Official, No. 162.

(9)

METEOROLOGICAL OFFICE, LONDON.

HINTS

TO

METEOROLOGICAL OBSERVERS IN TROPICAL AFRICA,

WITH

INSTRUCTIONS FOR TAKING OBSERVATIONS

AND

NOTES ON METHODS OF RECORDING LAKE LEVELS.

Published by the Authority of the Meteorological Council.
1902.

LONDON:
PRINTED FOR HIS MAJESTY'S STATIONERY OFFICE,
By DARLING & SON, Ltd., 34-40, Bacon Street, E.

And to be purchased, either directly or through any Bookseller, from
EYRE & SPOTTISWOODE, East Harding Street, Fleet Street, E.C.,
or OLIVER & BOYD, Edinburgh;
or E. PONSONBY, 116, Grafton Street, Dublin.

1902.

Price Ninepence.

PREFACE.

The following memorandum constitutes a revised edition of the "Hints to Meteorological Observers in Tropical Africa," prepared in 1892 by a Committee of the British Association for the Advancement of Science, 1891, consisting of E. G. Ravenstein, F.R.G.S. (Chairman); Baldwin Latham, C.E., F.G.S.; G. J. Symons, F.R.S.; and H. R. Mill, D.Sc., Secretary.

After ten years of activity the Committee made its final report to the meeting of the British Association at Glasgow in 1901; and, as official applications for information regarding the selection and exposure of instruments are from time to time referred to the Meteorological Office, and similar inquiries are addressed to the Office by private observers, the Meteorological Council have deemed it desirable to reprint the memorandum, with some slight modifications.

Notes on methods of recording lake levels have been added. They have been contributed by the Hydrographic Department of the Admiralty.

It may here be remarked that the meteorological observations made under the direction of the Government in Uganda and British Central Africa are forwarded by the Foreign Office to the Meteorological Office, where they are available for reference. The Council have in view the regular publication at the earliest opportunity of a summary of these and other observations issued from Dependencies and Crown Colonies of the British Empire.

By order of the Meteorological Council,

W. N. SHAW,

Secretary.

November, 1902.

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HINTS TO METEOROLOGICAL OBSERVERS

IN

TROPICAL AFRICA.

OBSERVATIONS