0·266	486·8	495·5	504·2	512·9	521·5	530·2	538·9

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
70	70	70·0	0·727	8·00	0·00	1·000	482·8	491·4	500·0	508·6	517·2	525·8	534·4
	69	68·5	0·692	7·62	0·38	0·953	483·0	491·6	500·2	508·8	517·4	526·0	534·6
	68	67·0	0·659	7·26	0·74	0·907	483·2	491·8	500·4	509·0	517·6	526·2	534·8
	67	65·5	0·628	6·91	1·09	0·865	483·3	491·9	500·5	509·1	517·7	526·3	534·9
	66	64·0	0·597	6·57	1·43	0·822	483·5	492·1	500·7	509·3	517·9	526·5	535·1
	65	62·5	0·568	6·25	1·75	0·781	483·7	492·3	500·9	509·5	518·1	526·7	535·3
	64	61·0	0·541	5·95	2·05	0·744	483·8	492·4	501·0	509·6	518·3	526·8	535·5
	63	59·5	0·515	5·66	2·34	0·708	484·0	492·6	501·2	509·8	518·5	527·1	535·7
	62	58·0	0·489	5·38	2·62	0·672	484·2	492·8	501·4	510·0	518·7	527·3	535·9
	61	56·5	0·465	5·12	2·88	0·640	484·3	492·9	501·5	510·1	518·8	527·4	536·0
	60	55·0	0·442	4·87	3·13	0·609	484·4	493·0	501·6	510·2	518·9	527·5	536·1
	59	53·5	0·421	4·62	3·38	0·578	484·6	493·2	501·8	510·4	519·1	527·7	536·3
	58	52·0	0·400	4·40	3·60	0·550	484·7	493·3	501·9	510·5	519·2	527·8	536·4
	57	50·5	0·380	4·18	3·82	0·522	484·8	493·4	502·0	510·6	519·3	527·9	536·5
	56	49·0	0·361	3·96	4·04	0·495	484·9	493·5	502·1	510·7	519·4	528·0	536·6
	55	47·5	0·343	3·76	4·24	0·470	485·1	493·7	502·3	510·9	519·6	528·2	536·8
	54	46·0	0·326	3·57	4·43	0·446	485·2	493·8	502·4	511·0	519·7	528·3	536·9
	53	44·5	0·309	3·40	4·60	0·425	485·3	493·9	502·5	511·1	519·8	528·4	537·0
	52	43·0	0·292	3·23	4·77	0·404	485·4	494·0	502·6	511·2	519·9	528·5	537·1
	51	41·5	0·279	3·07	4·93	0·384	485·5	494·1	502·7	511·3	520·0	528·6	537·2
	50	40·0	0·264	2·81	5·19	0·351	485·5	494·1	502·7	511·3	520·0	528·6	537·2
	49	38·5	0·251	2·70	5·24	0·345	485·6	494·2	502·8	511·4	520·1	528·7	537·3
	48	37·0	0·238	2·63	5·37	0·329	485·7	494·3	502·9	511·5	520·2	528·8	537·4
	47	35·5	0·226	2·50	5·50	0·315	485·8	494·4	503·0	511·6	520·3	528·9	537·5
	46	34·0	0·214	2·37	5·63	0·296	485·8	494·4	503·0	511·6	520·3	528·9	537·5
	45	32·5	0·203	2·24	5·76	0·280	485·9	494·5	503·1	511·7	520·4	529·0	537·6
	44	31·0	0·192	2·12	5·88	0·265	486·0	494·6	503·2	511·8	520·5	529·1	537·7
	43	29·5	0·182	2·01	5·99	0·251	486·1	494·7	503·3	511·9	520·6	529·2	537·8

Dry.	Wet.	Dew-Point.	Elastic Force	In a Cubic Foot	Reqd. for Satn.	Degree of Humidity	28·0	28·5	29·0	29·5	30·0	30·5	31·0
71	71	71·0	0·751	8·21	0·00	1·000	481·6	490·2	498·8	507·4	516·0	524·6	533·2
	70	69·5	0·715	7·82	0·39	0·953	481·8	490·4	499·0	507·6	516·2	524·8	533·4
	69	68·0	0·681	7·44	0·77	0·907	482·0	490·6	499·2	507·8	516·4	525·0	533·6
	68	66·5	0·648	7·09	1·12	0·865	482·2	490·8	499·4	508·0	516·6	525·2	533·8
	67	65·0	0·617	6·75	1·46	0·823	482·4	491·0	499·6	508·2	516·8	525·4	534·0
	66	63·5	0·588	6·41	1·80	0·782	482·6	491·2	499·8	508·4	517·0	525·6	534·2
	65	62·0	0·559	6·14	2·11	0·744	482·8	491·4	500·0	508·6	517·2	525·8	534·4
	64	60·5	0·532	5·81	2·40	0·709	483·0	491·6	500·2	508·8	517·4	526·0	534·6
	63	59·0	0·506	5·52	2·69	0·674	483·1	491·7	500·3	508·9	517·5	526·1	534·7
	62	57·5	0·481	5·24	2·97	0·640	483·2	491·8	500·4	509·0	517·7	526·3	534·9
	61	56·0	0·458	4·99	3·22	0·609	483·3	491·9	500·5	509·1	517·8	526·4	535·0
	60	54·5	0·435	4·74	3·47	0·579	483·5	492·1	500·7	509·3	518·0	526·6	535·1
	59	53·0	0·414	4·54	3·71	0·550	483·6	492·2	500·8	509·4	518·1	526·7	535·2
	58	51·5	0·393	4·31	3·94	0·522	483·8	492·4	501·0	509·6	518·3	526·9	535·4
	57	50·0	0·373	4·10	4·15	0·497	483·9	492·5	501·1	509·7	518·4	527·0	535·5
	56	48·5	0·355	3·89	4·36	0·473	484·0	492·6	501·2	509·8	518·5	527·1	535·6
	55	47·0	0·337	3·69	4·56	0·447	484·1	492·7	501·3	510·0	318·6	527·2	535·7
	54	45·5	0·320	3·51	4·74	0·425	484·2	492·8	501·4	510·1	518·7	527·3	535·8
	53	44·0	0·304	3·29	4·92	0·404	484·3	492·9	501·5	510·2	518·8	527·4	535·9
	52	42·5	0·288	3·16	5·09	0·383	484·4	493·0	501·6	510·3	518·9	527·5	536·0
	51	41·0	0·274	3·00	5·25	0·364	484·5	493·1	501·7	510·4	519·0	597·6	536·1
	50	39·5	0·260	2·85	5·40	0·345	484·6	493·2	501·8	510·5	519·1	527·7	536·2
	49	38·0	0·246	2·70	5·55	0·327	484·7	493·3	501·9	510·6	519·2	527·8	536·3
	48	36·5	0·234	2·57	5·68	0·312	484·7	493·3	501·9	510·6	519·2	527·8	536·3
	47	35·0	0·222	2·44	5·81	0·296	484·8	493·4	502·0	510·7	519·3	527·9	536·4
	46	33·5	0·210	2·31	5·94	0·280	484·9	493·5	502·1	510·8	519·4	528·0	536·5
	45	32·0	0·199	2·18	6·06	0·265	485·0	493·6	502·2	510·9	519·5	528·1	536·6
	44	30·5	0·188	2·08	6·17	0·252	485·0	493·6	502·2	510·9	519·5	528·1	536·6

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
72	72	72·0	0·776	8·50	0·00	1·000	480·6	489·2	497·8	506·4	514·9	523·5	532·1
	71	70·5	0·739	8·10	0·40	0·953	480·8	489·4	498·0	506·5	515·1	523·7	532·3
	70	69·0	0·704	7·71	0·79	0·907	481·0	489·6	498·2	506·7	515·3	523·9	532·5
	69	67·5	0·670	7·35	1·15	0·865	481·2	489·8	498·4	506·9	515·5	524·1	532·7
	68	66·0	0·638	7·00	1·50	0·824	481·4	490·0	498·5	507·1	515·7	524·3	532·9
	67	64·5	0·607	6·66	1·84	0·784	481·6	490·2	498·7	507·3	515·9	524·5	533·1
	66	63·0	0·578	6·33	2·17	0·745	491·7	490·3	498·8	507·4	516·1	524·7	533·3
	65	61·5	0·550	6·03	2·47	0·710	481·8	490·4	499·0	507·6	516·2	524·8	533·4
	64	60·0	0·253	5·73	2·77	0·674	482·0	490·6	499·2	507·8	516·4	525·0	533·6
	63	58·5	0·498	5·45	3·05	0·641	482·1	490·7	499·3	507·9	516·5	525·1	533·7
	62	57·0	0·473	5·18	3·32	0·610	482·3	493·9	499·5	508·1	516·7	525·3	533·9
	61	55·5	0·450	4·93	3·57	0·580	482·5	491·1	499·7	508.3	516·9	525·5	534·1
	60	54·0	0·428	4·68	3 82	0·551	482·6	491·2	499·8	508·4	517·0	525·6	534·2
	59	52·5	0·407	4·45	4·05	0·523	482·8	491·4	500·0	508·6	517·2	525·8	534·4
	58	51·0	0·386	4·23	4·27	0·498	482·9	491·5	501·1	508·7	517·3	525·9	534·5
	57	49·5	0·367	4·02	4·48	0·473	483·0	491·6	500·2	508·8	517·4	526·0	534·6
	56	48·0	0·349	3·82	4·68	0·449	483·1	491·7	500·3	508·9	517·5	526·1	534·7
	55	46·5	0·331	3·63	4·87	0·427	483·2	491·8	500·4	509·0	517·6	526·2	534·8
	54	45·0	0·315	3·45	5·05	0·406	483·3	491·9	500·5	509·1	517·7	526·2	534·9
	53	43·5	0·299	3·28	5·22	0 336	483·3	492·0	500·6	509·2	517·8	526·3	535·0
	52	42·0	0.283	3·11	5·33	0·366	483·5	492·1	500·7	509·3	517·9	526·4	535·1
	51	40·5	0·269	2·95	5·55	0·347	483·6	492·2	500·8	509·4	518·0	526·5	535·2
	50	39·0	0·255	2·80	5·70	0·329	483·7	492·3	500·9	509·5	518·1	526·6	535·3
	49	37·5	0·242	2·66	5·84	0·313	483·8	492·4	501·0	509·6	518·2	526·7	535·4
	48	36·0	0·230	2·52	5·98	0·296	483·8	492·4	501·0	509·6	518·2	526·7	535·4
	47	34·5	0·218	2·39	6·11	0·281	483·9	492·5	501·2	509·7	518·3	526·8	535·5
	46	33·0	0·207	2·27	6·23	0·267	484·0	492·6	501·3	509·8	518·4	526·9	535·6
	45	31·5	0·196	2·16	6·34	0·254	484·1	492·7	501·3	509·9	518·5	527·1	535·7
73	73	73·0	0·801	8·76	0·00	1·000	479·6	488·1	496·7	505·2	513·8	522·3	530·9
	72	71·5	0·736	8·35	0·41	0·953	479·8	488·3	496·9	505·4	514·0	522·5	531·1
	71	70·0	0·727	7·95	0·81	0·908	480·0	488·5	497·1	505·6	514·2	522·7	531·3
	70	68·5	0 692	7·57	1·19	0·864	490·2	488·7	497·3	505·8	514·4	522·9	531·5
	69	67·0	0·659	7·21	1·55	0·823	480·4	488·9	497·5	506·0	514·6	523·1	531·7
	68	65·5	0·628	6·87	1·89	0·784	480·5	489·0	497·6	506·1	514·8	523·3	531·9
	67	64·0	0·597	6·53	2·23	0·745	480·7	489·2	497·8	506·3	515·0	523·5	532·1
	66	62·5	0·56[illegible]	6·22	2·54	0·710	480·8	489·3	497·9	506·4	515·1	523·6	532·2
	65	61·0	0·541	5·92	2·84	0·676	481·0	489·5	498·1	506·6	515·3	523·8	532·4
	64	59·5	0·515	5·63	3·13	0·643	481·1	489·6	498·2	506·8	515·4	524·0	532·6
	63	58·0	0·489	5·34	3·42	0·610	481·2	489·8	498·4	507·0	515·6	524·2	532·8
	62	56·5	0·465	5·09	3·67	0·581	481·4	490·0	498·6	507·2	515·8	524·4	533·0
	61	55·0	0·442	4·84	3·92	0·553	481·6	490·2	498·8	507·4	516·0	524·6	533·2
	60	53·5	0·421	4·59	4·17	0·524	481·7	490·3	498·9	507·5	516·1	524·7	533·3
	59	52·0	0·400	4·37	4·39	0·499	481·8	490·4	499·0	507·6	516·2	524·8	533·4
	58	50·5	0·380	4·16	4·60	0·475	482·0	490·6	499·2	507·8	516·4	525·0	533·6
	57	49·0	0·361	3·94	4·82	0·450	482·1	491·7	499·3	507·9	516·5	525·1	533·7
	56	47·5	0·343	3·74	5·02	0·427	482·2	490·8	499·4	508·0	516·6	525·2	533·8
	55	46·0	0·326	3·56	5·20	0·406	482·3	490·9	499·5	508·1	516·7	525·3	533·9
	54	44·5	0·309	3·38	5·38	0·386	482·4	491·0	499·6	508·2	516·8	525·4	534·0
	53	43·0	0·293	3·21	5·55	0·366	482·5	491·1	499·7	508·3	516·9	525·5	534·1
	52	41·5	0·279	3·05	5·71	0·348	482·6	491·2	499·8	508·4	517·0	525·6	534·2
	51	40·0	0·264	2·89	5·87	0·330	482·7	491·3	499·9	508·5	517·1	525·7	534·3
	50	38·5	0·251	2·74	6·02	0·313	482·8	491·4	500·0	508·6	517·2	525·8	534·4
	49	37·0	0·239	2·60	6·16	0·297	482·9	491·5	500·0	508·6	517·2	525·8	534·4
	48	35·5	0·226	2·47	6·29	0·282	483·0	491·6	500·1	508·7	517·3	525·9	534·5
	47	34·0	0·214	2·34	6·42	0·267	483·1	491·7	500·2	508·8	517·4	526·0	534·6
	46	32·5	0·203	2·22	6·54	0·253	483·3	491·9	500·4	509·1	517·6	526·2	534·8

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000.)	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
74	74	74·0	0·827	9·04	0·00	1·000	478·4	486·9	495·5	504·0	512·6	521·1	529·7
	73	72·5	0·787	8·60	0·44	0·951	478·6	487·1	495·7	504·2	512·8	521·3	529·9
	72	71·0	0·751	8·20	0·84	0·907	478·8	487·3	495·9	504·4	513·0	521·5	530·1
	71	69·5	0·715	7·81	1·23	0·864	479·0	487·5	496·1	504·6	513·2	521·7	530·3
	70	68·0	0·681	7·44	1·60	0·823	479·2	487·7	496·3	504·8	513·4	521·9	530·5
	69	66·5	0·648	7·08	1·96	0·783	479·4	487·9	496·5	505·0	513·6	522·1	530·7
	68	65·0	0·617	6·75	2·29	0·747	479·6	488·1	496·7	505·2	513·8	522·3	530·9
	67	63·5	0·588	6·41	2·63	0·709	479·8	488·3	496·9	505·	514·0	522·5	531·1
	66	62·0	0·559	6·10	2·94	0·675	480·0	488·5	497·1	505·6	514·2	522·7	531·3
	65	60·5	0·532	5·81	3·23	0·643	480·1	488·7	497·3	505·9	514·4	522·9	531·5
	64	59·0	0·506	5·52	3·52	0·611	480·3	488·9	497·5	506·1	514·6	523·2	531·8
	63	57·5	0·481	5·24	3·80	0·580	480·5	489·1	497·7	506·3	514·8	523·4	532·0
	62	56·0	0·458	4·99	4·05	0·552	480·6	489·2	497·8	506·4	514·9	523·5	532·1
	61	54·5	0·435	4·75	4·29	0·525	480·7	489·3	497·9	506·5	515·0	523·6	532·2
	60	53·0	0·414	4·52	4·52	0·500	480·9	489·5	498·1	506·7	515·2	523·8	532·4
	59	51·5	0·393	4·29	4·75	0·475	481·0	489·6	498·2	506·8	515·3	523·9	532·5
	58	50·0	0·373	4·08	4·96	0·451	481·1	489·7	498·3	506·9	515·4	524·0	532·6
	57	48·5	0·355	3·86	5·18	0·427	481·2	489·8	498·4	507·0	515·5	524·1	532·7
	56	47·0	0·337	3·66	5·38	0·405	481·3	489·9	498·5	507·1	515·6	524·2	532·8
	55	45·5	0·320	3·48	5·56	0·385	481·4	490·0	498·6	507·2	515·7	524·3	532·9
	54	44·0	0·304	3·32	5·72	0·367	481·5	490·1	498·7	507·3	515·8	524·4	533·0
	53	42·5	0·288	3·15	5·89	0·348	481·6	490·2	498·8	507·4	515·9	524·5	533·1
	52	41·0	0·274	2·99	6·05	0·331	481·7	490·3	498·9	507·5	516·0	524·6	533·2
	51	39·5	0·260	2·83	6·21	0·313	481·8	490·	499·0	507·6	516·1	524·7	533·3
	50	38·0	0·246	2·69	6·35	0·298	481·9	490·5	499·1	507·7	516·2	524·8	533·4
	49	36·5	0·234	2·55	6·49	0·282	481·9	490·5	499·1	507·7	516·2	524·8	533·4
	48	35·0	0·222	2·42	6·62	0·266	482·0	490·6	499·2	507·8	516·3	524·9	533·5
	47	33·5	0·210	2·30	6·74	0·254	482·1	490·7	499·2	507·9	516·4	525·0	533·6
75	75	75·0	0·854	9·31	0·00	1·000	477·4	485·9	494·4	502·9	511·5	520·0	528·5
	74	73·5	0·814	8·87	0·44	0·953	477·6	486·1	494·6	503·1	511·7	520·2	528·7
	73	72·0	0·776	8·45	0·86	0·9 8	477·7	486·3	494·8	503·3	511·9	520 4	528·9
	72	70·5	0·739	8·05	1·26	0·865	478·0	486·5	495·0	503·5	51 ·1	520·6	529·1
	71	69·0	0·704	7·67	1·64	0·824	478·2	486·7	495·2	503·7	512·3	520·8	529·3
	70	67·5	0·670	7·30	2·01	0·784	478·3	486·9	495·3	503·8	512·5	521·0	529·5
	69	66·0	0·638	6·95	2·36	0·746	478·5	487·0	495·5	504·0	512·7	521·2	529·7
	68	64·5	0·607	6·62	2·69	0·711	478·7	487·2	495·7	504·2	512·9	521·4	529·9
	67	63·0	0·578	6·30	3·01	0·677	478·9	487·4	495·9	504·4	513·1	521·6	530·1
	66	61·5	0·550	5·99	3·32	0·643	479·1	487·6	496·1	504·6	513·3	521·8	530·3
	65	60·0	0·523	5·69	3·62	0·611	479·2	487·8	496·4	504·9	513·5	522·0	530·6
	64	58·5	0·498	5·42	3·89	0·582	479·3	488·0	496·6	505·1	513·7	522·2	530·8
	63	57·0	0·473	5·15	4·16	0·553	479·6	488·1	496·7	505·2	513·8	522·3	530·9
	62	55·5	0·450	4·90	4·41	0·526	479·7	488·2	496·8	505·3	513·9	522·4	531·0
	61	54·0	0·428	4·66	4·65	0·501	479·8	488·4	497·0	505·5	514 1	522·6	531·2
	60	52·5	0·407	4·43	4·88	0·476	480·0	488·5	497·1	505·6	514·2	522·7	531·3
	59	51·0	0·386	4·21	5·10	0·452	480·1	488·6	497·2	505·7	514·3	522·8	531·4
	58	49·5	0·367	4·00	5·31	0·429	480·2	488·8	497·4	505·9	514·5	523·0	531·6
	57	48·0	0·349	3·79	5·52	0·407	480·4	488·9	497·5	506·0	514·6	523·1	531·7
	56	46·5	0·331	3·60	5·71	0·387	480·5	489·0	497·6	506·1	514·7	523·2	531·8
	55	45·0	0·315	3·42	5·89	0·367	480·6	489·1	497·7	506·2	514·8	523·3	531·9
	54	43·5	0·299	3·25	6·06	0·349	480·7	489·2	497·8	506·3	514·9	523·4	532·0
	53	42·0	0·283	3·09	6·22	0·332	480·8	489·3	497·9	506·4	515 0	523·5	532·1
	52	40·5	0·269	2·93	6·38	0·315	480·8	489·3	497·9	506·4	515·0	523·5	532·1
	51	39·0	0·255	2·78	6·53	0·299	480·9	489·4	498·0	506·5	515·1	523·6	532·2
	50	37·5	0·242	2·64	6·67	0·284	481·0	489·5	498·1	506·6	515·2	523·7	532·3
	49	36·0	0·230	2·51	6 80	0·270	481·1	489·6	498·2	506·7	515·3	523·8	532·4
	48	34·5	0·218	2·39	6·92	0·257	481·2	489·7	498·3	506·8	515·4	523·9	532·5

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
76	76	76·0	0·882	9·60	0·00	1·000	476·3	484·8	493·3	501·8	510·3	518·8	527·3
	75	74·5	0·840	9·14	0·46	0·952	476·6	485·1	493·6	502·1	510·6	519·1	527·6
	74	73·0	0·801	8·71	0·89	0·907	476·8	485·3	493·8	502·3	510·8	519·3	527·8
	73	71·5	0·763	8·30	1·30	0·865	477·0	485·5	494·0	502·6	511·1	519·6	528·1
	72	70·0	0·727	7·90	1·70	0·823	477·2	485·7	494·3	502·8	511·3	519·8	528·3
	71	68·5	0·692	7·53	2·07	0·784	477·4	485·9	494·5	503·0	511·5	520·0	528·5
	70	67·0	0·659	7·17	2·43	0·747	477·6	486·1	494·7	503·2	511·7	520·2	528·7
	69	65·5	0·628	6·83	2·77	0·711	477·8	486·3	494·9	503·4	511·9	520·4	528·9
	68	64·0	0·597	6·49	3·11	0·676	477·9	486·4	495·0	503·6	512·1	520·6	529·2
	67	62·5	0·568	6·16	3·44	0·642	478·1	486·6	495·2	503·8	512·3	520·8	529·4
	66	61·0	0·541	5·88	3·72	0·613	478·2	486·7	495·3	503·9	512·4	520·9	529·5
	65	59·5	0·515	5·59	4·01	0·582	478·3	486·8	495·4	504·0	512·5	521·0	529·6
	64	58·0	0·489	5·31	4·29	0·553	478·5	487·0	495·6	504·2	512·7	521·2	529·8
	63	56·5	0·465	5·06	4·54	0·527	478·6	487·1	495·7	504·3	512·8	521·3	529·9
	62	55·0	0·442	4·81	4·79	0·501	478·8	487·3	495·9	504·5	513·0	521·5	530·1
	61	53·5	0·421	4·57	5·03	0·476	479·0	487·5	496·1	504·7	513·2	521·7	530·3
	60	52·0	0·400	4·34	5·26	0·452	479·1	487·6	496·2	504·8	513·3	521·8	530·4
	59	50·5	0·380	4·13	5·47	0·430	499·2	487·7	496·3	504·9	513·4	521·9	530·5
	58	49·0	0·361	3·92	5·68	0·408	499·3	487·8	496·4	505·0	513·5	522·0	530·6
	57	47·5	0·343	3·73	5·87	0·389	499·4	487·9	496·5	505·1	513·6	522·1	530·7
	56	46·0	0·326	3·54	6·06	0·369	499·5	488·0	496·6	505·2	513·7	522·2	530·8
	55	44·5	0·309	3·36	6·24	0·351	499·6	488·1	496·7	505·3	513·8	522·3	530·9
	54	43·0	0·293	3·19	6·41	0·332	499·7	488·2	496·8	505·4	513·9	522·4	531·0
	53	41·5	0·279	3·03	6·57	0·316	499·8	488·3	496·9	505·5	514·0	522·5	531·1
	52	40·0	0·264	2·88	6·72	0·301	499·9	488·4	497·0	505·6	514·1	522·6	531·2
	51	38·5	0·251	2·73	6·87	0·284	500·0	488·5	497·1	505·7	514·2	522·7	531·3
	50	37·0	0·238	2·59	7·01	0·269	500·1	488·6	497·2	505·8	514·3	522·8	531·4
	49	35·5	0·226	2·46	7·14	0·256	500·2	488·7	497·3	505·9	514·4	522·9	531·5
77	77	77·0	0·910	9·89	0·00	1·000	475·3	483·8	492·3	500·8	509·2	517·7	526·2
	76	75·5	0·868	9·42	0·47	0·953	475·5	484·0	492·5	501·0	509·4	517·9	526·4
	75	74·0	0·827	8·99	0·90	0·909	475·7	484·2	492·7	501·2	509·6	518·1	526·6
	74	72·5	0·787	8·57	1·32	0·867	475·9	484·4	492·9	501·4	509·9	518·4	526·9
	73	71·0	0·751	8·15	1·74	0·824	476·1	484·6	493·1	501·6	510·1	518·6	527·1
	72	69·5	0·715	7·77	2·12	0·786	476·3	484·8	493·3	501·8	510·3	518·8	527·3
	71	68·0	0·681	7·40	2·49	0·748	476·5	485·0	493·5	502·0	510·5	519·0	527·5
	70	66·5	0·648	7·04	2·85	0·712	476·7	485·2	493·7	502·2	510·7	519·2	527·7
	69	65·0	0·617	6·71	3·18	0·678	476·9	485·4	493·9	502·4	510·9	519·4	527·9
	68	63·5	0·588	6·37	3·52	0·644	477·0	485·6	494·1	502·6	511·1	519·6	528·1
	67	62·0	0·559	6·06	3·83	0·613	477·2	485·8	494·3	502·8	511·3	519·8	528·3
	66	60·5	0·532	5·77	4·12	0·583	477·4	486·0	494·5	503·0	511·5	520·0	528·5
	65	59·0	0·506	5·49	4·40	0·556	477·5	486·1	494·6	503·1	511·6	520·1	528·6
	64	57·5	0·481	5·21	4·68	0·527	477·7	486·3	494·8	503·3	511·8	520·3	528·8
	63	56.0	0·458	4·96	4·93	0·501	477·9	486·5	495·0	503·5	512·0	520·5	529·0
	62	54·5	0·435	4·70	5·19	0·476	478·0	486·6	495·1	503·7	512·1	520·6	529·1
	61	53·0	0·414	4·49	5·40	0·454	478·0	486·6	495·1	503·7	512·2	520·7	529·3
	60	51·5	0·393	4·26	5·63	0·431	478·1	486·7	495·2	503·8	512·3	520·8	529·4
	59	50·0	0·373	4·05	5·84	0·410	478·2	486·8	495·3	503·9	512·4	520·9	529·5
	58	48·5	0·355	3·85	6·04	0·389	478·3	486·9	495·4	504·0	512·5	521·0	529·6
	57	47·0	0·337	3·65	6·24	0·369	478·5	487·1	495·6	504·1	512·7	521·2	529·8
	56	45·5	0·320	3·47	6·42	0·351	478·6	487·2	495·7	504·2	512·8	521·3	529·9
	55	44·0	0·304	3·29	6·60	0·333	478·7	487·3	495·8	504·3	512·9	521·4	530·0
	54	42·5	0·288	3·13	6·76	0·317	478·8	487·4	495·9	504·4	513·0	521·5	530·1
	53	41·0	0·274	2·97	6·92	0·301	478·9	487·5	496·0	504·5	513·1	521·6	530·2
	52	39·5	0·260	2·82	7·07	0·285	479·0	487·6	496·1	504·6	513·2	521·7	530·3
	51	38·0	0·246	2·67	7·22	0·270	479·1	487·7	496·2	504·7	513·3	521·8	530·4
	50	36·5	0·234	2·53	7·36	0·256	479·1	487·7	496·2	504·7	513·3	521·8	530·4

Reading of Thermometer. Dry.	Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. =1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
78	78	78·0	0·940	10·19	0·00	1·000	474·1	482·5	491·0	499·4	508·0	516·4	524·9
	77	76·5	0·896	9·72	0·47	0·954	474·4	482·9	491·4	499·9	508·3	516·7	525·2
	76	75·0	0·854	9·25	0·94	0·908	474·7	483·2	491·6	500·1	508·6	517·1	525·6
	75	73·5	0·814	8·82	1·37	0·865	474·9	483·4	491·8	500·3	508·8	517·3	525·8
	74	72·0	0·776	8·40	1·79	0·824	475·2	483·7	492·1	500·6	509·1	517·6	526·1
	73	70·5	0·739	8·00	2·19	0·785	475·4	483·9	492·3	500·8	509·3	517·8	526·3
	72	69·0	0·704	7·62	2·57	0·748	475·6	484·1	492·5	501·0	509·5	518·0	526·5
	71	67·5	0·670	7·25	2·94	0·711	475·8	484·3	492·7	501·2	509·7	518·2	526·7
	70	66·0	0·638	6·91	3·28	0·678	475·9	484·4	492·9	501·4	509·9	518·4	526·9
	69	64·5	0·607	6·58	3·61	0·646	476·1	484·6	493·1	501·6	510·1	518·6	527·1
	68	63·0	0·578	6·26	3·93	0·614	476·3	484·8	493·3	501·8	510·3	518·8	527·3
	67	61·5	0·550	5·96	4·23	0·585	476·4	484·9	493·4	501·9	510·4	518·9	527·4
	66	60·0	0·523	5·66	4·53	0·555	476·6	485·1	493·6	502·1	510·6	519·1	527·6
	65	58·5	0·498	5·38	4·81	0·528	476·8	485·3	493·8	502·3	510·8	519·3	527·8
	64	57·0	0·473	5·12	5·07	0·502	476·8	485·3	493·9	502·4	510·9	519·4	527·9
	63	55·5	0·450	4·88	5·31	0·479	476·9	485·4	494·0	502·5	511·0	519·5	528·0
	62	54·0	0·428	4·63	5·56	0·454	477·1	485·6	494·2	502·7	511·2	519·7	528·2
	61	52·5	0·407	4·40	5·79	0·432	477·2	485·7	494·3	502·8	511·3	519·8	528·3
	60	51·0	0·386	4·18	6·01	0·409	477·3	485·8	494·4	502·9	511·4	519·9	528·4
	59	49·5	0·367	3·98	6·21	0·391	477·4	485·9	494·5	503·0	511·5	520·0	528·5
	58	48·0	0·349	3·78	6·41	0·371	477·5	486·0	494·6	503·1	511·6	520·1	528·6
	57	46·5	0·331	3·59	6·60	0·352	477·6	486·1	494·7	503·2	511·7	520·2	528·7
	56	45·0	0·315	3·41	6·78	0·335	477·8	486·3	494·8	503·3	511·9	520·4	528·9
	55	43·5	0·299	3·24	6·95	0·318	477·9	486·4	494·9	503·4	512·0	520·5	529·0
	54	42·0	0·283	3·07	7·12	0·301	478·0	486·5	496·0	503·5	512·1	520·6	529·1
	53	40·5	0·269	2·92	7·27	0·287	478·1	486·5	495·0	503·5	512·1	520·6	529·1
	52	39·0	0·255	2·77	7·42	0·272	478·2	486·6	495·1	503·6	512·2	520·7	529·2
	51	37·5	0·242	2·63	7·56	0·258	478·3	486·7	495·2	503·7	512·3	520·8	529·3
79	79	79·0	0·970	10·50	0·00	1·000	473·1	481·5	490·0	498·4	506·9	515·3	523·8
	78	77·5	0·925	10·01	0·49	0·953	473·4	481·8	490·3	498·7	507·2	515·6	524·1
	77	76·0	0·882	9·54	0·96	0·909	473·7	482·1	490·6	499·0	507·5	515·9	524·4
	76	74·5	0·840	9·10	1·40	0·867	473·8	482·2	490·7	499·2	507·7	516·2	524·7
	75	73·0	0·801	8·66	1·84	0·825	474·0	482·4	490·9	499·4	507·9	516·4	524·9
	74	71·5	0·763	8·25	2·25	0·786	474·3	482·7	491·2	499·7	508·2	516·7	525·2
	73	70·0	0·727	7·86	2·64	0·749	474·5	482·9	491·4	499·9	508·4	516·9	525·4
	72	68·5	0·692	7·48	3·02	0·712	474·7	483·1	491·6	500·1	508·6	517·1	525·6
	71	67·0	0·659	7·12	3·38	0·678	474·9	483·4	491·9	500·4	508·8	517·3	525·8
	70	65·5	0·628	6·79	3·71	0·647	475·1	483·6	492·1	500·6	509·0	517·5	526·0
	69	64·0	0·597	6·45	4·05	0·614	475·3	483·8	492·3	501·8	509·2	517·7	526·2
	68	62·5	0·568	6·14	4·36	0·585	475·4	483·9	492·4	501·9	509·3	517·8	526·3
	67	61·0	0·541	5·84	4·66	0·556	475·6	484·1	492·6	501·1	509·5	518·0	526·5
	66	59·5	0·515	5·55	4·95	0·529	475·7	484·2	492·7	501·2	509·6	518·1	526·6
	65	58·0	0·489	5·28	5·22	0·503	475·8	484·3	492·8	501·3	509·8	518·3	526·8
	64	56·5	0·465	5·02	5·48	0·478	476·0	484·5	493·0	501·5	510·0	518·5	527·0
	63	55·0	0·442	4·78	5·72	0·455	476·1	484·6	493·1	501·6	510·1	318·6	527·1
	62	53·5	0·421	4·54	5·96	0·432	476·3	484·8	493·3	501·8	510·3	518·8	527·3
	61	52·0	0·400	4·31	6·19	0·410	476·4	484·9	493·4	501·9	510·4	518·9	527·4
	60	50·5	0·380	4·10	6·40	0·390	476·5	485·0	493·5	502·0	510·5	519·0	527·5
	59	49·0	0·361	3·90	6·60	0·371	476·6	485·1	493·6	502·1	510·6	519·1	597·6
	58	47·5	0·343	3·71	6·79	0·353	476·7	485·2	493·7	502·2	510·7	519·2	527·7
	57	46·0	0·326	3·52	6·98	0·335	476·8	485·3	493·8	502·3	510·8	519·3	527·8
	56	44·5	0·309	3·34	7·16	0·318	476·9	485·4	493·9	502·4	510·9	519·4	527·9
	55	43·0	0·293	3·17	7·33	0·301	477·0	485·5	494·0	502·5	511·0	519·5	528·0
	54	41·5	0·279	3·01	7·49	0·287	477·1	485·6	494·1	502·6	511·1	519·6	528·1
	53	40·0	0·264	2·86	7·64	0·272	477·2	485·7	494·2	502·7	511·2	519·7	528·2
	52	38·5	0·251	2·72	7·78	0·260	477·3	485·8	494·3	502·8	511·3	519·8	528·3

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in 28·0	in. 28·5	in. 29·0	in. 29·5	in 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
80	80	80·0	1·001	10·81	0·00	1·000	472·0	480·4	488·9	497·3	505·7	514.1	522·6
	79	78·5	0·955	10·31	0·50	0·954	472·3	480·7	489·1	497·5	506·0	514·4	522·9
	78	77·0	0·910	9·83	0·98	0·909	472·5	480·9	489·4	497·9	506·3	514·7	523·2
	77	75·5	0·868	9·37	1·44	0·867	472·7	481·1	489·6	498·1	506·5	514·9	523·4
	76	74·0	0·827	8·93	1·88	0·826	473·0	481·4	489·9	498·4	506·8	515·2	523·7
	75	72·5	0·787	8·50	2·31	0·786	473·2	481·6	490·1	498·6	507·0	515·4	523·9
	74	71·0	0·751	8·11	2·17	0·750	473·4	481·8	490·3	498·8	507·2	515·6	524·1
	73	69·5	0·715	7·71	3·10	0·713	473·6	482·1	490·6	499·1	507·5	515·9	524·4
	72	68·0	0·681	7·35	3·46	0·680	473·8	482·3	490·8	499·3	507·7	516·1	524·6
	71	66·5	0·648	6·99	3·82	0·647	474·0	482·5	491·0	499·5	507·9	516·3	524·8
	70	65·0	0·617	6·66	4·15	0·616	474·2	482·7	491·2	499·7	508·1	516·5	525·0
	69	63·5	0·588	6·33	4·48	0·586	474·4	482·9	491·4	499·9	508·3	516·7	525·2
	68	62·0	0·559	6·03	4·78	0·558	474·5	483·0	491·5	500·0	508·4	516·8	525·3
	67	60·5	0·532	5·74	5·07	0·531	474·7	483·2	491·7	500·2	508·6	517·0	525·5
	66	59·0	0·506	5·45	5·36	0·504	474·9	483·4	491·9	500·4	508·8	517·2	525·7
	65	57·5	0·481	5·18	5·63	0·479	475·0	483·5	492·0	500·5	508·9	517·3	525·8
	64	56·0	0·458	4·95	5·96	0·456	475·2	483·7	492·2	500·7	509·1	517·5	526·0
	63	54·5	0·435	4·69	6·12	0·434	475·3	483·8	492·3	500·8	509·2	517·6	526·1
	62	53·0	0·414	4·46	6 35	0·413	475·4	483·9	492·4	500·9	509·3	517 7	526·2
	61	51·5	0·393	4·23	6·58	0 391	475·5	484·0	492·5	501·0	509·4	517·8	526·3
	60	50·0	0.373	4·02	6·79	0·372	475·6	484·1	492·6	501·1	509·5	517·9	526·4
	59	48·5	0·355	3·82	6·99	0·353	475·7	484·2	492·7	501·2	509·6	518·0	526·5
	58	47·0	0·337	3·63	7·18	0·336	475·9	484·4	492·9	501·4	509·8	518·2	526·7
	57	45·5	0·320	3·45	7·36	0·319	476·0	484·5	493·1	501·5	509·9	518·3	526·8
	56	44·0	0·304	3·27	7·54	0·302	476·1	484·6	493·2	501·6	510·0	518·4	526·9
	55	42·5	0·288	3·11	7·70	0·288	476·2	484·7	493 3	501·7	510·1	518·5	527·0
	54	41·0	0·274	2·96	7·85	0·274	476·3	464·8	493·4	501·8	510·2	518·6	527·1.
	53	39·5	0·260	2·82	7·99	0·261	476·3	464·8	493·4	501·8	510·2	518·6	527·1
81	81	81·0	1·034	11·14	0·00	1·000	471·0	479·4	487·8	496·2	504·6	513·0	521·4
	80	79·5	0·986	10 62	0·52	0·953	471·3	479·7	488·1	496·5	504·9	513·3	521·7
	79	78·0	0·940	10·30	1·01	0·910	471·5	489·9	488.4	496·8	505·2	513·6	522·1
	78	76·5	0 896	9·65	1·49	0·866	471·7	480·1	488.6	497·0	505·4	513·8	522·3
	77	75·0	0·854	9·20	1·94	0·825	472·0	480·4	488.9	497·3	505·7	514·1	522·6
	76	73·5	0·814	8·77	2·37	0·787	472·2	480·6	489.1	497·5	505·9	514·3	522·8
	75	72·0	0·776	8·35	2·79	0·750	472·5	480·9	489.4	497·8	506·2	514·6	523·1
	74	70·5	0·739	7·95	3·19	0·713	472·6	481·0	489.5	497·9	506·4	514·8	523·3
	73	69·0	0 704	7·57	3·57	0·680	472·8	481·2	489.7	499·1	506·6	515·0	523·5
	72	67·5	0·670	7·21	3·93	0·647	473·0	481·4	489.9	498·3	506·8	515·2	523·7
	71	66·0	0·638	6·87	4·27	0·617	473·2	481·6	490·1	498·5	507·0	515·4	523·9
	70	64·5	0·607	6·54	4·60	0·587	473·4	481·8	490·3	498·7	507·2	515·6	524·1
	69	63·0	0·578	6·22	4·92	0·558	473·6	482·0	490·5	498·9	507·4	515·8	524·3
	68	61·5	0·550	5·92	5·22	0·531	473·7	482·2	490·7	499·1	507·6	516·0	524·5
	67	60·0	0·523	5·62	5·52	0·505	473·8	482·3	490·8	499·2	507·7	516·1	524·6
	66	58·5	0·496	5·31	5·83	0·477	474·0	482·5	491·0	499·4	507·9	516·3	524·8
	65	57·0	0·473	5·08	6·06	0·456	474·1	482·6	491·1	499·5	508·0	516·4	524·9
	64	55·5	0·450	4·84	6·30	0·434	474·3	482·8	491·3	499·7	508·2	516·6	525·1
	63	54·0	0·428	4·60	6·54	0·413	474·4	482·9	491·4	499·8	508·3	516·7	525·2
	62	52·5	0·407	4·37	6·77	0·392	474·5	483·0	491·5	499·9	508·4	516·8	525·3
	61	51·0	0·386	4·15	6·99	0·373	474·6	483·1	491·6	500·0	508·5	516·9	525·4
	60	49·5	0·367	3·95	7·19	0·355	474·7	483·2	491·7	500·1	508·6	517·0	525·5
	59	48·0	0·349	3·75	7·39	0·337	474·9	483·4	491·9	500·3	508·8	517·2	525·7
	58	46·5	0·331	3·56	7·58	0·320	475 0	483·5	492·0	500·4	508·9	517·3	525·8
	57	45·0	0·315	3·38	7·76	0·303	475·1	483·6	492·1	500·5	509·0	517·4	525·9
	56	43·5	0·299	3·21	7·93	0·289	475·2	463·7	492·2	500·6	509·1	517·5	526·0
	55	42·0	0·283	3·05	8·09	0·274	475·3	483·8	492·3	500·7	509·2	517·6	526·1
	54	40·5	0·269	2·90	8 24	0·260	475·3	483·8	492·3	500·7	509·2	517·6	526·1

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
			in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
82°	82°	82·0°	1·067	11·47	0·00	1·000	470·0	478·4	486·8	495·2	503·5	511·9	520·3
	81	80·5	1·017	10·94	0·53	0·954	470·3	478·7	487·0	495·4	503·8	512·2	520·6
	80	79·0	0·970	10·44	1·03	0·910	470·6	479·0	487·3	495·7	504·1	512·5	520·9
	79	77·5	0·925	9·95	1·52	0·868	470·7	479·1	487·5	495·9	504·3	512·7	521·1
	78	76·0	0·882	9·49	1·98	0·827	471·0	479·4	487·8	496·2	504·6	513·0	521·4
	77	74·5	0·840	9·03	2·44	0·787	471·2	479·6	488·0	496·4	504·8	513·2	521·6
	76	73·0	0·801	8·60	2·87	0·750	471·5	479·9	488·3	496·7	505·1	513·5	521·9
	75	71·5	0·763	8·19	3·28	0·714	471·6	480·0	488·5	496·9	505·3	513·7	522·1
	74	70·0	0·727	7·81	3·66	0·681	471·8	480·2	488·6	497·1	505·5	513·9	522·4
	73	68·5	0·692	7·43	4·04	0·648	472·0	480·4	488·8	497·3	505·7	514·1	522·6
	72	67·0	0·659	7·08	4·39	0·618	472·2	480·6	489·0	497·5	505·9	514·3	522·8
	71	65·5	0·628	6·75	4·72	0·588	472·4	480·8	489·2	497·7	506·1	514·5	523·0
	70	64·0	0·597	6·41	5·06	0·559	472·5	480·3	489·4	497·9	506·3	514·7	523·2
	69	62·5	0·568	6·10	5·37	0·532	472·6	481·0	489·5	498·0	506·4	514·8	523·3
	68	61·0	0·541	5·81	5·66	0·507	472·8	481·2	489·7	498·2	506·6	515·0	523·5
	67	59·5	0·515	5·52	5·95	0·481	473·0	481·4	489·9	498·4	506·8	515·2	523·7
	66	58·0	0·489	5·25	6·22	0·458	473·1	481·5	490·0	498·5	506·9	515·3	523·8
	65	56·5	0·465	4·99	6·48	0·435	473·2	481·6	490·1	498·6	507·0	515·4	523·9
	64	55·0	0·442	4·75	6·72	0·414	473·4	481·8	490·3	498·8	507·2	515·6	524·1
	63	53·5	0·421	4·51	6·96	0·393	473·5	482·0	490·5	499·0	507·4	515·8	524·3
	62	52·0	0·400	4·29	7·18	0·374	473·6	482·1	490·6	499·1	507·5	515·9	524·4
	61	50·5	0·380	4·08	7·39	0·356	473·7	482·2	490·7	499·2	507·6	516·0	524·4
	60	49·0	0·361	3·87	7·60	0·337	473·8	482·3	490·8	499·3	507·7	516·1	524·5
	59	47·5	0·343	3·68	7·79	0·320	473·9	482·4	490·9	499·4	507·8	516·2	524·6
	58	46·0	0·326	3·50	7·97	0·305	474·0	482·5	491·0	499·5	507·9	516·3	524·7
	57	44·5	0·309	3·32	8·15	0·289	474·1	482·6	491·1	499·6	508·0	516·4	524·8
	56	43·0	0·293	3·15	8·32	0·274	474·2	482·7	491·2	499·7	508·1	516·5	524·9
	55	41·5	0·279	2·99	8·48	0·260	474·3	482·8	491·3	499·8	508·2	516·6	525·1
83	83	83·0	1·101	11·82	0·00	1·000	468·8	477·2	485·5	493·9	502·3	510·6	519·0
	82	81·5	1·050	11·27	0·55	0·953	469·1	477·5	485·8	494·2	502·6	511·0	519·4
	81	80·0	1·001	10·75	1·07	0·909	469·4	477·8	486·1	494·5	502·9	511·3	519·7
	80	78·5	0·955	10·25	1·67	0·868	469·7	478·1	486·4	494·8	503·2	511·6	520·0
	79	77·0	0·910	9·78	2·04	0·828	470·0	478·4	486·7	495·1	503·5	511·9	520·3
	78	75·5	0·868	9·31	2·51	0·786	470·3	478·7	487·0	495·4	503·8	512·2	520·6
	77	74·0	0·827	8·88	2·94	0·751	470·5	478·9	487·2	495·6	504·0	512·4	520·8
	76	72·5	0·787	8·45	3·37	0·715	470·6	479·0	487·4	495·8	504·2	512·6	521·0
	75	71·0	0·751	8·05	3·77	0·681	470·8	479·2	487·6	496·0	504·4	512·8	521·2
	74	69·5	0·715	7·66	4·16	0·647	471·0	479·4	487·8	496·2	504·6	513·0	521·4
	73	68·0	0·681	7·30	4·52	0·618	471·2	479·6	488·0	496·4	504·8	513·2	521·6
	72	66·5	0·648	6·95	4·87	0·588	471·4	479·8	488·2	496·6	505·0	513·4	521·8
	71	65·0	0·617	6·62	5·20	0·560	471·6	480·0	488·4	496·8	505·2	513·6	522·0
	70	63·5	0·588	6·29	5·53	0·533	471·7	480·1	488·5	497·0	505·4	513·8	522·3
	69	62·0	0·559	5·99	5·83	0·507	471·9	480·3	488·7	497·2	505·6	514·0	522·5
	68	60·5	0·532	5·70	6·12	0·482	472·0	480·4	488·8	497·3	505·7	514·1	522·6
	67	59·0	0·506	5·42	6·40	0·459	472·2	480·6	489·0	497·5	505·9	514·3	522·8
	66	57·5	0·481	5·15	6·67	0·435	472·4	480·8	489·2	497·7	506·1	514·5	523·0
	65	56·0	0·458	4·90	6·92	0·414	472·4	480·8	489·3	497·8	506·2	514·6	523·1
	64	54·5	0·435	4·66	7·16	0·394	472·5	480·9	489·4	497·9	506·3	514·7	523·2
	63	53·0	0·414	4·43	7·39	0·375	472·7	481·1	489·6	498·1	506·5	514·9	523·4
	62	51·5	0·393	4·21	7·61	0·356	472·8	481·2	489·7	498·2	506·6	515·0	523·5
	61	50·0	0·373	4·00	7·82	0·339	472·9	481·3	489·8	498·3	506·7	515·1	523·6
	60	48·5	0·355	3·80	8·02	0·322	473·1	481·4	489·9	498·4	506·8	515·2	523·7
	59	47·0	0·337	3·60	8·22	0·305	473·2	481·5	490·0	498·5	506·9	515·3	523·8
	58	45·5	0·320	3·42	8·40	0·289	473·3	481·6	490·1	498·6	507·0	515·4	523·9
	57	44·0	0·304	3·25	8·57	0·276	473·4	481·7	490·2	498·7	507·1	515·5	524·0
	56	42·5	0·288	3·09	8·73	0·261	473·5	481·8	490·3	498·8	507·2	515·6	524·1

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
84	84	84·0	1·136	12·17	0·00	1·000	467·8	476·2	484·5	492·7	501·2	509·6	517·9
	83	82·5	1·083	11·61	0·56	0·954	468·1	476·4	484·8	493·2	501·5	509·8	518·2
	82	81·0	1·034	11·07	1·10	0·910	468·4	476·7	485·1	493·5	501·8	510·1	518·5
	81	79·5	0·986	10·55	1·62	0·867	468·6	476·9	485·4	493·7	502·1	510·5	518·8
	80	78·0	0·940	10·07	2·10	0·827	468·9	477·3	485·7	494·0	502·4	510·8	519·1
	79	76·5	0·896	9·59	2·58	0·788	469·1	477·5	485·9	494·2	502·6	511·0	519·3
	78	75·0	0·854	9·14	3·03	0·751	469·4	477·8	486·1	494·5	502·9	511·3	519·7
	77	73·5	0·814	8·71	3·46	0·716	469·6	478·0	486·3	494·7	503·1	511·5	519·9
	76	72·0	0·776	8·30	3·87	0·682	469·8	478·2	486·5	494·9	503·3	511·7	520·1
	75	70·5	0·739	7·90	4·27	0·649	470·1	478·5	486·8	495·2	503·6	512·0	520·4
	74	69·0	0·704	7·53	4·64	0·619	470·3	478·7	487·0	495·4	503·8	512·2	520·6
	73	67·5	0·670	7·17	5·00	0·589	470·5	478·9	487·2	495·6	504·0	512·4	520·8
	72	66·0	0·638	6·83	5·34	0·561	470·6	479·0	487·4	495·8	504·2	512·6	521·0
	71	64·5	0·607	6·50	5·67	0·534	470·7	479·1	487·5	495·9	504·3	512·7	521·1
	70	63·0	0·578	6·18	5·99	0·508	470·9	479·3	487·7	496·1	504·5	512·9	521·3
	69	61·5	0·550	5·87	6·30	0·482	471·1	479·5	487·9	496·3	504·7	513·1	521·5
	68	60·0	0·523	5·59	6·58	0·459	471·2	479·6	488·0	496·4	504·8	513·2	521·6
	67	58·5	0·498	5·31	6·86	0·436	471·4	479·8	488·2	496·6	505·0	513·4	521·8
	66	57·0	0·473	5.05	7·12	0·415	471·6	480·0	488·3	496·7	505·2	513·6	522·1
	65	55·5	0·450	4·81	7·36	0·395	471·6	480·0	488·4	496·8	505·3	513·7	522·2
	64	54·0	0·428	4·57	7·60	0·375	471·7	480·1	488·5	496·9	505·4	513·8	522·3
	63	52·5	0·407	4·35	7·82	0·357	471·8	480·2	488·6	497·0	505·5	513·9	522·4
	62	51·0	0·386	4·13	8·04	0·339	471·9	480·4	488·8	497·2	505·7	514·0	522·5
	61	49·5	0·367	3·93	8·24	0·323	472·1	480·5	488·9	497·3	505·8	514·1	522·6
	60	48·0	0·349	3·73	8·44	0·306	472·2	480·6	489·0	497·4	505·9	514·2	522·7
	59	46·5	0·331	3·55	8·62	0·292	472·3	480·7	489·1	497·5	506·0	514·3	522·8
	58	45·0	0·315	3·37	8·80	0 277	472·4	480·8	489·2	497·6	506·1	514·4	522·9
	57	43·5	0·299	3·20	8·97	0·263	472·5	480·9	489·3	497·7	506·2	514·5	523·0
85	85	85·0	1·171	12·53	0·00	1·000	466·8	475·2	483·5	491·8	500·1	508·5	516·8
	84	83·5	1·118	11·95	0·58	0·954	467·1	475·4	483·7	492·1	500·4	508·7	517·1
	83	82·0	1·067	11·40	1·13	0·910	467·3	475·6	484·0	492·4	500·7	509·0	517·4
	82	80·5	1·017	10·87	1·66	0·868	467·6	475·9	484·3	492·7	501·0	509·3	517·7
	81	79·0	0·970	10·38	2·15	0·829	467·8	476·1	484·5	492·9	501·2	509·5	517·9
	80	77·5	0·925	9·89	2·64	0·789	468·1	476·4	484·8	493·2	501·5	509·8	518·2
	79	76·0	0·882	9·43	3·10	0·753	468·4	476·7	485·1	493·5	501·8	510·1	518·5
	78	74·5	0·840	8·98	3·55	0·717	468·6	476·9	485·3	493·7	502·0	510·3	518·7
	77	73·0	0·801	8·55	3·98	0·682	468·7	477·1	485·5	493·9	502·2	510 5	518·9
	76	71·5	0·763	8·15	4·38	0·650	469·0	477·4	485·8	494·2	502·5	510·8	519·2
	75	70·0	0·727	7·76	4·77	0·619	469·2	477·6	486·0	494·4	502·7	511·0	519·4
	74	68·5	0·692	7·39	5·14	0·589	469·4	477·8	486·2	494·6	502·9	511·2	519·6
	73	67·0	0·659	7·04	5·49	0·562	469·7	478·1	486·5	494·9	503·2	511·5	519·9
	72	65·5	0·628	6·71	5·82	0·536	469·9	478·3	486·7	495·1	503·4	511·7	520·1
	71	64·0	0·597	6·37	6·16	0·508	470·1	478·5	486·9	495·3	503·6	511·9	520·3
	70	62·5	0·568	6·07	6·46	0·484	470·3	478·7	487·1	495·5	503·8	512·1	520·5
	69	61·0	0·541	5·77	6·76	0·460	470·5	478·9	487·2	495·6	504·0	512·4	320·8
	68	59·5	0·515	5·48	7·05	0·437	470·6	479·0	487·3	495·7	504·1	512·5	520·9
	67	58·0	0·489	5·21	7·32	0·415	470·6	479·0	487·4	495·8	504·2	512·6	521·0
	66	56·5	0·465	4·96	7·57	0·396	470·7	479·1	487·5	495·9	504·3	512·7	521·1
	65	55·0	0·442	4·72	7·81	0·377	470·8	479·2	487·6	496·0	504·4	512·8	521·2
	64	53·5	0·421	4·49	8·04	0·359	470·9	479·3	487·7	496·1	504·5	512·9	521·3
	63	52·0	0·400	4·26	8·27	0·340	471·1	479·5	487·9	496·3	504·7	513·1	521·5
	62	50·5	0·380	4·05	8·48	0·323	471·2	479·6	488·1	496·4	504·8	513·2	521·6
	61	49·0	0·361	3·85	8·68	0·307	471·3	479·7	488·2	496·5	504·9	513·3	521·7
	60	47·5	0·343	3·66	8·87	0·292	471·4	479·8	488·3	496·6	505·0	513·4	521·8
	59	46·0	0·326	3·48	9·05	0·278	471·5	479·9	488·4	496·7	505·1	513·5	521·9
	58	44·5	0·309	3·31	9·22	0·264	471·6	480·1	488·5	496·8	505·2	513·6	522·1

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn.=1·000.)	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
86	86	86·0	1·209	12·91	0·00	1·000	465·7	474·0	482·3	490·6	498·9	507·2	515·5
	85	84·5	1·153	12·31	0·60	0·954	466·0	474·3	482·6	490·9	499·2	507·5	515·8
	84	83·0	1·101	11·75	1·16	0·910	466·3	474·6	482·9	491·2	499·5	507·8	516·1
	83	81·5	1·050	11·20	1·71	0·868	466·5	474·8	483·2	491·5	499·8	508·1	516·5
	82	80·0	1·001	10·69	2·22	0·828	466·8	475·1	483·5	491·8	500·1	508·4	516·8
	81	78·5	0·955	10·19	2·72	0·789	467·1	475·4	483·8	492·1	500·4	508·7	517·1
	80	77·0	0·910	9·71	3·20	0·752	467·3	475·6	484·0	492·3	500·7	509·0	517·4
	79	75·5	0·868	9·25	3·66	0·717	467·5	475·8	484·2	492·5	500·9	509·2	517·6
	78	74·0	0·827	8·82	4·09	0·683	467·8	476·1	484·5	492·8	501·2	509·5	517·9
	77	72·5	0·787	8·40	4·51	0·651	468·0	476·3	484·7	493·0	501·4	509·7	518·1
	76	71·0	0·751	8·00	4·91	0·619	468·2	476·5	484·9	493·2	501·6	509·9	518·3
	75	69·5	0·715	7·62	5·29	0·590	468·3	476·6	485·0	493·4	501·8	510·2	518·6
	74	68·0	0·681	7·26	5·65	0·562	468·5	476·8	485·2	493·6	502·0	510·4	518·8
	73	66·5	0·648	6·91	6·00	0·535	468·8	477·1	485·5	493·9	502·2	510·6	519·0
	72	65·0	0·617	6·58	6·33	0·509	468·9	477·2	485·6	494·0	502·4	510·8	519·2
	71	63·5	0·588	6·26	6·65	0·485	469·1	477·4	485·8	494·2	502·6	511·0	519·4
	70	62·0	0·559	5·95	6·96	0·461	469·2	477·5	485·9	494·3	502·7	511·1	519·5
	69	60·5	0·532	5·66	7·25	0·438	469·4	477·7	486·1	494·5	502·9	511·3	519·7
	68	59·0	0·506	5·38	7·53	0·417	469·6	477·9	486·3	494·7	503·1	511·5	519·9
	67	57·5	0·481	5·11	7·80	0·396	469·8	478·1	486·5	494·9	503·3	511·7	520·1
	66	56·0	0·458	4·87	8·04	0·377	469·9	478·2	486·6	495·0	503·4	511·8	520·2
	65	54·5	0·435	4·63	8·28	0·359	470·0	478·3	486·7	495·1	503·5	511·9	520·3
	64	53·0	0·414	4·40	8·51	0·341	470·1	478·4	486·8	495·1	503·6	512·0	520·4
	63	51·5	0·393	4·19	8·72	0·325	470·2	478·5	486·9	495·2	503·7	512·1	520·5
	62	50·0	0·373	3·98	8·93	0·308	470·4	478·7	487·1	495·4	503·9	512·2	520·7
	61	48·5	0·355	3·78	9·13	0·293	470·5	478·8	487·2	495·5	504·0	512·3	520·8
	60	47·0	0·337	3·59	9·32	0·278	470·6	478·9	487·3	495·6	504·1	512·4	520·9
	59	45·5	0·320	3·40	9·51	0·263	470·7	479·0	487·4	495·7	504·2	512·5	521·0
87	87	87·0	1·247	13·29	0·00	1·000	464·5	472·8	481·1	489·4	497·7	506·0	514·3
	86	85·5	1·119	12·68	0·61	0·954	464·8	473·1	481·4	489·7	498·0	506·3	514·6
	85	84·0	1·136	12·10	1·19	0·910	465·1	473·4	481·7	490·0	498·3	506·6	514·9
	84	82·5	1·083	11·54	1·75	0·868	465·4	473·7	482·0	490·3	498·6	506·9	515·2
	83	81·0	1·034	11·01	2·28	0·828	465·7	474·0	482·3	490·6	498·9	507·2	515·5
	82	79·5	0·986	10·49	2·80	0·789	466·0	474·3	482·6	490·9	499·2	507·5	515·8
	81	78·0	0·940	10·01	3·28	0·753	466·3	474·6	482·9	491·2	499·5	507·8	516·1
	80	76·5	0·896	9·54	3·75	0·718	466·5	474·8	483·1	491·4	499·8	508·1	516·5
	79	75·0	0·854	9·09	4·20	0·684	466·8	475·1	483·5	491·8	500·1	508·4	516·8
	78	73·5	0·814	8·66	4·63	0·652	467·0	475·3	483·7	492·0	500·3	508·6	517·0
	77	72·0	0·776	8·24	5·05	0·620	467·2	475·5	483·9	492·2	500·5	508·8	517·2
	76	70·5	0·739	7·85	5·44	0·591	467·3	475·6	484·0	492·3	500·7	509·0	517·4
	75	69·0	0·704	7·48	5·81	0·563	467·5	475·8	484·2	492·5	500·9	509·2	517·6
	74	67·5	0·670	7·12	6·17	0·536	467·7	476·0	484·4	492·7	501·1	509·4	517·8
	73	66·0	0·638	6·78	6·51	0·510	467·9	476·2	484·6	492·9	501·3	509·6	518·0
	72	64·5	0·607	6·46	6·83	0·486	468·1	476·4	484·8	493·1	501·5	509·8	518·2
	71	63·0	0·578	6·14	6·15	0·462	468·3	476·6	485·0	493·3	501·7	510·1	518·5
	70	61·5	0·550	5·85	7·44	0·440	468·4	476·7	485·1	493·5	501·9	510·3	518·7
	69	60·0	0·523	5·56	7·73	0·418	468·5	476·9	485·3	493·7	502·0	510·4	518·8
	68	58·5	0·498	5·28	8·01	0·397	468·7	477·1	485·5	493·9	502·2	510·6	519·0
	67	57·0	0·473	5·02	8·27	0·378	468·8	477·2	485·6	494·0	502·3	510·7	519·1
	66	55·5	0·450	4·77	8·52	0·359	468·9	477·3	485·7	494·1	502·4	510·7	519·2
	65	54·0	0·428	4·54	8·75	0·342	469·1	477·5	485·9	494·3	502·6	510·9	519·4
	64	52·5	0·407	4·33	8·96	0·326	469·2	477·6	486·1	494·4	502·7	511·0	519·5
	63	51·0	0·386	4·12	9·17	0·310	469·3	477·7	486·2	494·5	502·8	511·1	519·6
	62	49·5	0·367	3·91	9·38	0·294	469·4	477·8	486·3	494·6	502·9	511·2	519·7
	61	48·0	0·349	3·71	9·58	0·279	469·6	477·9	486·5	494·8	503·1	511·4	519·9
	60	46·5	0·331	3·51	9·78	0·264	469·7	478·1	486·6	494·9	503·2	511·5	520·0

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. =1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in 28·5	in. 29·0	in. 29·5	in. 30·0	in 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
88	88	88·0	1·286	13·68	0·00	1·000	463·5	471·7	480·0	488·3	496·6	504·8	513·1
	87	86·5	1·228	13·06	0·62	0·954	463·8	472·0	480·3	488·6	496·9	505·1	513·4
	86	85·0	1·171	12·46	1·22	0·911	464·2	472·4	480·7	489·0	497·3	505·6	513·9
	85	83·5	1·118	11·88	1·80	0·868	464·4	472·7	481·0	489·3	497·6	505·9	514·2
	84	82·0	1·067	11·34	2·34	0·829	464·7	473·0	481·3	489·6	497·9	506·2	514·5
	83	80·5	1·017	10·81	2·87	0·790	465·0	473·3	481·6	489·9	498·2	506·5	514·8
	82	79·0	0·970	10·31	3·37	0·754	465·2	473·5	481·8	490·1	498·4	506·7	515·0
	81	77·5	0·925	9·83	3·85	0·718	465·5	473·8	482·1	490·4	498·7	507·0	515·3
	80	76·0	0·882	9·37	4·31	0·685	465·8	474·1	482·4	490·7	499·0	507·3	515·6
	79	74·5	0·840	8·93	4·75	0·653	466·1	474·4	482·7	491·0	499·3	507·6	515·9
	78	73·0	0·801	8·50	5·18	0·621	466·3	474·6	482·9	491·2	499·5	507·8	516·2
	77	71·5	0·763	8·09	5·59	0·591	466·4	474·7	483·[illegible]	491·3	499·7	508·0	516·4
	76	70·0	0·727	7·71	5·97	0·563	466·6	474·9	483·2	491·5	499·9	508·2	516·6
	75	68·5	0·692	7·34	6·34	0·537	466·8	475·1	483·4	491·7	500·1	508·4	516·8
	74	67·0	0·659	6·99	6·69	0·511	467·0	475·3	483·6	491·9	500·3	508·6	517·0
	73	65·5	0·628	6·66	7·02	0·487	467·2	475·5	483·8	492·1	500·5	508·8	517·2
	72	64·0	0·597	6·33	7·35	0·463	467·4	475·7	484·0	492·3	500·7	509·0	517·4
	71	62·5	0·568	6·03	7·65	0·441	467·4	475·7	484·0	492·4	500·8	509·1	517·5
	70	61·0	0·541	5·74	7·94	0·420	467·6	475·9	484·2	492·6	501·0	509·3	517·7
	69	59·5	0·515	5·45	8·23	0·398	467·7	476·0	484·3	492·7	501·2	509·4	517·8
	68	58·0	0.489	5·18	8·50	0·378	467·9	476·2	484·5	492·9	501·3	509·6	518·0
	67	56·5	0·465	4·93	8·75	0·359	468·1	476·4	484·7	493·1	501·5	509·8	518·2
	66	55·0	0·442	4·69	8·99	0·342	468·2	476·5	484·8	493·2	501·6	509·9	518·3
	65	53·5	0·421	4·47	9·21	0·326	468·3	476·6	484·9	493·3	501·7	510·0	518·4
	64	52·0	0·400	4·25	9·43	0·310	468·4	476·7	485·1	493·4	501·8	510·1	518·5
	63	50·5	0·380	4·04	9·64	0·295	468·6	476·9	485·3	493·6	502·0	510·3	518·7
	62	49·0	0·361	3·83	9·85	0·280	468·7	477·1	485·4	493·7	502·1	510·4	518·8
	61	47·5	0·343	3·62	10·06	0·265	468·8	477·2	485·5	493·8	502·2	510·5	518·9
89	89	89·0	1·326	14·08	0·00	1·000	462·4	470·6	478·9	487.1	495·4	503·6	511·9
	88	87·5	1·266	13·44	0·64	0·951	462·7	470·9	479·2	487.4	495·7	503·9	512·2
	87	86·0	1·209	12·84	1·24	0·912	463·0	471·2	479·5	487.8	496·1	504·4	512·7
	86	84·5	1·153	12·24	1·84	0·869	463·3	471·5	479·8	488.1	496·4	504·7	513·0
	85	83·0	1·101	11·68	2·40	0·830	463·6	471·8	480·1	488.4	496·7	505·0	513·3
	84	81·5	1·050	11·13	2·95	0·791	464·0	472·2	480·5	488.8	497·1	505·4	513·7
	83	80·0	1·001	10·62	3·46	0·754	464·2	472·5	480·8	489.1	497·4	505·7	514·0
	82	78·5	0·955	10·13	3·95	0·719	464·4	472·7	481·0	489.3	497·6	505·9	514·2
	81	77·0	0·910	9·66	4·42	0·686	464·7	473·0	481·3	489.6	497·9	506·2	514·5
	80	75·5	0·868	9·20	4·88	0·653	464·9	473·2	481·5	489.8	498·1	506·4	514·7
	79	74·0	0·827	8·77	5·31	0·623	465·2	473·5	481·8	490.1	498·4	506·7	515·0
	78	72·5	0·787	8·35	5·73	0·593	465·4	473·7	482·0	490.3	498·6	506·9	515·2
	77	71·0	0·751	7·96	6·12	0·565	465·6	473·9	482·2	490.5	498·8	507·1	515·4
	76	69·5	0·715	7·57	6·51	0·537	465·8	474·1	482·4	490.7	499·0	507·3	515·7
	75	68·0	0·681	7·21	6·87	0·512	466·0	474·3	482·6	490.9	499·2	507·5	515·8
	74	66·5	0·648	6·87	7·21	0·488	466·2	474·5	482·8	491.1	499·4	507·7	516·0
	73	65·0	0·617	6·54	7·54	0·465	466·3	474·6	482·9	491.2	499·6	507·9	516·3
	72	63·5	0·588	6·22	7·86	0·442	466·5	474·8	483·1	491.4	499·8	508.1	516·5
	71	62·0	0·559	5·91	8·17	0·420	466·7	475·0	483·3	491.7	500·0	508·3	516·7
	70	60·5	0·532	5·62	8·46	0·399	466·8	475·1	483·4	491.8	500·1	508·4	516·8
	69	59·0	0·506	5·35	8·73	0·380	467·0	475·3	483·6	492.0	500·3	508·6	517·0
	68	57·5	0·481	5·08	9·00	0·361	467·1	475·4	483·7	492.1	500·4	508·7	517·1
	67	56·0	0·458	4·84	9·24	0·343	467·2	475·5	483·8	492.2	500·5	508·8	517·2
	66	54·5	0·435	4·61	9·47	0·327	467·4	475·7	483·9	492.4	500·7	509·1	517·4
	65	53·0	0·414	4·39	9·69	0·312	467·5	475·8	484·1	492.5	500·8	509·2	517·5
	64	51·5	0·393	4·17	9·91	0·296	467·6	475·9	484·2	492.6	500·9	509·3	517·6
	63	50·0	0·373	3·96	10·12	0·281	467·7	476·1	484·3	492.7	501·0	509·4	517·7
	62	48·5	0·355	3·76	10·32	0·267	467·8	476·2	484·4	492.8	501·1	509·5	517·8

Reading of Thermometer. Dry.	Reading of Thermometer. Wet.	Temperature of the Dew-Point.	Elastic Force of Vapour in inches of Mercury.	Wgt. of Vpr. In a Cubic Foot of Air.	Wgt. of Vpr. Reqd. for Satn. of a Cubic Foot of Air.	Degree of Humidity (complete Satn. = 1·000).	Weight in Grains of a Cubic Foot of Air. Height of the Barometer. in. 28·0	in. 28·5	in. 29·0	in. 29·5	in. 30·0	in. 30·5	in. 31·0
°	°	°	in.	gr.	gr.		gr.	gr.	gr.	gr.	gr.	gr.	gr.
90	90	90·0	1·368	14·50	0·00	1·000	461·3	469·5	477·8	486·0	494·3	502·5	510·8
	89	88·5	1·306	13·84	0·66	0·954	461·6	469·8	478·1	486·3	494·6	502·8	511·1
	88	87·0	1·247	13·22	1·28	0·910	462·0	470·2	478·5	486·7	495·0	503·2	511·5
	87	85·5	1·190	12·61	1·89	0·870	462·3	470·5	478·8	487·0	495·3	503·5	511·8
	86	84·0	1·136	12·03	2·47	0·830	462·7	470·9	479·2	487·4	495·7	503·9	512·1
	85	82·5	1·083	11·47	3·03	0·791	463·0	471·2	479·5	487·7	496·0	504·2	512·5
	84	81·0	1·034	10·94	3·56	0·755	463·2	471·5	479·8	488·0	496·3	504·5	512·8
	83	79·5	0·986	10·43	4·07	0·719	463·4	471·7	480·0	488·2	496·5	504·7	513·0
	82	78·0	0·940	9·95	4·55	0·686	463·7	472·0	480·3	488·5	496·8	505·0	513·3
	81	76·5	0·896	9·48	5·02	0·653	464·0	472·3	480·6	488·8	497·1	505·3	513·6
	80	75·0	0·854	9·03	5·47	0·622	464·2	472·5	480·7	488·9	497·3	505·5	513·9
	79	73·5	0·814	8·61	5·89	0·594	464·3	472·6	480·9	489·1	497·5	505·7	514·1
	78	72·0	0·776	8·20	6·30	0·565	464·5	472·8	481·1	489·3	497·7	505·9	514·3
	77	70·5	0·739	7·80	6·70	0·538	464·7	473·0	481·3	489·5	497·9	506·1	514·5
	76	69·0	0·704	7·43	7·07	0·512	465·0	473·3	481·6	489·8	498·2	506·4	514·8
	75	67·5	0·670	7·08	7·42	0·488	465·2	473·5	481·8	490·0	498·4	506·6	515·0
	74	66·0	0·638	6·74	7·76	0·465	465·4	473·7	482·0	490·2	498·6	506·8	515·2
	73	64·5	0·607	6·42	8·08	0·443	465·6	473·9	482·2	490·4	498·8	507·0	515·4
	72	63·0	0·578	6·10	8·40	0·421	465·7	474·0	482·3	490·5	498·9	507·1	515·5
	71	61·5	0·550	5·81	8·69	0·400	465·9	474·2	482·5	490·7	499·1	507·3	515·7
	70	60·0	0.523	5·52	8·98	0·381	466·1	474·4	482·8	491·0	499·3	507·5	515·9
	69	58·5	0·498	5·25	9·25	0·362	466·2	474·5	482·9	491·1	499·4	507·6	516·0
	68	57·0	0·473	4·99	9·51	0·344	466·4	474·7	483·1	491·3	499·6	507·8	516·2
	67	55·5	0·450	4·74	9·76	0·327	466·5	474·8	483·2	491·4	499·7	507·9	516·3
	66	54·0	0·428	4·52	9·98	0·312	466·6	474·9	483·3	491·5	499·8	508·0	516·4
	65	52·5	0·407	4·30	10·20	0·297	466·7	475·0	483·4	491·6	499·9	508·1	516·5
	64	51·0	0·386	4·09	10·41	0·282	466·9	475·2	483·6	491·8	500·1	508·3	516·6
	63	49·5	0·367	3·90	10·60	0·269	467·0	475·3	483·7	491·9	500·2	508·4	516·7

LIST OF HEIGHTS, &c., OF VARIOUS PLACES UNDER THE BOMBAY PRESIDENCY.

Places.	Feet above Mean Level of the Sea.	Remarks.
Aghunba	3763.0	Hill 14 miles S W of Poona.
Asseerghur	1154·0	Tree in fort, 10 miles W of Yewur in N. Konkan.
Alsunda	2177·7	Hill 2 miles N E of Khorti.
Aukai	3232·6	High peak in the Dang Country.
Arh Tree	3615·3	Tree in fort, 9 miles S W of Sinnur.
Arnalla	62·1	Station in fort in the island, 10 miles N W of Bassein
Asseeree	1713·0	Fort 18 miles N E of Mahim.
Awnda	4338·6	Old fort 12 miles S E of Sinnur.
Awpa	3789·6	Near the village of Awpa, on the Ghauts.
Aboo, Mount	3850·0	Fifty miles N E of Deesa.
Ahmednuggur	1900·0	Mean range of thermometer 77°
Baleshwur	3827·1	Hill Pagoda, 10 miles, of Sungumnair.
Baphloon	2213·6	Top of hill, 12 miles W of Soolgana.
Barur	1761·4	Station on hill, 10 miles N E of Dhanoo.
Bassein Church	508·6	Top of Church at Bassein.
Beder	2350·0	Top of Beder Minaret point (Base 2250·0 feet.)
Beema Shunkar	3447·8	High Hill on the Ghauts 15 miles W S W of Ambagaum.
Bhatras	3635·0	Hill station 3 miles S E of Karleh, and 2 miles E of Esapoor hill fort.
Bholeshwar	2781·0	Hill Pagoda, 13 miles W N W of Soopeh.
Bhow Mullung	2649·6	Hill 10 miles N E of Panwell.
Bhowurghur	3560·9	Hill fort, 9 miles N W of Nassick.
Bori	2014·1	Hill 8 miles S W of Pangaon, on the Bheema River.
Chowrung Tree	2607·1	Tree on Hill, 5 miles N E of Pent.
Chanderi Peak	2368·6	Peak, 8 miles N of Parbbul hill fort in the Konkan.
Ditto Highest Peak	2601·3	Ditto ditto ditto.
Dharur	2356·8	Station on the Ghauts, 6 miles N E of Toljapoor.
Dholeshwar	2949·6	Station hill Pagoda, 12 miles N E of Saswar.
Dhorub	4745·3	Hill fort, 17 miles W of Chandore.
Dighi	2489·0	Hill 7 miles N from Poona near the village of Dighi.
Dhongurgaum	2079·5	Western extremity of the Karleh Base at Dhongurgaum.
Doorheswar	2730·1	Station on hill Pagoda, 14 miles E of Sungumnair.
Gumbeerghur	2270·8	Station on hill fort in the Northern Konkan.
Ghoutunil	2234·7	Tree on hill, 12 miles E of Dhurumpoor, N Konkan.
Hurrichunder	4680·0	Pile of Stones on Hurrichundergurh, Hill Fort.
Hursh	3658·8	Station on ruined Hill Fort, 4 miles N W of Kaumbala, 3 miles W of Trimbuk.
Ikhara	4481·5	Hill fort, 10 miles N W of Chandwar.
Jeenkhor	2064·9	Ditto 2 ditto N of Chowk.
Jewra	2881·1	Station on hill, 4 miles N W of Karleh.
Kalas	2018·5	Station on small hill, 16 miles W of Indapoor.
Kuldrug	1552·6	Old small fort in N Konkan, 7 miles N E of Mahim.
Kalsubai (Highest Peak in Deccan)	5409·5	Station near Pagoda, on hill 12 miles N W of Rajoor.
Kundeshwar	4103·9	Centre of Pagoda, 15 miles W of Kheir on Nassick road.
Kumandrug	2160·1	Station on hill, 10 miles E of Bassein.
Kapria	1531·3	Ditto 5 miles S E of Chowk.
Karunja	997·3	Highest part of the Southward hill.
Kamala	1552·1	Hill fort, 7 miles S of Panwell.
Katurwary	3003·3	Hill 16 miles S E of Vinchoor.
Kem	1962·8	Station on a small hill, 1½ miles from the town of Kem.
Kem, H. P	1956·0	On the hill, 2 miles W of the station.
Khumpecsurree	2765·3	Station on hill, 24 miles S of Ahmednuggur.
Koj	1505·8	Station on a ruined hill fort, 2 miles N W of Gorah in the Northern Konkan.
Koolung	4812·4	Station on hill fort.
Kolwa	973·1	Hill about 1 mile E of Kolwa village, and 3 miles E of Tanna.
Kankeshwur	937·6	Tree near Pagoda on hill near Poener.
Light-house, Bombay	148·4	Top of Spire, Top of Dome 141 0.—Annual fall of rain 87 inches; mean range of thermometer 82°.
Mahaluximee	1540·0	Centre of a high conical peak called by Marrwers Valentina's Peak.

APPENDIX B.

LIST OF HEIGHTS, &c., OF VARIOUS PLACES UNDER THE BOMBAY PRESIDENCY.

PLACES.	Feet above Mean Level of the Sea.	REMARKS.
Mahableshwur	4712·0	Station on the highest point on the rock in the Resident's compound, E of Sir Sidney Beckwith's monument.—Annual fall of rain 289 inches; mean range of thermometer 66°.
Mahadew	3116·0	Hill Pagoda, 20 miles S of Baramutee.
Mandavie	4123·0	Hill 3 miles E of Tekona fort.
Manli	2791·0	Station on a ruined hill fort in the Northern Konkan.
Mera	1860·4	Station on hill, 5 miles S E of Penn.
Manjiree	3725·4	Station 3 miles W of Tong fort, near the edge of the Ghaut.
Nagphumny	2601·2	Hill 2 miles S W of Khandalah.
Nalowda	1365·5	Station on hill, 4 miles S E of Chowk.
Narayengur	2887·6	Narrayengurh Hill Pag., 4 miles E of Narayungaum.
Neckoorda	1910·4	Station on hill, 24 miles E of Purwura fort in the Konkan.
Nimbahdera	2310·7	Station 9 miles North of Ahmednuggur.
Observatory, Bombay	61·0	Top of Pillar under the Dome.—Annual fall of rain 70 inches; mean range of thermometer 82°.
Otoor	4095·8	Otoor station, 6 miles W of Trimbuck (fort.)
Pala	3486·4	Station on Peak on range of hills, 7 miles N of Karleh.
Pangole	2726·7	Hill 6 miles N E of Khundalla.
Parlehal	2320·2	Hill fort in the Konkan, 5 miles N of Chowk.
Parner	3260·5	Hill 17 miles S E of Behla.
Parnera	623·3	Station in fort, 12 miles N W of Damaun.
Pilwa	2033·5	
Purundhur	4571 0	Station in the upper fort.
Putta	4568·5	Station in old fort, 10 miles S W of Sinnur.
Poona	1850 0	Annual fall of rain 24 inches; mean range of ther. 76°.
Punchgunnee	4000·0	Eleven miles East of Mahableshwur.—Annual fall of rain 48 inches; mean range of thermometer 68°.
Rajmachie	2715·8	Peak 6 miles N N E of Khandalla.
Ramsej	3292·1	Top of hill, 7 miles N W of Nassick.
Rawra	3872·0	Station on high peak on the Ghauts, 10 miles S E of Soolgaum.
Roopgurh	1707·0	Hill fort in the Bheel Jungles, 17 miles S of Songurh.
Sawargaon	1927 9	Station on a small hill, 17 miles N of Sholapoor.
Salera	5232·3	Peak on hill Fort.
Shilatun	2070·8	Eastern extremity of the Karla Base, 2 miles N E of Karleh.
Singi	4260·2	Station on high Peak, 15 miles of Tulligaum.
Singurh	4322·0	Station inside the fort, 15 miles S W of Poonah.
Sinnur	2842·5	Hill Pagoda, 2 miles N of Sinnur, 18 miles S of Nassick.
Soudi Peak	2090·7	Peak 5 miles E of Purbhul, in Konkan.
St. Mary's Church, Poona	2035·0	Top of Spire.
St. Thomas's Church, Bombay	168·0	Ditto.—Annual fall of rain 87 inches; mean range of thermometer 82°.
Sulki	2363·0	Pagoda on hill, 12 miles S W of *Aklooj*.
Tarapur	43·5	Station on fort, on the coast, 4 miles S of Dhanoor.
Tanna Steeple	105·5	Top of Spire.
Tanna	1369·3	Station on hill, 3 miles East of Tanna.
Toorna	4619·0	Station on fort, 24 miles S W of Poonah.
Trimbuck	4254·7	Hill fort, 2 miles S of Trimbuck Town.
Tringulwarree	3241·4	Top of hill near Tulligaum, on the Thull Ghaut.
Tramlia	1000·6	Station on hill, between Trombay Mahol above Pair Peri.
Tukmuk	2616·3	Old hill fort, 7 miles S W of Gorah, in N Konkan.
Tulloja	......	Hill 3 miles W of the town of Tulloja.
Umbra	3695·8	Station near village of Nowlak Umbra, N of Tullegaon.
Urun Hill Pagoda	696·9	Pagoda 2 miles to the N W of Urun.
Vinchoor	2267·1	L. Pagoda at Vinchoor town, 29 miles East of Nassick.
Wanawree	1942·0	House.
Wandew	2775·0	Hill Pagoda 22 miles S of Ahmednuggur.
Wankulwar	2847·6	Station on hill, 5 miles W of Pabul, and 9 miles N E of Chakun.
Waphgaon	2874·6	Ditto 8 miles N of Pabul.
Wujrabhai	1900·6	Hill N of Wujrabhi, in the Northern Konkan.
Wurada	4654·7	Wurada, Station on Hill, 6 miles N of Jooneer.
Wurwund	2999·6	Station on hill near the town of Karrackwahal, in Northern Konkan.

GENERAL ALPHABETICAL LIST OF LATITUDES, LONGITUDES, AND HEIGHTS, OF VARIOUS PLACES UNDER THE BENGAL PRESIDENCY.

Extract from the Rangir Meridional Series Report.

Names of Places.	Lat.	Long.	Heights above Sea.	Names of Places.	Lat.	Long.	Heights above Sea.
	° ′ ″	° ′ ″	feet.		° ′ ″	° ′ ″	feet.
Ataria Station...	28 38 5·0	79 37 42·3	677·8	Husapura S. ...	26 21 40·3	79 21 30·3	562·8
Atsu S. ...	26 35 15·0	79 23 38·4	584·2	Jagesar S. ...	29 38 59·0	79 54 36·0	7720·9
Bagwara S. ...	28 58 53·2	79 21 55·9	734·7	Janjiri S. ...	28 10 48·0	79 26 43·3	606·3
Beheri S. ...	28 51 48·2	79 38 18·6	701·6	Kulsan S. ...	26 57 7·6	79 41 7·4	573·9
Bhoraj S. ...	24 50 28·2	79 5 31.6	1438 3	Kankra S. ...	30 2 51·8	79 26 13·8	10095·4
Birona S. ...	26 50 59·7	79 24 31·3	594·0	Kanwa S. ...	26 4 6·4	79 18 56·0	607·4
Birond S. ...	29 15 8·7	79 45 24·2	6971·2	Kasrak S. ...	28 3 18·8	79 42 12·2	632·5
Bisangarh S. ...	27 6 27·4	79 27 15·2	585·6	Mamdabad S....	27 18 21·0	79 28 6·9	603·3
Chandenpur S...	27 13 30·8	79 41 29·8	551·2	Manang S. ...	25 17 27·6	79 45 35·1	1227·0
Chandla S. ...	24 36 33·3	79 29 45·0	1874 9	Mao S. ...	27 30 0·9	79 42 50·9	551·7
Dalipur S. ...	24 26 57·4	79 11 45·8	1678·1	Nagonath S. ...	25 26 53·1	79 22 39 6	1065·2
Datiari S. ...	25 6 21·5	79 24 51·9	1230·9	Nipenia S. ...	26 13 28·8	79 37 52·2	542·1
Dhaka S. ...	27 44 54·9	79 43 25·8	564·9	Para or Phara S..	25 41 6·3	79 42 54·6	713.0
Fatiganj S. ...	28 27 24·3	79 21 5 9	628·0	Pothari S. ...	27 23 13·3	79 27 21·4	609·3
Gajnera S. ...	28 19 57·8	79 40 58·2	651 6	Saipur S. ...	27 54 55·4	79 27 5·6	566·7
Gandaspur S. ...	26 28 26·6	79 38 21·5	542·3	Saonchalia S. ...	29 30 17·1	79 21 35·0	8526·2
Gokalphara S....	25 45 35·6	79 19 46·1	772·2	Seontara S. ...	26 42 23·2	79 37 55·0	572·9
Gura S. ...	25 57 39·8	79 36 10·3	547·2	Sisgarh S. ...	28 43 33·4	79 21 16·8	691·7
Guri S. ...	27 39 57·4	79 28 43·2	564·8	Thanela S. ...	24 57 53·4	79 47 29·5	1178·9

Extract from the Pilibit Terai Series Report.

Dhalelnagar S...	28 4 12·7	80 41 9·1	628·1	Ramnagar S......	28 16 32·6	80 41 35·7	629·3
Donao S. ...	28 41 35·8	79 48 3·2	745·0	Ramuapur S.....	28 22 34·5	80 31 5·3	652·7
Kainkera S. ...	28 37 21·0	79 55 23·1	730·4	Semrao S. ...	28 22 44·8	80 4 19·7	691·7
Kalianpur S. ...	28 35 6·6	79 47 0·9	723·8	Shagarh S. ...	28 33 10·8	80 3 56·9	739 5
Karai S. ...	28 15 54·4	80 20 57·2	666·3	Sultanpur S. ...	28 25 3·9	80 21 11·3	690·6
Kokra S. ...	28 12 3·4	80 30 35·6	633·0	Udepur S. ...	28 28 31·9	80 13 14·4	701·9
Piperia S. ...	28 19 37·1	80 13 7·8	677·9	Umra S. ...	28 28 35·1	79 55 11·1	708.0

Extract from the Amua Meridional Series Report.

Asu ...	26 4 35·5	80 31 14·0	523·0	Lakanpura ...	24 2 50 7	80 49 51·3	1833·1
Bakseria ...	26 50 50·5	80 31 55·6	476·4	Marfa ...	25 7 1·8	80 44 28·4	1295·3
Baraoli ...	27 8 14·3	80 43 6·6	506·4	Mawa ...	26 15 59·0	80 33 47·7	494·0
Bulandpur ...	27 51 7·9	80 42 35·6	546·4	Meyhar ...	24 17 0·8	80 46 13·3	2039·3
Dagri ...	24 51 5·2	80 44 7·0	1644·5	Musapur ...	25 46 33·4	80 40 47·1	466·0
Dewarsan ...	26 15 51·1	80 20 41·4	492·7	Namana ...	26 28 8·6	80 38 49·0	500·7
Dharkana ...	24 28 1·1	80 35 38·0	1917·7	Nimkar ...	27 21 5·1	80 31 30·3	527·7
Durawal ...	27 33 32·7	80 31 15·6	543·8	Parser ...	27 46 13·6	80 32 22·7	549·3
Etora ...	26 54 15·4	80 42 5·2	469·1	Patra ...	24 16 47·2	81 11 14·6	2306·5
Fatehnagar ...	27 23 55·5	80 42 50·8	510·3	Pavya ...	25 27 16·5	80 46 39·1	533·0
Jafrabad ...	26 0 42·5	80 38 3·6	476·4	Peprendi ...	25 37 39·2	80 26 45·2	494·9
Jajmao ...	26 25 46·6	80 27 9·7	515·8	Potenda ...	24 37 23·1	80 59 34·0	1050·2
Jalhotr ...	26 41 35·6	80 40 30·6	485·6	Rao ...	26 38 40·4	80 29 37·2	494·4
Jehanabad ...	26 6 1·8	80 24 18·3	488·1	Sarang ...	24 45 42·1	80 23 46·4	1748·9
Jerura ...	27 59 52·2	80 30 37·9	579·1	Seonda ...	25 18 9·1	80 24 5·5	908·6
Kanakera ...	25 51 19·6	80 27 58·6	473·7	Serwaya ...	27 37 40·1	80 40 50·1	542·2
Kartar ...	25 1 29·5	80 22 38·0	1179·8				

Extract from the Karara Meridional Series Report.

Amoli T Station.	27 5 38·1	81 23 48·0	514·2	Donri H. S. ...	24 53 56·6	81 13 45·1	1480·3
Asrafpur T. S...	27 29 23·7	81 4 8·5	550·0	Horesa T. S. ...	26 55 21·8	81 17 16·8	470·7
Bagala H. S. ...	25 14 8·6	81 39 12·7	657·7	Imlia T. S. ..	27 19 16·0	81 10 3·6	547·7
Basantpur T. S..	26 43 25·5	81 24 56·0	480·5	Jaliadhar H. S...	24 22 25·2	81 26 42·5	2237·5
Burwa H. S. ...	24 33 14·3	81 31 16·5	1360·8	Janai T. S. ...	26 22 4·9	81 23 57·6	495·6
Dudar H. S. ...	24 36 14·0	81 14 45·9	1149·2	Kachar H. S. ...	24 56 43·6	81 5 18·0	1532·9

GENERAL ALPHABETICAL LIST OF LATITUDES, LONGITUDES, AND HEIGHTS OF VARIOUS PLACES UNDER THE BENGAL PRESIDENCY.

Extract from the Karara Meridional Series Report.—(Continued.)

Names of Places.	Lat.	Long.	Heights above Sea.	Names of Places.	Lat.	Long.	Heights above Sea.
	° ′ ″	° ′ ″	feet.		° ′ ″	° ′ ″	feet.
Karra T. S... ..	25 41 55·5	81 24 38·3	476·5	Perewa T. S... ...	26 38 1·8	81 14 37·5	494·2
Keimur H. S..	24 17 2·8	81 11 49·2	2320·2	Pesar T. S..... ..	26 48 45·5	81 14 46·3	491·9
Khanpur T. S..	27 38 57·3	81 11 49·9	543·1	Ragaopur T. S..	27 17 41·5	81 23 6·1	436·6
Khara T. S......	26 7 38·0	81 13 9·7	483·4	Salaon T. S.. ...	26 1 42·5	81 29 43·5	484·4
Kotar Keimari H. S....	24 43 19·9	81 2 51.7	1503·6	Samnadio T. S ...	27 10 4·6	81 14 1·1	525·8
				Singrour T. S..	25 35 2·6	81 41 10·0	448·9
Lalapur H. S.. ..	25 14 13·4	81 8 23·2	843·7	Sirmoul H. S... ..	24 53 6·8	87 26 7·3	1180·2
Majilgaon T. S..	25 45 13·8	81 13 17·1	470·6	Sora T. S.. .. .	26 17 17.0	81 14 49·6	485·4
Masi T. S...	27 38 22·0	81 25 35·1	528·7	Tangan T. S.. ..	26 2 51·2	81 19 9·4	485·5
Mhow H. S.......	25 0 43·8	81 18 11·7	1447·4	Taoli T. S.... ...	26 27 16·4	81 15 20.6	491·5
Munai T. S.. ...	26 10 49·5	81 23 6·3	474·0	Thana T. S.. ...	27 28 20·9	81 17 6·5	520·8
Nagdilpur T. S...	25 34 15·9	81 11 52·9	475·1	Tikiri T. S..... ...	26 32 40·5	81 25 0·9	492·6
Naru H. S..... ...	24 29 38·7	80 59 57·5	2034·5	Turkani T. S	26 54 46·4	81 25 20·1	507·1
Pabhosa H. S......	25 21 16·6	81 21 35·0	630·1	Utiamao T. S....	26 59 54·5	81 14 43·5	520·0
Pariaon T. S.. ..	25 50 4·0	81 24 42·8	458·3				

Extract from the South Parasnat Meridional Series Report.

Amjhori H. S....	21 51 26·7	86 21 47·7	3541·8	Kusumbani H. S	21 57 28·9	86 28 25·0	3285·4
Badampahar H. S	22 4 11·3	86 9 52·1	2706·2	Ledasal H. S.. ...	22 41 15·3	86 31 0·8	1701·7
Bagmuri H. S..	22 29 1·7	86 9 26·2	2003·1	Meghasini H. S..	21 37 56·6	86 23 29·6	3779·4
Bandari H. S....	22 50 32·9	86 34 7·3	1446·6	Murari H. S... ..	21 48 49·9	86 33 21·6	3106·7
Bari H. S	23 6 52·4	86 35 45·1	729·2	Nilgiri H. S... ...	21 28 25·4	86 48 32·7	1733·3
Bolpal H. S... ...	21 22 2·4	86 30 27·5	1604·9	Parasa H. S... ...	23 7 17·2	86 43 7·1	915·4
Dalma H S.. ..	22 53 24·9	86 15 43·7	3049·7	Satbakra H. S...	22 19 2·8	86 28 12·7	1979·5
Gurgaburu H. S	23 8 32·4	86 10 21·4	2220·4	Sideshar H. S...	22 36 38·0	86 45 57·0	1415·6
Kimira H. S... ...	21 39 35.7	86 41 10·4	530·0				

Extract from the Himalaya Longitudinal Series Report.

Banog H. S.. ...	30 28 29·9	78 3 23·5	7548·7	Ghungti H. S....	21 45 29·9	78 57 47·9	7918·3
Bagwara S......	28 58 53·2	79 21 55·9	813·2	Girjwala H. S....	29 32 55·1	78 44 34·3	2820·8
Chandipahar H.S.	29 55 23·4	78 13 37·4	2013·4	Mabagarh H. S..	29 52 33·3	78 29 52·3	5748·4
Daila H. S..... ...	29 26 26·0	79 1 53·9	2333·6	Ranigarh H. S...	30 3 58·0	78 45 2·9	7151·2
Dhoiwala H. S..	30 7 5·6	78 4 29·9	3064·3	Saonchalia H. S..	29 30 17·1	79 21 35·0	8591·9
Ghandial H. S...	30 13 18·6	78 27 54·9	7459·8				

Extract from the North Longitudinal or Connecting Series Report.

Asogapur S.. ..	27 53 23·7	80 58 50·0	566·9	Khanpur S......	27 38 57·5	81 11 50·3	541·1
Bela S	27 47 15·1	81 20 31·1	528·2	Kutia S	28 2 38·0	80 58 8·	581·7
Chelua S..........	27 55 40·9	81 17 14·4	545·0	Lakan S	27 48 50·7	81 9 9·8	554·7
Dalelnagar S....	28 4 12·7	80 41 9·1	618·3	Masi S	27 38 22·1	81 25 33·3	530·7
Daorara S..	27 59 50·8	81 7 54·5	571·2	Ramuapur No. 2.	28 22 34·3	80 31 5·0	653·7
Hilji S...........	28 8 24·4	80 50 11·0	610·4	Ramnagar S.. ...	28 16 32·6	80 41 35·6	623·0
Karai S....	28 15 54·4	80 20 57·2	666·3	Sultanpur S... ...	28 25 3·9	80 21 11·3	69 ·6
Kakra S	28 12 3·4	80 30 35·6	636·4	Sydara S	27 58 4·0	80 19 13·3	612·0

Extract from the Calcutta Longitudinal Series Report.

Akistepur Tower S.....	23 4 10·4	87 58 54·2	124·5	Calcutta Base line N. Tower ...	22 43 35·0	88 25 3·9	85·6
Aknapur T. S...	22 54 26·0	88 5 33·9	111·3	Calcutta Base line S. Tower ...	22 36 58·9	88 25 21·8	81·6
Amua H. S........	23 59 57·0	80 31 44·2	2176·2				
Balki T. S.. ..	23 28 1·2	87 39 23·3	242·2	Chamki H. S... ...	23 34 10·9	81 40 43·0	2308·7
Baragai H. S	23 32 5·6	85 29 38·2	3158·8	Chapri H. S... ...	24 18 47·6	82 16 12·6	1899·4
Beharinat H. S..	23 34 32·9	86 59 8·7	1469·1	Cheinpur H. S...	23 33 19·0	85 53 45·6	2096·7
Bola T. S...	22 49 31·2	88 13 58·0	101·	Chendwar H. S..	23 57 16·0	85 28 35·5	2827·8
Budhon H S.. ..	24 5 9·0	78 33 39·1	1940·4	Dilakas T. S... ..	22 43 7·2	88 4 17·7	100·1
Bulbul H. S... ...	23 37 46·5	84 28 40·5	3354·2	Durgapur H. S ..	23 49 43·9	86 49 2·0	1185·9
Calcutta Observatory. Park St	22 33 0·8	88 23 58·8	78·4	Ganjua T. S... ...	22 58 29·8	78 36 2·3	193·0

GENERAL ALPHABETICAL LIST OF LATITUDES, LONGITUDES, AND HEIGHTS, OF VARIOUS PLACES UNDER THE BENGAL PRESIDENCY.

Extract from the Calcutta Longitudinal Series Report.—(Continued.)

Names of Places.	Lat. °	′	″	Long. °	′	″	Heights above Sea. feet.
Gobra H. S......	23	37	6·5	83	31	26·0	3237·1
Gora H. S	24	4	57·2	83	16	39·9	1867·6
Gurwani H. S.....	24	1	26·9	82	19	55·0	2120·9
Haori H. S...... ..	24	12	20·8	82	46	15·6	1909·6
Himilia H. S.. .	23	44	59·6	79	23	21·0	1539·9
Hurilaong H. S..	24	2	7·9	84	24	16·9	1374·9
Kalumar H. S..	23	27	52·9	79	46	51·0	2544·4
Karara H. S ..	24	4	43·0	81	18	14·1	2018·5
Karasoli H. S....	23	14	18·1	87	27	37·3	325·2
Kasiatu H. S.. ..	23	58	31·8	84	56	45·9	2662·5
Kusmar H. S......	24	14	45·4	79	22	51·0	1892·3
Lakanpura H. S .	24	2	50 7	80	49	51·3	1833·1
Lora H. S...	23	29	42·1	80	12	24·5	1993·3
Lul H. S...... ..	23	44	54·0	82	32	58·3	3088·8
Madhpur T. S...	23	9	56 2	87	47	4·2	173·3
Maluncha H. S...	23	54	32·1	87	8	8·2	958·7
Mandra H. S	23	38	42·1	79	8	53·3	1723·8
Marchari H. S...	23	48	14 5	82	56	10·9	2336·3
Mahrwas H. S	24	5	0 4	81	49	2·0	1829 9
Mubarakpur T. S	22	50	31·3	87	49	56·3	123·2
Murergarh S . .	23	35	35 8	82	0	15 1	3074·1
Narmao H. S....	23	30	18·6	78	52	16·4	2323·2
Nibria T. S..	22	35	37·1	88	17	9·8	99·8
Noda T. S... ..	22	40	10·6	88	25	6·6	95.8
Parasnat H. S...	23	57	37·6	86	10	37·1	4483·9
Patal H. S...... ..	23	40	27·8	85	9	53·4	2179·1
Pokra H. S.. ...	24	18	49·0	82	31	5·0	2245·1
Punchi H. S..	23	32	9·2	80	40	47·1	2341·7
Radamadapur H. S...... .. .	23	31	58·3	87	21	3·8	368·9
Rampur H. S...	23	40	39·9	81	6	31·3	2435·6
Rangir H. S.....	24	0	20·9	79	28	26·4	1235·7
Sagar H. S... ..	23	49	48·6	78	48	45·4	2120·9
Salaia H. S.. ..	23	49	51·7	79	58	30·8	1738·5
Sateria H. S..	23	54	22·3	79	41	20 6	1641·8
Sewari H. S..	23	58	25·8	83	47	39·3	1980·2
Susinia H. S..	23	23	45·8	87	1	39 8	1439·9
Teonda H. S..	23	48	33·4	78	14	0·0	1952·7
Tikeria H. S...	24	7	41·1	79	56	18·3	1763·8
Tilabani H. S ..	23	25	2·5	86	35	41.2	1336·1
Tins H. S.. ...	23	38	21·9	78	29	31·3	2345·4
Tinsmal H. S ..	24	7	13·5	79	2	12·4	2218·9
Turer H. S.....	23	38	3·8	84	3	33·2	3107·4

Extract from the Budhon Meridional Series Report.

Names of Places.	Lat. °	′	″	Long. °	′	″	Heights above Sea. feet.
Akbarpur S.. ..	29	4	51·5	78	40	51·3	787·6
Algi H. S..	25	29	45·0	78	23	58·2	1235 5
Andhiari H. S .	24	41	6·5	78	16	16·2	1708·7
Athgath S..	26	47	56 8	78	45	4·1	663·3
Atora S	28	42	37·0	78	39	43·6	763·2
Bansgopal S.. ..	28	33	23·3	78	34	27·1	749·7
Baragaon S... ...	27	14	59·7	78	44	42·6	708·4
Baraoli S..	28	31	57·6	78	47	56·4	723·2
Bhataoli S...	28	53	55 4	78	46	1·0	757·9
Bhind S	26	33	30·5	78	50	14·4	647·9
Bhitari H. S.. ..	25	28	3·4	78	46	39·5	1135·6
Chandanpur S...	28	33	54·2	78	20	59·5	721·0
Chandi H. S.. ..	29	55	23·4	78	13	37·4	1981·7
Dargawa H. S...	24	37	13·1	79	3	51·8	1531·1
Dariapur H. S..	25	42	11·0	78	40	55·9	875·1
Ferozabad S... ..	27	8	34·3	78	25	56·3	690·2
Godna S.....	29	37	12·5	77	56	30·4	966·3
Gurmi S.....	26	36	1·1	78	33	17·1	660·6
Gwali H. S.......	25	10	25.0	78	28	5·2	1289·2
Haldour S...	29	16	35·6	78	18	33·6	873 9
Harpalised H. S.	29	39	44·9	78	35	48·3	2944·0
Dhandkura H. S.	24	47	35·0	78	45	44·0	1369·4
Jamalpur S	27	48	6·9	78	51	35·3	684·5
Jhankri H. S.. ...	26	18	51·6	78	34	41·4	709·5
Karaia H. S.. ..	25	53	45·4	78	2	43·7	1370·2
Kariami S..... ..	28	15	3·0	78	48	2.2	701·7
Kathera H. S....	25	14	20 0	78	59	39·1	1429·3
Kilarmao S........	27	33	7·8	78	48	58 4	691·3
Kundurki S.. ...	28	43	32·2	78	27	2·8	760·8
Lut S.....	28	53	37·1	78	20	58·2	786·9
Marbegarh S.....	29	52	33·3	78	29	52·3	5715·8
Maharajpur H. S.	25	53	52.8	78	16	40·3	1097·3
Mahesari S........	29	30	12·4	78	11	19·2	845·3
Majhar H. S.. ...	26	6	15.1	78	30	44·9	1112·0
Mehtra S..	28	22	1.4	78	41	21·1	726·6
Milik S..	29	4	37.3	78	27	55·9	812·1
Nandi S..	29	17	1·9	78	48	59·8	839·9
Narwar H. S . ..	25	37	21·0	77	57	56·4	1571·9
Paraoli S.........	28	9	41·0	78	23	31·6	720·7
Patna H. S..	24	20	3·9	78	39	36·2	1899·7
Pinaht S....	26	52	36·3	78	24	58·9	675·0
Pandri S	27	27	49·0	78	26	52·3	731·0
Raipur H. S	26	8	12·4	78	7	16·1	1302·7
Rajaoli S..........	28	22	23·0	78	27	40 [illegible]	701·4
Sakrora S	28	13	8·2	78	35	43·4	691·9
Salempur S...... ..	27	46	32·6	78	33	16 0	732·4
Sanichri H. S....	26	23	29·0	78	15	30·0	909·8
Sankrao S..	28	2	24·8	78	31	30·3	752·9
Sarkara S...	29	15	41·3	78	34	47·7	830·5
Sarsotha S...... ..	28	5	55 6	78	47	40·6	687·5
Sheopuri S...... ..	29	18	53·5	78	1	58·	935.1
Sherpur S...	27	0	3·4	78	41	33·9	665·4
Sirsa S.............	28	54	34·5	78	34	33·8	810·4

LATITUDES AND LONGTITUDES TAKE IN MALWA AND MEWAR, WITH THE BAROMETRICAL ELEVATIONS ABOVE THE SEA.

Places.	North Latitude.			East Longtitude.			Height above the Sea.
	°	′	″	°	′	″	Feet.
Amgherra	22	33	24	75	13	00	1890
Aggur	23	42	51	76	00	50	1598
Bangla	22	32	32	...	...	...	1990
Bopawur	22	36	47·5	75	05	10	1836
Budwassa	23	29	39·5	75	07	40	1686
Bheindur	24	30	01	74	13	00	1872
Borekairee	24	26	56	70	06	35	1459
Bumoorie (Small)	24	27	27·5	75	36	40	1341
Bampoora	24	30	45	75	50	00	1344
Burrode	23	47	11	75	52	55	1530
Banswarra	23	31	30	74	31	40	......
Chittoor	24	52	01	74	44	30	......
Dhar	22	35	30	75	23	40	1908
Dessye	22	42	42	75	13	30	1872
Dhodur	23	45	38	75	10	25	1482
Dulowda	23	55	35	75	09	20	1518
Dewla or Dewgurh	24	02	09	74	43	40	1770
Duryawad	24	05	33·5	74	31	50	816
Deybur Tulao Bund	24	14	18	74	01	30	1044
Doodeakairee	24	25	51	75	46	50	......
Doomnar Caves	24	11	51	75	34	30	1425
Doongurpoor	23	47	44	73	49	40	......
Dektaun	22	34	40	75	33	57	1881
Ginglah	24	18	18	74	06	40	1638
Gungsaur	23	55	41	75	41	25	1498
Indore	22	42	02	75	46	50	1998
Julwa	22	32	52	75	40	30	2016
Jowrah	23	38	13.2	75	11	25	1437
Jeerun	24	18	25	74	55	20	1590
Jawud	24	35	56	74	58	25	1410
Kaunwun	22	51	49	75	21	20	1792
Kursode	23	13	03	75	25	55	1679
Kachrode	23	24	58·5	75	20	05	1638
Korabur	24	27	18·5	74	02	00	1272
Kairoda	24	35	00	74	06	05	1902
Kaunore	24	25	43	74	18	35	1656
Kookreysur	24	28	50	75	22	15	1412
Kuchowlee	24	18	03	74	41	10	1397
Mhow	22	33	29·5	75	50	30	2019
Mandoo	22	20	32	75	28	00	1944
Mundissor	24	02	43	75	07	05	1452
Maunpoor	24	07	47	74	20	25	1414
Munassa	24	28	49	75	14	49	1440
Moree	24	28	40	75	43	30	......
Maheedpoor	23	29	26	75	45	40	1600
Nalcha	22	25	37	75	29	10	2022
Noyle or Burnuggur	23	02	42·5	75	26	40	1698
Neemuch, Town of	24	27	10	75	00	00	......
Ditto Cantonments	24	27	51·4	75	78	45	1476
Odey Sagur Bund	24	34	17·5	73	52	20	2046
Odeypoor, City of	24	34	45·6	73	44	00	2064
Oojein	23	11	11	75	51	00	1698
Pertaubgurgh	24	01	55	74	51	00	1698
Phoonga Tullao	24	03	19	74	38	50	1068
Ratlam	23	19	01	75	05	00	1577
Rampoora	24	27	33·5	75	32	25	1360
Sagore	22	36	04·5	75	41	30	1932
Suledew	24	06	22	74	26	25	750
Soiloombur	24	08	11	74	09	20	876
Sadree (Burrwa)	24	24	55·5	74	30	30	1782
Sadree (Chota)	24	23	10	74	44	10	1968
Seeswee	24	32	18	73	59	25	1872
Sharze Gurgh	...	...	...	...	...	...	2628
Baz Bahadur Chuttree	...	...	...	...	...	...	2070
Jaum Ghaut	22	23	00	75	49	10	2328
Mundleisir	23	11	45	75	45	30	696
Palace at Deybur	...	...	...	...	...	...	1260
Village of Beerpoor at Deybur	...	...	...	...	...	...	978

LATITUDES AND LONGITUDES TAKEN IN CENTRAL INDIA AND MALWA.

Places.	North Latitude. °	′	East Longitude. °	′	Height above the Sea.
Agra	27	11	77	53	......
Ahmedabad	23	01	73	42	...
Ajmeer	26	31	74	28	....
Allote	23	45	75	38	....
Ally	22	13	74	25	....
Amber	26	57	75	40	....
Asseergurh	21	28	76	23	....
Aurungabad	19	54	75	33	....
Baglee	22	39	76	28	....
Banswarra	23	31	74	32	....
Barreah	22	44	74	00	....
Bassein	19	20	72	56	....
Baug	22	26	75	54	....
Beejagurh	21	36	75	30	....
Beirseah	23	40	77	31	....
Bhilsa	23	33	77	55	....
Bhopal	23	17	77	30	....
Bhurtpore	27	17	77	23	....
Bicaneer	27	57	73	02	....
Boondee	25	28	75	30	....
Beerwannee	22	04	74	58	....
Cambay	22	21	72	48	.....
Chandore	20	19	74	19	....
Cumbheer	27	17	77	14	....
Cundwah	21	53	76	25	....
Dacca	23	42	90	17	....
Deeg	27	30	77	12	....
Delhi	28	41	77	05	.....
Dewass	22	59	76	10	....
Dewla	24	02	74	44	.....
Deypaulpore	22	50	75	25	.....
Dhamonee	24	11	78	50	....
Dhurmpooree	22	10	75	26	....
Doheeda	22	55	74	20	....
Doongurhpoor	23	48	73	50	....
Deebboy	22	09	73	25	....
Dug	24	00	76	01	....
Dwaraca	22	15	60	07	.....
Eirwass	22	31	76	33	.....
Ellora	19	57	75	25	......
Furruckabad	27	24	79	27	....
Gagroon	24	37	76	16	......
Gawelgurh	21	22	77	24	.....
Gaya	24	49	85	00	....
Goa	15	30	74	02	....
Gohua	26	24	78	20	....
Gualior	26	15	73	07	.....
Gungraur	23	56	75	41	1498
Gunnoorgurh	22	50	77	34	.....
Gurrote	24	20	75	42	.....
Hindia	22	26	77	00	.....
Hinglaisgurh	24	23	75	57	.....
Hussingabad	22	42	77	43	.....
Hydrabad	17	15	78	35	....
Indore	22	42	75	50	1998
Jaborah	22	46	74	39	......
Jaulnah	19	52	76	08	.....
Jaum	22	23	75	49	.....
Jeypore	22	50	75	37	.....
Joudpoor	26	18	73	49	......
Juggernauth	19	49	85	54	.....
Katchrode	23	25	75	20	.....
Kedarnauth	30	53	79	18	11,897
Kooksu	22	16	74	51	....
Kotah	25	12	75	45	.....

LATITUDES AND LONGITUDES TAKEN IN CENTRAL INDIA AND MALWA

Places.	North Latitude. °	′	East Longitude. °	′	Height above the Sea.
Kumeelner	25	10	73	36	....
Kurgoon	21	50	75	40	....
Lahore	31	36	74	03	....
Lucknow	26	51	80	50	....
Leenawarra	23	08	73	43	....
Madhoorajpoor	26	35	75	30	....
Meirtah	26	38	73	49	....
Mhow	22	33	75	50	2019
Mhysis	22	11	75	31	....
Moradabad	28	51	78	42	....
Muckandra	24	47	76	04	....
Mulhargurh	24	17	70	03	....
Mulligaum	20	31	74	36	....
Munassa	24	29	75	15	1440
Mundatta	22	14	76	17	....
Mundawall	23	35	75	29	....
Muttra	27	31	77	33	....
Nagore	27	08	73	33	....
Nagpoor	21	09	79	11	....
Narwar	25	40	77	51	....
Neemuch	24	27	75	00	1470
Nemawor	22	27	77	00	....
Nugibahad	29	37	78	12	....
Nunderbar	21	25	74	18	....
Odeypoor	24	35	73	44	2064
Paneput	29	22	76	51	....
Patun	24	32	76	16	....
Pertaubgurh	24	02	74	51	1698
Petlawua	23	04	74	50	....
Poona	18	30	74	02	....
Ragoogurh	24	27	77	14	....
Rasseen	23	20	77	52	....
Ramisseram	9	17	79	26	....
Rathgurh	23	37	78	33	....
Sarungpoor	23	35	76	35	....
Saugor	24	48	78	46	....
Seepra River	22	32	76	04	....
Seeta Mhow	24	02	75	26	....
Seonte	23	12	73	54	....
Seringapatam	12	25	76	45	....
Seronjee	24	08	77	41	....
Shahjehanpoor	23	26	76	23	....
Sujahalpoor	23	24	76	44	....
Soneil	24	23	76	03	....
Seetwass	22	30	76	42	....
Tal	23	40	75	26	....
Tonk	24	12	75	38	....
Talluckwara	21	57	73	37	....
Woon	21	50	75	32	....

REGISTER OF THE PLUVIOMETER AT BOMBAY FROM THE YEAR 1817 TO 1850.

Years.	June.	July.	August.	Sept.	Oct.	Total fall in June, July, Aug., September, and Oct., of each year.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1817	45·72	23·67	9·34	24·87	......	103·60
1818	22·54	17·69	28·45	10·39	2·07	81·14
1819	15·95	31·66	20·24	10·11	......	77·76
1820	18·82	28·37	29·49	10·66	......	77·34
1821	15·18	20·60	28·52	18·29	......	82·59
1822	29·64	26·59	33·83	22·16	......	112·22
1823	21·76	15·96	19·70	4·28	......	61·70
1824	3·89	8·07	17·86	1·78	2·37	33·97
1825	24·45	25·17	12·94	9·68	......	72·24
1826	17·75	26·97	8·40	23·50	1·87	78·49
1827	49·15	10·29	10·51	10·16	0·92	81·03
1828	22·53	52·75	17·22	22·08	6·40	121·98
1829	27·86	19·78	12·40	4.95	0·66	65·65
1830	20·96	32·46	10·66	7·78	......	71·89
1831	22·46	27·31	27·64	22·34	2·08	101·83
1832	13·63	48·05	4·65	7·11	0·65	74·09
1833	12·50	21·80	13·35	23·54	0·20	71·39
1834	14·16	21·83	18·05	12·55	3·88	70·47
1835	9·99	4·27	35·76	12·17	0·42	62·61
1836	21·36	24·53	37·41	4·69	......	87·99
1837	12·61	24·39	22·43	5·15	......	64·58
1838	29·70	8·70	7·34	5·04	......	50·78
1839	18·28	32·19	18·45	4·70	......	73·62
1840	25·04	24·24	4·20	7·55	2·12	63·15
1841	25·27	21·21	20·53	1·27	3·21	71·49
1842	16·84	26.45	37·10	10·41	4·36	95·16
1843	9·33	22·49	18·20	9·00	0·25	59·27
1844	14·17	35·52	16·55	9·16	......	65·40
1845	19·70	20·44	6·56	8·03	......	54·73
1846	31·71	40·56	5·60	8·45	1·16	87·48
1847	35·47	16·80	8·92	5·80	0·32	67·31
1848	42·37	13·83	7·87	4·01	5·34	73·42
1849	22·82	51·68	13·66	29·65	1·07	118·88
1350	17·69	19·13	6·39	4·56	3·38	51·15
Average for 34 years.	22·13	24·88	16·77	11·05	1·25	76·08

FALL OF RAIN IN THE N. W. PROVINCES, FOR 4 YEARS ENDING 30TH APRIL, 1849.

Districts.	Year 1845-6	Year 1846-7	Year 1847-8	Year 1848-9	Average.
Delhi.					
Paniput	27·09	25·50	29·39	20·03	25·50
Hurrianah	9·59	12·24	15·69	8·12	11·47
Delhi	21·14	23·75	23·92	17·31	21·53
Rotuck	21·25	24·49	28·00	18·11	21·46
Goorgawun	23·74	24·72	18·95	17·68	21·52
Meerut.	20·53	22·14	22·00	16·25	20·28
Saharunpore	27·86	00·00	39·64	30·56	30·27
Mozuffernuggur	31·58	42·06	37·70	24·33	33·94
Meerut	26·75	35·22	34·54	21·36	29·47
Bolundshehur	37·78	4·74	33·83	18·89	23·56
Allyghur	30·21	19·16	24·65	25·50	24·13
Rohilcund.	30·83	35·04	34·07	23·55	30·27
Brijnore	22·68	48·31	37·47	29·01	34·37
Moradabad	27·93	49·82	63·11	25·26	41·53
Budaon	27·07	34·18	33·29	26·84	30·33
Bareilly	38·98	59·04	31·15	28·00	39·29
Shajehanpore	31·01	51·18	43·47	23·11	37·79
Agra.	39·52	48·50	41·69	26·45	36·54
Muttra	24·04	11·97	20·40	17·04	18·36
Agra	28·77	16·55	16·54	16·12	19·49
Furruckabad	18·02	28·46	22·49	18·31	21·82
Mynpoorie	20·02	21·39	20·04	19·69	20·86
Etawa	26·14	24·77	26·29	20·06	24·31
Allahabad.	23·39	20·62	21·15	18·24	20·97
Cawnpore	23·77	23·45	25·83	20·37	23·35
Futtypore	26·83	26·46	39·84	17·95	25·31
Humeerpore	33·12	27·86	38·13	24·55	30·90
Banda	28·52	25·00	27·90	24·78	26·55
Allahabad	30·99	40·60	24·68	29·05	33·06
Benares.	30·42	28·68	29·27	23·34	27·83
Goruckpore	27·34	46·50	70·25	36·02	45·03
Azimghur	34·35	31·38	46·52	31·92	36·04
Jounpore	30·34	31·07	44·49	33·33	34·80
Mirzapore	31·59	30·86	37·21	39·70	34·79
Benares	32·66	44·27	49·53	59·57	54·01
Ghazeepore	31·71	32·69	28·85	43·38	45·32
Commissionerships.	31·33	36·09	46·14	40·65	41·66
Delhi	20·53	22·14	22·00	16·25	20·28
Meerut	30·83	35·04	34·07	23·54	30·27
Rohilcund	29·52	48·50	40·67	26·45	36·54
Agra	23·39	20·62	21·15	18·24	20·97
Allahabad	30·42	28·68	29·29	23·34	27·83
Benares	31·33	36·09	46·04	49·65	41·66
	27·68	31·84	32·38	24.74	29·59

Average greatest fall of rain is, in Benares, 54·01; Goruckpore, 45·03; Ghazeepore, 45·32; smallest in Hurrianah, 11·41; Muttra, 18·36; Agra, 19·49.

Greatest fall in any one year. 1846-47—Goruckpore, 70·25; 1846-47—Moradabad, 63·11; 1847-48—Benares, 59·57.

Smallest fall in Hurrianah for 4 years.

From this statement it is not known (or explained) if the fall of rain is merely noted and averaged at the sudder station of the district, or the average struck from the several Teseeldaries of the district, or if it is of these cities alone, or the entire zilla.

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS FROM THE YEAR 1824 TO 1837.

NAMES.	Altitude in feet.	Latitude North.	Longitude East.	1824	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	1835	1836	1837
		° ′ ″	° ′ ″	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Madras (1)...	Sea Level.	13 5	80 21	33·21	55·94	...	...	...	...	...	..	..	..	..	..	..	..
Moulmein (2)...	ditto	16 3	97 38	..	..	...	...	...	132·90	113·15	141·6	180·00	218·50	177·12	—	177·02	202·59
Tanna (4)..	ditto	19 11	73 6	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Bombay (5)..	ditto	18 52 35	72 49 43	33·97	72·24	78·49	81·03	121·98	65·65	78·86	101·83	74·09	71·39	70·47	62·61	87·99	64·58
Calcutta (5).....	4 feet.	22 35	88 30	..	..	...	...	...	...	...	..	..	..	..	..	50·54	43·61
Calcutta (5).....	40	....	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Quilon (5)...	30	8 53	76 39	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Allepee (5)...	3	....	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Cape Comorin (5)...	50	8 4	77 55	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Vaurioor (5)..	60	....	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Trevandrum (5)..	130	8 9	79 37	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Rutnagherry (5)..	150	7 2	73 25	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Palamcottah (5)...	200	8 35	79 37	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Shencottah (5)...	600or700	....	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Dapoolie (4)..	900	18 33	74 2	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Kandalla (4)..	1740	27 35	75 15	..	..	...	...	...	...	...	..	..	..	..	..	168·75	..
Poona (4)..	1842	18 30	74 2	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Ahmednuggur (4)..	1900	19 5	74 55	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Belgaum (4)...	2000	15 52	74 42	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Phultun (4)..	2000	18 00	74 30	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Ghutt (4)...	2000	....	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Attagherry (4)..	2200	....	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Sattara (4)...	2320	17 40	74 2	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Wye (4)...	2320	....	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Meera (4)...	2340	....	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Bhoee (4)..	2350	....	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Enteshwar (4)..	3700	....	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Malcolm Pait (4)...	4500	....	....	..	..	...	...	...	257·06	232·93	185·32	226·87	203·74	297·41	226·71	243·56	267·76
Malcolm Sindala (4)...	4600	17 00	73 30	..	..	...	...	...	...	...	..	..	..	..	..	..	..
Mercara (4)..	4500	.. ..	....	..	..	...	...	...	...	...	..	..	..	..	..	..	..

No. 1. Taken from Manuscript Register. No. 2 from the Madras Medical Topography of 1844. No. 4 from Transactions of the Medical and Physical Society of Bombay. No. 5 from Lieut. Colonel Sykes's Report on Meteorology of India.

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS FROM THE YEAR 1838 TO 1849.

Names.	Altitude in feet.	Latitude North.	Longitude East.	1838	1839	1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	Means
		° ′ ″	° ′ ″	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	
Madras (1)	Sea Level	13 5	80 21	...	...	..	58·00	36·60	50·95	80·95	27·20	78·45	72·20	42·70	..	49·19
Maulmein (2)	ditto	16 3	97 38	229·99	181·19	27·62	173·06	192·10	150·12	...	...	...	...	..	..	189·68
Tanna (4)	ditto	19 11	73 6	...	...	184·41	..	...	...	98·54	87·83	133·97	104·83	..	..	106·54
Bombay (5)	ditto	18 52 35	72 49 43	60·78	62·62	..	71·49	97·16	59·27	65·40	54·73	87·48	67·31	78·37	..	71·25
Calcutta (5)	4 feet.	22 35	88 30	52·99	64·97	63·15	62·52	76·12	64·36	73·86	60·92	76·44	72·38	58·79	52·32	62·09
Calcutta (5)	40	....	....	...	...	59·41	..	...	56·30	62·35	...	...	..	52·32	...	56·99
Quilon (5)	30	8 53	76 39	...	...	..	105·72	60·57	61·70	74·75	...	...	..	..	...	76·76
Allepee (5)	3	....	....	...	...	81·06	131·85	18·70	97·80	113·43	...	...	..	..	...	113·25
Cape Comorin (5)	50	8 4	77 45	...	...	104·52	..	...	19·20	19·50	18·00	56·72	..	..	...	28·35
Vaurioor (5)	60	....	....	...	...	..	..	20·27	25·75	18·05	36·83	22·45	..	..	...	24·67
Trevandrum (5)	130	8 9	79 37	...	...	..	..	57·70	85·45	47·05	62·57	69·92	..	..	...	64·54
Rutnagherry (5)	150	7 2	73 25	...	...	..	..	...	...	87·77	88·28	145·50	133·6	..	...	113·20
Palamcottah (5)	200	8 35	79 37	...	...	..	..	23·12	26·90	11·68	25·63	17·75	..	..	...	21·06
Shencottah (5)	600 or 700	....	....	...	...	..	..	Mean	of five	years.	...	...	..	..	...	39·19
Dapoolie (4)	900	18 33	74 2	...	...	..	..	...	...	135·14	147·64	133·31	113·17	..	...	132·46
Kandalla (4)	1740	27 35	75 15	...	...	..	..	...	...	...	...	...	..	..	...	168·57
Poona (4)	1842	18 30	74 2	...	...	..	..	48·67	14·67	14·19	14·34	25·35	22·21	..	...	26·57
Ahmednuggur (4)	1900	19 5	74 55	...	...	..	..	...	...	19·53	24·22	24·22	26·03	...	...	23·66
Belgaum (4)	2000	15 52	74 42	...	...	..	54·46	51·74	50·85	...	...	...	41·57	..	...	48·88
Phulltun (4)	2000	18 00	74 30	...	...	..	..	...	...	...	...	18·09	24·04	24·18	...	22·10
Ghutt (4)	2000	....	....	...	...	..	..	...	...	...	...	...	...	18·07	...	18·07
Attagherry (4)	2200	....	....	...	...	..	..	...	...	...	...	...	...	..	170·00	170·00
Sattara (4)	2320	17 4	74 2	...	...	..	..	...	...	36·06	40·34	39·32	40·98	27·81	...	36·97
Wye (4)	2320	....	....	...	...	..	..	...	...	...	..	...	...	20·73	...	20·73
Meera (4)	2340	....	....	...	...	..	..	...	...	...	..	...	...	49·64	...	49·64
Bhoee (4)	2350	....	....	...	...	..	..	...	...	...	..	...	...	29·42	...	29·42
Enteshwar (4)	3700	....	....	...	...	..	..	...	...	...	..	...	...	36·69	...	36·69
Malcolm Pait (4)	4500	....	....	180·17	233·23	284·43	281·00	289·37	285·67	262·23	249·93	288·34	218·80	245·00	...	248·50
Malcolm Sindala (4)	4600	17 00	73 30	...	...	..	..	...	...	...	...	...	...	165·16	...	...
Mercara (4)	4500	....	....	...	...	..	..	...	...	...	...	...	Mean	of 3	years.	143·55

No. 1. Taken from Manuscript Registers. No. 2 from the Madras Medical Topography of 1844. No. 4 from Transactions of the Medical and Physical Society of Bombay. No. 5 from Lieut. Colonel Sykes's Report on Meteorology of India.

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS FROM THE YEAR 1824 TO 1837.

Names.	Altitude in feet.	Lat. N.	Lon. E.	1824	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	1835	1836	1837
		° ′ ″	° ′ ″	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Kotergherry (4).. ...	6100	31 18	77 28	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Augutt Peak (4).. ...	6200	....	....	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Cannanore (4).. ...	....	....	....	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Masulipatam (4).. ...	....	16 10	81 14	...	...	...	...	...	...	...	...	...	...	..	...	...	...
St. Thomas's Mount(1)	....	....	....	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Trichinopoly (1).. ...	....	....	....	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Nassick (1)..	....	19 59	73 56	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Dharwar (4	....	15 28	75 8	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Vizagapatam (1).. ...	....	....	....	...	...	...	...	...	...	..	...	...	...	..	...	...	...
Poonamallee (4)... ...	....	13 2	80 8	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Batticote (4)..	4500	13 15	74 37	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Ultray Mullay (5).. ...	....	....	....	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Kurrachee (6).... ...	....	21 57	67 2	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Kolapore (4)..	8640	....	....	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Dodabetta (5)..	....	....	....	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Sawunt Warree (6).....	....	....	....	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Nagpore (6)..	....	21 9	79 11	...	...	65·16	50·99	46·61	50·55	33·00	65·31	37·14	...	..	...	...	...
Futtegurh (6).	....	27 21	79 30	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Aurungabad (6).. ...	on ground	19 54	75 30	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Hoshungabad (6).. ...	....	....	....	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Hoshungabad (6).. ...	....	....	....	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Alibaugh (7)..	....	....	....	...	...	...	...	...	...	...	...	...	...	..	...	...	...
Secunderabad (7). ...	....	15 5	78 35	...	...	...	...	...	...	...	...	...	...	..	...	...	..
Soorpoor (7)..	....	13 36	76 47	...	...	...	...	...	...	..	...	...	...	..	...	...	...
Bellary (7).	....	15 5	76 59	...	...	...	...	...	...	...	..	...	...	..	..	...	...
Mirkae (7)....	....	12 30	75 21	...	...	...	...	...	...	...	...	...	...	..	...	87·04	...
Ahmedabad (7)... ...	....	....	....	...	...	...	...	...	...	..	...	...	...	..	...	...	...
Tavoy (8)......	....	19 4	98 50	...	...	..	...	...	...	..	209·50	...	...	..	...	...	...
Penang (2).	....	5 25	100 12	...	...	...	...	..	...	...	...	...	62·27	89·78	94·52	83·74	...
Kamptee (2)..	....	....	....	...	...	...	...	...	...	..	...	...	...	..	...	...	...
Malacca (2).	....	2 16	102 12	...	...	...	...	50·12	...	...	...	...	...	..	...	...	...
Woosung (9)..	....	30 30	121 00	...	...	...	...	...	...	...	...	...	...	..	...	...	...
				1810	1811	1812	1813	1814	1815	1816	1817	1818	1819	1820	1821	1822	1823
Angarakandy (10). ...	....	....	....	125·90	101·90	102.70	94·85	115·10	133·40	100·00	136·7	169·19	135·47	147·58	98·44	145·60	121·67

No. 1. Taken from Manuscript Register. No. 2 from the Madras Medical Topography of 1844. No. 4 from Transactions of the Medical and Physical Society of Bombay. No. 5 from Lieutenant Colonel Sykes's Report on Meteorology of India. No. 6 from Manuscript Register. No. 7 from Dr Buist's Manuscript Book. No. 8 from Medical Topography 1848. No 9 Manuscript Register. No. 10 from Transactions of the Literary Society Madras 1827.

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS FROM THE YEAR 1838 TO 1849.

Names.	Altitude in feet.	Lat. N.	Lon. E.	1838	1839	1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	Means.
		° ′ ″	° ′ ″	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	
Kotergherry (4)... ...	6100	31 18	77 28	...	...	...	...	...	...	...	...	Mean	of one	year.	...	81·71
Augutt Peak (4)... ...	6200	...	...	...	...	...	...	...	...	...	...	...	...	...	194·00	194·00
Cannanore (4)...... ...	...	...	...	...	...	...	...	116·96	146·70	111·47	120·05	140·25	113·25	8[illegible]·35	...	121·29
Masulipatam (4)... ...	...	16 10	81 14	...	...	...	...	36·63	37·59	32·00	[illegible]6·18	41·77	37·6[illegible]	28·59	...	43·33
St. Thomas's Mount(1)	...	...	...	...	...	...	...	33 55	44·40	[illegible]9·50	26·25	51·30	45·5[illegible]	34·39	...	42·12
Trichinopoly (1)... ...	...	...	...	...	...	...	...	33·[illegible]5	33·00	29·40	17·10	27·25	3[illegible]·03	31·60	...	29·56
Nassick (1)...	...	19 59	73 56	...	...	...	...	...	...	25·80	[illegible]6·78	28·38	25·90	...	...	26·72
Dharwar (4)...	...	15 28	75 8	...	...	...	...	...	...	22·75	39·50	48·91	34·90	...	...	39·01
Vizagapatam (1)... ...	...	...	...	...	...	...	...	...	...	...	...	42·60	40·29	...	...	42·16
Poonamallee (4)... ...	...	13 2	80 8	...	...	...	...	...	...	...	...	62·60	42·20	...	...	52·40
Battecotte (4)...	4500	15 15	74 37	...	...	...	...	...	...	...	...	54·10	51·50	...	...	52·80
Ultrary Mullay 5)......	...	...	...	...	...	...	...	...	...	...	...	...	...	164·00	...	164·08
Kurrachee (6)......	...	24 57	67 2	...	...	...	...	...	...	...	...	...	...	3·00	...	3·00
Kolapore (4)...	8640	...	...	...	...	...	...	...	...	...	...	...	...	20·74	...	20·74
Dodabeta (5)... ...	...	...	...	...	...	...	...	...	...	...	...	...	101·12	...	...	101·12
Sawunt Warree (6)......	...	...	...	...	...	...	...	...	...	...	...	...	...	138·93	113·67	126·29
Nagpoor (6)...	...	21 9	79 11	...	...	...	...	...	...	...	...	...	...	...	...	50·21
Futtegurh (6)...... ...	...	27 21	79 30	...	...	...	...	...	...	...	...	...	...	28·05	33·00	3·55
Aurungabad (6)... ...	on ground	19 54	75 30	...	...	...	...	...	...	...	...	...	44·00	...	...	44·00
Hoshungabad (6)... ...	...	...	...	...	...	...	...	...	...	...	...	...	...	11·20	...	11·20
Hoshungabad (6)... ...	...	...	...	...	...	...	...	...	...	...	...	...	...	11·27	...	11·27
Alibaugh (7)...	...	...	...	...	...	...	...	...	...	...	67·17	...	...	...	...	67·17
Secunderabad (7)... ...	...	15 5	78 35	...	...	...	...	...	41·60	43·44	...	...	...	...	...	47·52
Soorpoor (7)...	...	13 36	76 47	...	...	...	...	...	...	...	...	...	29·23	...	...	29·24
Bellary (7).....	...	15 5	76 59	...	...	...	26·40	17·57	...	...	...	...	...	...	...	21·98
Mirkae (7).....	...	12 30	75 23	...	...	...	...	...	...	...	...	...	...	...	...	87·04
Ahmedabad (7)..... ...	...	...	...	...	...	...	...	...	16·[illegible]0	...	...	...	...	...	...	16·00
Tavoy (8).	...	19 4	98 5	...	...	...	240 60	2[illegible]0·7[illegible]	190·60	[illegible]75·20	229·60	184·60	...	...	...	208·68
Penang (2).....	...	5 25	190 12	...	...	...	...	...	...	...	...	...	...	...	...	82·57
Kamptee (2)...	...	...	...	...	...	...	...	...	61·60	...	...	...	...	...	...	41·60
Malacca (2)...	...	2 28	102 12	...	...	...	...	...	...	...	...	...	...	...	...	90·12
Woosung (9)...	...	30 30	121 00	...	...	...	...	...	...	...	...	...	...	34·55	47·77	41·16
Angarakandy (10)......	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	124·60

No. 1. Taken from Manuscript Registers. No. 2 from the Madras Medical Topography of 1844. No. 4 from Transactions of the Medical and Physical Society of Bombay. No. 5 from Lieutenant Colonel Sykes's Report on Meteorology of India. No. 6 from Manuscript Register. No. 7 from Dr Buist's Manuscript Book. No. 8 from Medical Topography 1848. No. 9 Manuscript Register. No. 10 from Transactions of the Literary Society Madras 1827.

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Cannanore.							Masulipatam.							Vizagapatam.		Poonamallee.	
	1842	1843	1844	1845	1846	1847	1848	1842	1843	1844	1845	1846	1847	1848	1847	1848	1847	1848
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	0·45	2·70	...	0·30	..	..	...	...	1·25	0·02	0·5	..	...	..	..	..	..	..
February	0·85	...	...	...	..	..	...	..	..	4·75	1·8	2·20	2·48	..	...	..	0·15	...
March	...	...	..	2·50	0·80	1·10	..	2·32	..	..	..	...	..	...	..	...	..	..
April	3·00	7·10	4·50	2·60	0·75	12·40	5·55	..	0·25	..	0·57	..	0·15	0·90	...	6·31	..	2·60
May	28·50	26·00	9·16	1·55	8·90	6·95	9·10	1·45	3·9	1·23	3·5	1·38	1·25	1·15	2·90	0·65	1·05	..
June	23·63	43·05	26·19	45·40	52·90	49·90	24·90	3·80	2·50	3·72	4·75	6·38	4·90	5·90	4·90	2·69	3·90	...
July	26·70	38·90	35·03	22·90	29·50	26·50	23·65	3·11	7·31	5·06	2·4	5·73	5·85	2·50	1·80	2·40	3·15	1·45
August	19·20	9·50	18·10	16·20	32·45	15·05	9·40	6·46	7·15	2·14	2·8	4·48	8 20	3·7	5·55	1·60	5·30	6·10
September	9.95	7·70	10·13	5·75	5·45	5·35	2·10	7·07	1·69	9·91	6·4	8·67	2·9	4·90	8·25	4·90	4·5	4·65
October	3·35	7 15	7.18	16·95	7·55	8·50	2·45	7·77	7·42	3·65	2·05	9·78	9·30	7·25	17·41	14·15	13·85	6·85
November	1·30	..	..	0·15	1·90	6·50	3·15	3·95	...	..	...	0·15	1·80	2·[illegible]0	0·69	8·44	13·50	18·40
December	...	4·60	1·16	5·75	0·05	1·00	0·05	0 70	6·10	1·50	1·33	3·90	0·30	..	1·10	0·35	17·20	2·15
Sum	116·96	146·70	111·47	120·05	140·25	133·25	80·35	36·6[illegible]	37·59	32·00	26·18	41·77	37·63	28·55	42·60	41·67	62·60	42·20
Mean	9·75	12·22	9·29	10·00	11·68	11·10	6·69	3·05	3·13	2·66	2·18	3·65	3·13	2·38	3·55	3·47	5·21	3·51

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Anjarakandy, Malabar Coast.				St. Thomas's Mount.							Trichinopoly.						
	1820	1821	1822	1823	1842	1843	1844	1845	1846	1847	1848	1842	1843	1844	1845	1846	1847	1848
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	..	..	0·73	0·04	1·43	8·30	...	1·25	2·90	...	..	5·80	7·00	...	0·25	...	1·00	...
February	0·12	...	..	...	..	..	2·25	..	..	...	...	...	..	..	...	0·50	0·98	0·25
March	..	0·14	...	3·55	0·10	2·50	..	..	...	...	...	...†	..	0·50	1·60	..	1·00	...
April	3·44	0·91	8·80	0·96	..	..	...	...	..	...	2·20	...†	2·25	0·50	..	..	0·45	5·15
May	17·54	10·07	9·20	2·35	..	11·40	0·40	1·75	3·93	...	0·20	...†	6·25	2·25	3·25	2·60	0·10	1·70
June	45·29	19·77	32·64	32·97	0·40	..	1·80	2·55	1·30	...	0·60	4·50	2·00	1·15	0·50	0·25	1·05	..
July	29·53	36·29	41·99	60·02	2·40	...*	3·40	1·5	7·15	..	2·20	..	..	..	..	4·00	4·30	9·90
August	29·2	24·80	24·85	10·22	2·20	1·35	2·00	2·65	6·40	..	2·35	1·00	0·75	1·00	0·50	0·50	6·50	3·10
September	16·49	4·15	16·91	8·74	5·75	5·85	9·00	1·25	0·65	...	3·40	11·25	.*	4·75	3·50	7·80	1·75	8·10
October	2·40	1·61	12·45	1·99	6·75	7·25	13·75	3·50	18·10	*5·50	4·01	6·75	9·50	6·75	3·50	5·00	5·75	2·15
November	0·92	0·70	4·61	0·83	14·50	3·00	1·65	3·9	10·90	19·85	18·13	3·75	0·50	0·50	0·75	4·15	7·80	1·05
December	2·63	..	1·66	...	...	4·75	25·25	8·00	...	20·10	1·27	0·50	4·75	12·00	3·25	2·45	5·35	3·20
Sum	147·58	98·44	145·60	121·67	33·55	44·40	59·50	26·25	51·30	45·45	34·39	33·55	33·00	29·40	17·10	27·25	36·03	31·60
Mean					2·79	4·03	4·95	2·19	4·27	3·7[illegible]	2·[illegible]	3·72	3·00	2·45	1·4[illegible]	2·27	3·00	26·3

* Instrument out of repair. † No Register kept.

APPENDIX C.

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Poona.—Altitude 4000 feet.							Sattara.—Altitude 2320 feet.						Belgaum.—Alt. 200 feet.				Dharwar.
	1842	1844	1845	1846	1847	1818	1849	1836	1844	1845	1846	1847	1848	1841	1842	1843	1847	1844
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	..	...	..	..	...	..	...	..	0·03	0·04	..	..	...	..	0·20	..	...	...
February	..	...	...	..	...	...	...	...	0·07	0·06	0·18	..	..	..	...	...	0·04	..
March	..	...	..	..	0·24	...	...	0·18	..	...	...	0·18	0·04	..	...	3·00	0·30	...
April	...	...	...	...	4·41	1·82	...	0·52	1·02	0·01	..	10·88	0·78	3·10	..	5·30	5·84	2·32
May	..	..	..	1·27	2·51	7·88	1·02	1·16	1·16	...	3·49	0·39	2·79	..	4·35	3·45	5·14	2·20
June	4·43	5·91	3·22	8·79	2·79	3·11	11·87	6·99	9·87	6·04	10·49	3·77	3·36	10·90	7·35	4·15	7·85	6·59
July	24·90	4·29	2·78	9·85	2·71	6.90	6·84	10·59	11·72	7·77	16·04	6·28	12·02	18·50	14·34	18·55	7·90	7·34
August	12·24	1·07	1·66	0·10	1·48	1·69	7·92	6·98	4·41	11·91	2·13	2·68	2·55	4·90	12·20	11·20	4·65	3·79
September	7·00	2·93	5·55	1·48	2·11	2·12	...	4·40	4·12	9·71	0·77	3·55	1·40	3·50	8·70	5·10	1·04	0·72
October	..	...	1·13	4·73	0·87	3·08	..	3·15	3·55	2·70	2·98	5·25	2·28	6·78	1·15	5·09	6·49	3·32
November	..	..	..	1·42	5·09	1·34	..	4·45	...	2·00	0·98	8·00	1·71	3·78	3·46	...	2·42	...
December	...	..	...	0·23	..	..	..	0·11	0·11	...	2·46	0·05	...	..	...	...	...	0·47
Sum	48·67	14·19	14·34	25·35	22·21	27·95	27·65	38·51	36·06	40·24	39·52	40·98	37·81	51·46	51·74	50·84	41·57	32·65

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Dharwar.			Ahmednuggur.—Altitude 1900 feet.				Malcolm Pait.—Alt. 4500 feet.						Phultun.			Rutnagherry.	
	1845	1846	1847	1844	1845	1846	1847	1820	1842	1844	1845	1846	1847	1846	1847	1848	1844	1845
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	...	...	...	...	0.10	...	..	...	...	...	1·96	..	...	...	..	..	..	...
February	0·06	...	...	...	..	...	0·78	...	...	0·14	...	0·09	...	...	0·02	...	...	...
March	1·70	...	1·55	...	1.81	..	0·73	...	...	..	7·64	...	1·00	..	0·5[illegible]	..	..	...
April	1·02	...	0·54	0·75	0·09	0·23	2·29	...	...	...	0·06	...	11·48	1·14	4·19	...	...	...
May	3·75	1·50	4·15	0·95	8·63	4·06	2·96	...	..	..	0·13	3·81	6·84	1·06	2·88	6·24	...	...
June	6·98	8·14	2·87	4·03	3·30	4·36	8·96	53·60	37·86	47·89	45·69	69·73	41·80	3·80	1·53	4·39	19·80	29·33
July	7·21	12·06	4·39	1·83	0·03	8·79	2·[illegible]0	43·60	117·76	114·78	92·06	119·52	56·61	1·97	0·84	2·70	33·55	29·83
August	6·94	12·21	5 9	1·21	3·22	1·63	2·58	61·62	77·75	74.65	74·49	50·07	64·65	..	0·50	1·24	17·03	11·35
September	4·71	3·63	3·56	10·54	0·71	7·02	8·94	37·57	56·00	21.81	24·59	41·10	25·94	1·05	2·00	34·57	10·70	10·95
October	6·41	2·15	2·26	0·21	0·04	0·72	0·12	..	..	2.88	3·27	2·45	3·30	2·50	3·06	2·45	6·69	6·92
November	0·69	7·79	8·80	...	1·10	..	6·4[illegible]	...	..	...	..	1·20	7·15	5·05	4·60	3·59	...	...
December	...	0·40	...	...	...	0·37	...	...	...	0.17	0·04	0·32	..	1·50	0·89	...	...	...
Sum	39·50	48·91	34·90	19·50	24·22	24·22	26·03	196·42	389·37	262·32	249·93	83·34	218·80	18·09	24·01	24·18	87·77	88·26

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Rutnagherry.		Tanna.				Dapoolie.—Alt. 9000 feet.				Paunchgunnee. Alt. 400 feet.			Nassik.			
	1846	1847	1844	1845	1846	1847	1844	1845	1846	1847	1835	1842	1843	1844	1845	1846	1847
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
March	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
April	..	..	..	..	..	..	..	..	..	11·67	..	..	..	..	..	..	..
May	..	5·79	..	..	..	..	..	..	..	5·36	..	..	..	..	..	..	..
June	59·20	58·00	26·57	28·89	36 76	45·00	26·31	28·89	36 76	45·24	12·96	4·48	10·94	12·94	4·35	6·37	3·71
July	51·72	28·81	44·09	31·28	57·72	20·69	63·85	31·28	57·72	32·74	10.75	24·93	18·37	6·59	4·26	10.87	5·00
August	13·27	21·44	15·49	15·64	13·59	25·03	25·96	15·64	13·59	15·98	13·28	12·24	16·37	2·88	6·05	2·27	3·65
September	16·95	6·00	12·39	12·02	22·90	14·20	13·32	12·02	22·90	8·47	13·52	7·04	7·12	2·69	5·11	2 18	1·80
October	4·36	3·61	..	..	..	..	5·70	..	..	0·63	..	..	..	0·70	..	6·89	5·70
November	..	9·97	..	..	..	..	..	..	..	3·68	..	..	..	..	..	..	6·05
December	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Sum	145·51	133·65	98·54	87·83	133·97	104·83	135·14	147·64	133·31	113·77	50·54	48·67	52.80	25·80	26·78	26·38	25·94

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Batticotte, Near Jaffna.		Baroda					Meera.	Entreshwar.	Bhore.	Whye.	Jhutt.	Ultray Mullay.	Trevandrum.	Quilon.
	1847	1848	1838	1839	1840	1841	1842	1848	1848	1848	1848	1848	1844	1844	1844
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	1·57	1·35	..	..	..	...	...	...	...	...	..	...	...	...	...
February	1·70	0·76	..	..	..	...	...	...	...	...	...	...	...	...	...
March	1·42	0·95	..	..	..	...	...	...	...	...	...	...	...	...	...
April	2·06	10·96	..	..	..	...	...	...	...	...	...	...	...	...	...
May	0·24	2·80	5·09	..	..	...	...	...	...	...	...	...	...	...	...
June	1·80	0·08	5·10	0·55	10·67	8·46	5·95	2·75	2·60	2·10	2·00	1·59	...	...	...
July	0·96	1·76	12·00	16·80	8·40	11·96	16·76	10·93	5·98	2·37	2·20	3·07	7·75	0·75	0·75
August	1·00	2·35	3·04	7·81	1·15	10·83	10·50	22·90	19·83	13·20	9·05	4·80	26·75	3·75	5·75
September	0·09	5·14	1·14	3·60	2·20	0·43	11·92	6·16	5·02	5·19	1·61	2·64	23·00	5·75	6·75
October	18·28	2·24	..	..	...	..	1·50	2·30	1·80	0·91	0·96	3·88	6·00	3·75	2·50
November	11·62	18·72	..	..	...	...	...	2·75	2·27	1·50	2·75	2·17	41·50	15·25	14·00
December	12·26	4·4	..	..	...	..	...	1·85	0·19	4·15	2·25	2·17	36·25	4·50	3·25
								...	..	...	..	...	22·85	2·25	3·25
Sum	54·18	51·50	26·28	28·76	22·42	31·68	46·13	46·64	38·69	29·42	20·73	18·17	164·00	36·00	36·50

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Kurrachee.	Kolapoor.	Sawunt Waree. No. 1		Futteghurh. No. 1		Aurungabad. No. 1	Hoshungabad. No. 1		Alibaugh. No. 2	Secunderabad. No. 2		Soorapoor. No. 2	Ahmedabad No. 2
	1847	1847	1848	1849	1848	1849	1847	on ground. 1819	13 feet. 1849	1845	1843	1844	1847	1843
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	..	...	...	..	...	1·75	..	1·49	1·44	...	4·25	0·25	..	...
February	...	...	..	..	...	..	...	..	...	...	...	0·05	..	...
March	...	..	...	...	..	..	...	..	...	..	2·20	5·40	...	..
April	..	..	..	..	..	...	0·12	0·12	0·12	...	...	0·30	..	...
May	...	..	4·37	...	..	0·03	5·69	0·72	0·72	..	0.30	11·25	..	2·03
June	3·00	1·62	41·09	23·41	..	5·40	7·85	9·07	8·93	29·67	0·75	...	8·14	4·16
July	..	6·40	45·63	50·99	3.47	1·40	6·78	...	..	19·05	18·80	8·60	9·03	7·62
August	..	3.75	36·70	11·68	3·16	7·62	2·39	...	..	10·04	4·55	7·39	8·28	2·19
September	..	0·82	6·77	26·10	10·57	10·91	18·31	..	...	8·41	7·35	4·80	8·79	..
October	...	4·72	4·37	0·75	0·26	5·80	1·00	...	..	..	3·40	5·20	...	...
November	..	3·43	...	0·63	..	0·12	1·86	..	..	...	..	...	...	..
December	...	...	..	...	0·57	0·03	...	..	..	...	..	0·20	..	...
Sums	3·00	20·74	38·93	113·57	28·05	33·06	44·00	11·36	11·27	67·17	41·63	43·44	29·24	16·00

No. 1. Taken from Manuscript Registers. No. 2 from Dr Buist's Manuscript Book.

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

MONTHS.	BELLARY. No. 2.		MERKAE. No. 2. 4560 feet.		DODABETTA. No. 3. 86·40 feet.		TAVOY No. 4.	MADRAS.								
	1841	1842	1836	1837	1847	1848	1831	1820	1821	1822	1823	1824	1825	1840	1841	1842
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in	in.	in.	in.	in.	in.
January	..	...	..	...	..	0·12	..	..	3·60	1·67	1·45	1·27	0·17	...	1·75	2·40
February	0·02	..	..	..	7·43	..	..	...	...	..	...	...	...	...	..	...
March	0·03	...	...	1·29	3·61	..	..	6·75	0·32	..	0·92	..	...	..	..	0·30
April	4·19	0·02	..	0·21	19·80	...	...	0·50	1·70	0·52	...	...	..	..	1·00	..
May	0·09	1·81	...	7·64	4·86	...	23·30	17·17	...	...	0·27	...	4·25	..	4·50	..
June	4·40	2·75	20·3	...	4·55	...	36·40	0·85	1·10	1·52	2·05	...	1·37	...	3·35	..
July	1·17	0·60	23·74	..	7·41	...	57·40	3·52	1·29	0·55	2·87	0·25	3·07	4·75	1·15	2·15
August	6·10	1·74	24·74	..	9·32	...	39·20	3·17	3·17	6·70	3·15	2·65	7·67	6·55	8·60	4·15
September	4·61	8·45	7.02	...	7·52	..	28·70	1·70	7·30	2·37	4·40	0·47	3·50	6·07	5·55	5·20
October	5·38	2·21	0·56	...	12·49	...	24·50	12·28	13·02	20·57	10·40	14·35	17·47	7·55	24·40	7·45
November	0·39	0·03	1·55	..	11·85	...	...	4·50	11·35	21.37	0·90	10·27	11·09	2·70	6·55	11·70
December	0·02	..	0·37	..	12·28	..	...	19·70	4·35	3·27	0·20	3·95	7·35	...	1·15	0·25
SUMS	26·40	17·57	78·32	9·14	10·12	0·12	209·50	70·14	47·11	58·48	26·61	33·21	55·94	27·62	58·00	33·60

No. 2 from Dr Buist's Manuscript Book. No. 3 from Meteorological Register of Dodabetta. No. 4 from Medical Topography, 1844, Madras.

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Madras.								Mangalore.	Nagpore.						
	1843	1844	1845	1846	1847	1848	1849	1839	1850	1826	1827	1828	1829	1830	1831	1832
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	5·40	16·15	4·10	1·16	...	...	...	3·342	...	2·30	0·40	0·19	...	...	...	...
February	0·20	9·50	...	3·50	0·90	...	1·431	...	...	..	0·50	1·21	0·76	...	...	2·98
March	2·05	...	...	...	...	...	0·587	...	...	...	3·84	0·71	2·49	1·57	...	...
April	...	...	...	...	0·50	2·234	1·570	1·624	...	...	0·01	0·06	0·06	0·68	...	...
May	13·15	2·90	...	19·00	0·10	2·557	2·014	0·694	9·39	1·10	0·21	1·55	...	1·35	...	...
June	1·15	3·00	...	2·10	3·18	0·184	2·371	2·584	48·51	22·23	6·25	8·37	8·07	8.34	13·78	8·01
July	0·80	2·14	0·15	6·17	1·05	2·654	1·504	4·614	32·00	12·00	14·95	9·33	15·94	7·10	7·22	14·49
August	2·10	1·17	1·90	3·14	6·80	1·689	5·292	6·826	12·68	18·50	7·51	9·07	7·89	7·00	14·58	3·46
September	4·55	6·30	4·16	0·11	5·35	3·797	8·784	11·142	6·46	0·13	16·32	9·40	6·32	4·73	11·98	7·77
October	7·20	15·00	3·70	24·15	16·00	15·804	6·314	0·992	..	0·04	...	6·40	8·22	1·98	7·24	...
November	7·00	0·70	3.12	18·60	16·10	17·166	21·894	21·269	..	1·31	2·89	0·20	...	...	2·27	...
December	7·15	14·14	10·10	...	23·00	3·492	3·216	...	...	...	0·13	...	0·50	...	8·24	...
Sums	50·95	80·95	27·23	73·43	72·20	49·677	54·977	53·187	109·04	65·16	53·99	46·61	50·25	33·00	65·31	37·14

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

	Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
30 feet. Cochin.	1842	..	...	..	3·05	25·07	25·05	13·70	21·65	10·15	3·55	3·65	...	105·27
	1843	5·15	...	2·00	4·50	27·15	37·32	21·05	4·27	7·75	9·45	0·10	5·75	124·49
	1844	..	0·45	1·70	1·70	13·35	22·42	19·10	11·75	2·25	17·55	4·50	7·07	101·97
	1845	3·52	..	3·80	2·20	3·57	31·37	16·10	11·21	1·67	11·85	0·92	4·45	9·60
	1846	0·02	..	0·70	4·80	19·70	37·32	16·72	16·27	2·15	5·95	2·25	0·10	106·00
Means.	....	1·72	0·09	2·04	3·25	18·97	30·39	17·33	13·09	4·82	9·67	2·28	2·27	106.00
30 feet. Quilon.	1842	..	1·17	1·32	3·20	22·24	16·00	8·65	8·60	7·42	4·87	7·47	...	81·06
	1843	1·42	0·47	0·50	9·85	24·62	26·52	20·72	7·45	5·15	5·86	2·15	1·00	105·72
	1844	..	...	0·55	0·70	8·15	15·55	9·75	6·70	2·37	13·95	3·25	3·60	6·57
	1845	3·30	..	4·65	0·25	4·85	13·80	9·55	3·95	0·45	15·35	1·85	3·70	61·71
	1846	..	..	2·90	1·60	22·70	17·65	10·55	3·80	1·30	9·40	4·75	0·10	74·75
Means.	....	0·94	0·30	1·98	3·14	16·51	17·90	11·04	6·10	3·34	9·88	3·89	1·68	76·76
30 feet. Allepy.	1842	1·15	0·25	2·92	2.50	27·67	20·00	10·60	12·30	7·57	12·95	6·50	0·10	104·02
	1843	3·20	0·75	6·90	5·75	30·12	32·80	21·57	5·22	9·72	9·12	0·90	5·77	131·85
	1844	0·37	2·87	2·55	3·00	23·33	23·13	16·60	10·42	4·92	15·37	9·90	5·40	118·71
	1845	4·92	0·50	8·80	2·65	17·80	25·30	11·92	6·47	1·00	9·67	4·35	4·50	97·80
	1846	..	1·70	0·20	3·15	31·45	29·00	12·45	12·27	3·42	13·00	5·77	1·00	113·43
Means..........	.....	1·90	1·21	4·27	3·41	26·27	26·02	14·63	9·33	5·32	12·02	5·48	3·35	113·26
50 feet. Cape Comorin.	1843	0·90	..	...	...	6·50	0·80	0·95	...	0·65	4·80	...	4·60	19·20
	1844	...	...	..	...	1·20	3·00	...	...	1·00	7·50	4·60	2·20	19·00
	1845	0·20	...	0·90	..	1·30	2·20	0·70	...	...	10·70	1·40	hy. sh.	18·00
	1846	...	...	2·80	3·20	9·40	12·25	1·20	1·45	...	12·10	9·82	4·40	56·72
Means..................	....	0·27	...	0·98	0·75	4·55	4·56	0·71	0·36	0·41	8·77	3·95	2·80	28·36

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

	Years	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
60 feet. Vaurioor close to Cape Comorin.	1842	0·35	0·65	...	...	2·25	1·20	..	0·40	1·82	4.35	9·25	...	20·27
	1843	1·40	1·00	0·75	0·40	9·90	2·05	0·80	0·10	0·35	4·15	0·45	4·40	25·75
	1844	...	0·50	0·20	...	0·90	3·00	0·80	...	0·15	7·45	3·70	1·35	18·05
	1845	2·75	...	3·65	...	1·70	1·45	2·70	...	0·35	12·92	2·40	8·90	36·82
	1846	...	...	0·90	1·65	5·20	2·60	0·55	...	...	4·00	5·50	1·75	22·45
Means..............	....	0·90	0·43	1·10	0·41	3·99	2·12	0·97	0·10	0·53	6·57	4·26	3·28	22·67
130 feet. Trevandrum.	1842	3·70	0·35	0·85	3·60	13·70	9·30	4·25	3·75	6·30	3·05	8·30	0·35	57·70
	1843	0·80	0·02	2·52	8·80	17·12	16·62	12·90	2·55	3·10	7·52	2·[illegible]5	11·42	85·45
	1844	...	...	1·10	0·30	4·55	6·15	3·80	5·67	3·75	15·[illegible]7	4·10	2·15	47·05
	1845	4·40	0·77	3·40	0·[illegible]5	4·55	15 80	4·30	0·90	0·16	18·52	3·92	5·0[illegible]	62·57
	1846	0·10	...	1·07	4·02	11 42	17·75	6·92	3·67	0·75	17·50	4·40	2·80	69·90
Means..................	....	1·80	0·[illegible]3	1·79	3·57	10·27	13·16	6·50	3·31	2·81	12·35	4·61	4·24	64·54
200 feet. Palamcottah.	1842	1·2	0·19	1·05	0·45	0·55	0·02	0·01	0·03	2·50	6·60	9·62	0·95	23·12
	1843	4·02	2·50	0·77	1·20	5·65	..	...	...	...	7·15	1·65	3·95	26·90
	1844	0·20	0·55	...	0·75	0·10	1·17	0·05	...	1·75	2·65	1·70	2·76	11·68
	1845	0·43	...	5·27	0·55	1·62	0·15	..	...	0·6[illegible]	6·17	2·02	8·75	25·63
	1846	0·80	1·35	0·57	2·30	4·05	0·07	0·07	...	0·30	1·80	5·97	0·65	17·75
Means..................	....	1·33	0·92	1·53	1·05	2·39	0·28	0·03	0·06	1·05	4·87	4·19	3·41	21·06
600 or 700 feet. Shenkottah.	1·42	1·20	1·30	...	2·05	3·90	5 65	2·80	1·40	3·10	3·2[illegible]	14·85	...	39·45
	1843	4·15	0·80	2·45	4·15	11·20	4·80	6·20	1·05	1·15	7·15	1·50	3·50	48·10
	1844	..	...	2·40	...	0·50	3·60	...	1·80	1·60	6·25	4·25	3·70	24·10
	1845	2·00	..	4·40	2·20	..	3 80	4·65	0·35	...	15·40	4·05	5 58	42·70
	1846	0·57	..	0·70	4·65	6·20	8·60	3·40	1·10	2·50	5·9[illegible]	4·47	3·45	41·60
Means..................	....	1·58	0·42	1·99	2·61	4·36	5·29	3·41	1·14	1·67	7·59	5·82	3·30	39·19

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Anjarakandy.—Altitude 20 feet.														Calcutta.			
	1810	1811	1812	1813	1814	1815	1816	1817	1818	1819	1820	1821	1822	1823	1836	1837	1838	1839
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	...	...	...	...	..	..	...	...	...	..	...	...	0·73	0·04	..	...	..	1·34
February	..	...	...	...	1·10	..	...	..	..	..	0·12	..	...	...	2·16	0·06	0·12	0·23
March	...	0·15	..	0·03	..	...	..	..	..	0·30	..	0·14	..	3·55	0·25	0·22	0·36	0·31
April	0·37	3·22	0·45	0·27	0·90	2·05	0·95	0·10	0·19	1·76	3·44	0·91	0·86	0·96	..	0·98	1·43	1·31
May	20·82	5·70	4·85	10·55	...	3·80	2·00	5.85	1·07	3·45	17·54	10·07	9·20	2·35	2·35	3·07	2·13	7·84
June	27·00	36·75	39·05	18·30	23·40	31·50	24·95	27·70	43·17	34·94	45·29	19·77	32·64	32·97	5·19	5·73	11·76	9·12
July	36·85	23·35	18·45	21·70	43·20	47·70	37·15	53·00	53·98	41·58	29·53	36·29	41·99	60·02	11·74	7·93	10·43	14·77
August	15·70	18·50	20·20	25·60	25·55	10·90	22·80	13·90	49·97	23·81	29·22	24·80	24·85	10·22	10·00	10·12	11·08	9·45
September	12.65	2·70	13·55	7·55	15·90	18·40	7·90	14·90	11·77	20·31	16·49	4·15	16·91	8·74	13·61	9·82	8·16	18·95
October	3·47	13·67	3·05	9·85	3·65	10·25	3·55	12·75	6·27	2·66	2·40	1·61	12·45	1·99	...	4·68	7·52	0·59
November	1·60	0·85	0·10	...	1·40	8·15	0·60	6·80	2·57	6·66	0·92	0·70	4·61	0·83	6·16	0·03	..	1·06
December	7·47	...	3·00	...	...	0·65	..	1·07	0·23	..	2·63	..	1·66	..	...	0·07	..	..
Sums	125·90	104·90	102·70	93·85	115·10	133·40	100·00	136·07	169·19	135·47	147·58	98·44	145·60	121·67	51·66	43·61	52·99	64·97

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Calcutta.													Maulmain No. 1.					
	1840	1841	1842	1843	1844	1845	1846	1847	1848	Elev. 40 feet 1848	Elev. 4 feet. 1848	1849	1850	1829	1830	1831	1832	1833	1834
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.		in.	in.
January	...	0·84	...	1·67	1.22	1.10	0·82	...	...	2·36	2·44	...	0·00	...	...	..	It rained on 126 days, and there fell 180 inches.	..	...
February	...	0·24	...	0·64	1·08	0·64	1·80	..	...	1·35	1·67	...	2·00	...	..	...		...	...
March	0·44	0·76	3·76	1·20	0·22	0·17	2·30	...	0·41	1·77	2·16	...	1·52	...	1·03	..		..	..
April	0·80	3·26	3·73	2·42	3·13	7·30	0·57	2·38	1·31	0·16	0·32	...	1·28	3·41	1·32	...		...	...
May	8·05	5·31	1·92	5·33	7·44	1·42	2·49	4·79	6·22	6·78	7·22	...	3·30	5·21	6·39	13·00		22·00	29·00
June	13·05	7·03	26·24	8·64	12·13	10·66	12·14	12·01	13·52	11·94	13·40	...	11·99	24·57	16·38	28·35		57·00	36·00
July	9·01	14·09	9·61	10·15	13·72	12·88	20·07	15·69	17·50	15·52	12·24	..	15·34	31·66	31·12	42·00		46·00	23·50
August	21·31	13·96	21·97	20·05	26·91	15·26	...	15·09	9·22	8·67	9·62	...	14·88	39·72	20·34	23·33		42·00	37·00
September	4·94	11·69	4·08	11·19	5·02	4·80	9·97	10·95	4·74	4·63	5·35	...	20·59	27·63	27·93	22·55		44·00	30·12
October	1·84	3·16	3·96	2·16	4·99	5·86	10·76	5·86	5·61	3·84	4·03	...	3·61	...	2·43	10·55		7·50	14·50
November	...	...	0·19	...	...	...	0·74	5·59	0·20	..	...	...	1·76	...	5·19	1·90		...	7·00
December	...	...	0·76	0·86	...	0·86	1·52	0·05	0·16	...	...	...	0·00	..	1·02	...		...	..
Sums	69·41	62·25	76·12	64·34	73·86	60·92	63·18	72·41	58·79	49·02	58·45	70·51	76·27	132·20	113·15	141·65	80·00	218·50	177·12

No. 1. Taken from the Madras Medical Topography of 1844.

REGISTER OF THE PLUVIOMETER AT OUTSTATIONS.

Months.	Maulmain. No. 1.								Penang. No. 2.				Kamptee. No. 1.	Secunderabad. No. 1.	Malacca.	Woosung. No. 3.	
	1837	1838	1839	1840	1841	1842	1843	Mean fall in year.	1833	1834	1835	1836	1843	1843	1828	1848	1849
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	..	...	..	..	...	..	...	...	0·90	5·92	4·85	1·70	4·25	0·25	10·00	3·83	0·70
February	...	...	...	..	0·15	0·30	...	0·03	3·85	2·40	2·85	1·25	..	0·05	7·92	1·09	3·85
March	...	1·80	..	..	..	...	...	0·23	1·95	6·10	9·77	3·30	2·20	5·40	9·80	2·59	2·91
April	...	3·45	2·87	1·90	...	0·80	...	1·14	5·45	6·60	6·12	10·52	...	0·30	4·35	4·66	3·01
May	33·25	15.32	23·61	19·61	13·40	11·10	13·40	17·52	3·25	7·50	5·05	2·17	0·30	11·25	6·85	0·86	15·98
June	15·93	39·36	35·69	30·10	44·80	52·50	32·10	34·39	9·75	4·80	6·60	8·60	0·75	..	4·00	3·88	9·99
July	44·36	59·07	56·82	54·79	57·80	55·10	34·45	41·85	3·90	6·77	12·47	4·27	18·30	8·60	...	7·01	11·33
August	63·64	62·11	24·32	46·91	26·55	24·60	39·10	37·46	6·30	10·80	9·07	14·85	4·55	7·39	8·70	3·57	..
September	26·00	39·95	23·20	16·10	20·40	40·20	26·97	28·74	6·17	12·95	8·10	11·80	7·35	4·80	12·50	2·00	..
October	13·27	5·83	13·18	12·90	2·21	6·60	2·00	7·58	10·65	13·45	11·12	14·25	3·40	5·20	9·00	3·15	..
November	6·14	3·10	1·50	2·10	0·80	1·00	0·50	2·43	5·12	9·02	14·97	6·12	...	..	7·75	1·37	..
December	..	..	...	...	1·95	...	1·60	0·36	5·02	3·42	3·45	4·91	...	0·20	9·28	0·54	...
Sums	202·59	229·99	181·19	184·41	173·06	192·10	150·12	189·68	62·27	89·78	94·52	83·74	41·60	43·64	90·12	34·55	47·77

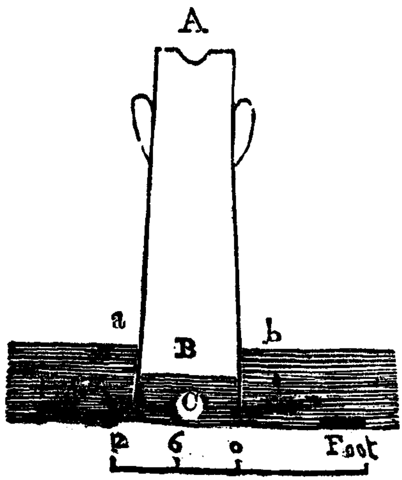
No. 2. These Observations were made on the North Beach, at a few feet above the Level of the Sea. Taken from the Madras Medical Topography for 1844. No. 3. Manuscript Registers kept at the Woosung Dispensary.

THE MARINE TELESCOPE.

(From Jameson's Edinburgh Philosophical Journal for July.)

Description of the Marine Telescope. By John Adie, F. R. S. E., F. R. S. S. A. Communicated by the Author.

The instrument which has been popularly named the Water, or Marine Telescope, from the power given by its use to see into the water, consists of a tube of metal or wood, of a convenient length, to enable a person looking over the gunnel of a boat to rest the head on the one end, while the other is below the surface of the water; the upper end is so formed, that the head may rest on it, both eyes seeing freely into the tube. Into the lower end is fixed (water-tight) a plate of glass, which, when used, is to be kept under the surface of the water.



A very convenient size for the instrument represented in the above figure, is to make the length A. C. 3 feet and the mouth A, where the face is applied, of irregular oval form, that both eyes may see freely into the tube, with an indentation on one side, that the nose may breathe freely, not throwing the moisture of the breath into the tube. B is a round plate of glass, 8 inches diameter, over which is the rim or edge C; this rim is best formed of lead, ¼ of an inch thick, and 3 inches deep; the weight of the lead serves to sink the tube a little into the water. Holes must be provided at the junction of B to C, for the purpose of allowing the air to escape, and bring the water into contact with the glass; on each side there is a handle for holding the instrument. This size and form, is very much that of the instrument brought from Norway by John Mitchell, Esquire, Belgian Consul of Mayville, with the improvement for excluding the breath, and allowing the water to get into contact with the glass, which was not provided for in that instrument.

The reason why we so seldom see the bottom of the sea, or of a pure lake, where the depth is not beyond the power of natural vision, is not that the rays of light reflected from the objects at the bottom are so feeble as to be imperceptible to our sense, from their passage through the denser medium of the water, but from the irregular refraction given to the rays in passing out of the water into the air, caused by the constant ripple or motion of the surface of the water, where that refraction takes place. Refractions of light from the surface also add to the difficulty; and before we can with any just hopes expect to see the objects distinctly at the bottom, these obstructions must be removed.

This is done to a very great extent by the use of the instrument which forms the subject of this notice; the tube serves to screen the eyes from the reflections, and the water being in contact with the glass plate, all ripple is got rid of, so that the spectator, looking down the tube, sees all objects at the bottom, whose reflective powers are able to send off rays of sufficient intensity to be impressed on the retina, after suffering the loss of light caused by the absorbing power of the water which obeys certain fixed laws, proportionate to the depth of water passed through; for as light passing through pure sea-water loses half its intensity for each 15 feet through which it passes,* we must, from this cause alone, at a certain depth lose sight of objects of the brightest lustre. The perfect purity of the water, and its freedom from all muddy particles floating in it, form an important element in the effective use of the water telescope; for example, in the Firth of Forth and similar estuaries, where the influx and reflux of the tide keep particles of mud in constant motion, the instrument is of little or no use; for these act in exactly the same way in limiting our vision through water as a fog does through the air: it is therefore only in the pure waters of our northern and western shores that this countrivance is applied with any advantage; and in such situations we can speak of its powers with confidence. In a trial made with the instrument last autumn on the west coast of Scotland, the bottom was distinctly seen (a white bottom) at a depth of 12 fathoms, and on a black, rocky bottom, at 5 fathoms under water, objects were so distinctly seen that the parts of a wreck were taken up—the exact place of which was not known previous to its use. In these experiments a lenticular form of glass was made use of at the bottom of the tube, having a plane surface to the water, but no great or marked advantage was observable from this construction. With respect to the history of this contrivance for viewing the bottom of the sea, we are unable to assign any particular date: so far as our information goes, it has been in use from a very remote period. We are informed that it is in general use in seal-shooting along our northern and western islands, where, sometimes in the form of an ordinary washing-tub, with a piece of glass filled in its bottom, the shot-seal was looked for, and the grappling-hook let down to bring him to the surface. It may not be generally known, that in seal-shooting, the shot or wounded seal always seeks the bottom, from which he never rises after death, till washed ashore by the action of the sea: it is only when the fatal ball deprives him of the power of diving that he is ever found at the surface. In such employments, therefore, the use of this instrument however modified, must form an important auxiliary to the best rifle. Throwing oil over the surface of the water is used in the same pursuits; but this only so far stills the ripple, leaving the reflections. Our eminent engineer, Mr Robert Stevenson, made use of the water-telescope more than 30 years ago, in works connected with harbour improvement in the north of Scotland; it has also been used to examine the sand-banks, &c.,

* Leslie's Elements of Nat. Phil., p. 19.

at the bottom of the River Tay, but in this case the mud prevented its use in any considerable depth of water. To obviate this difficulty, the construction was modified thus: by making the tube of considerable length, and placing the glass at the lower end, this tube was thrust through the water till within a few feet of the bottom, acting as a cofferdam to set aside the dirty water, and enable the bottom to be seen; but in this method of application it was found very difficult to hold the tube down in the water from its buoyant power, and we are informed by Mr Thomas Stevenson, C. E., that he understood from this cause its use had been discontinued. He suggested a simple remedy viz., to fill up the empty tube with pure water. We are indebted to Mr Mitchell, the gentleman already mentioned, for having brought this instrument into notice in the public, prints, under the name of the Norwegian water-telescope, on the shores of which country it is stated to be much used in fishing—in particular, that of the herring; but the herring-fishers on the east coast of Scotland inform us, that they require no such auxiliary, as from the surrounding elevated grounds, they can tell the position of the shoal, and, from their motions seen from such situations, they know where they are to be found when they go out afishing.*

NOTE.—The water-telescope is thus noticed in a very promising periodical, the American Annual of Scientific Discovery, just published, of which a copy reached us a few days ago —ED. *Phil. Journal.*

" The water-telescope is an instrument which the people of Norway have found of so great utility, that there is scarcely a single fishing boat without one of three or four feet in length, which they carry in their boats with them when they go a fishing. When they reach the fishing-grounds, they immerse one end of this telescope in the water, and look through the glass, which shews objects some ten or fifteen fathoms deep as distinctly as if they were within a foot of the surface. When a shoal of fish comes into their bays, the Norwegians instantly prepare their nets, man their boats, and go out in pursuit. The first progress is minutely to survey the ground with their glasses, and where they find the fish swarming about in great numbers, they give signal, and surround the fish with their large draught-nets, and often catch them in hundreds at a time. Without these telescopes their business would often prove precarious and unprofitable; as the fish by these glasses, are as distinctly seen in the deep clear sea of Norway, as gold-fish in a crystal jar. This instrument is not only used by the fishermen, but is also found aboard the navy and coasting-vessels of Norway. When their anchors get into foul ground, or their cables are warped on a roadstead, they immediately apply the glass, and, guided by it, take steps to put all to rights, which they could not do so well without the aid of the rude and simple instrument, which the meanest fisherman can make up with his own hands without the aid of a craftsman. This instrument has been lately adopted by the Scotch fishermen on the Tay, and by its assistance, they have been enabled to discover stones, holes, and uneven ground, over which their nets travels and have found the telescopes answer to admiration, the minutest object in twelve feet of water being as clearly seen as on the surface. We see no reason why it could not be used with advantage in the River and Bays of the United States."

* *Norwegian Water Telepe.oos*

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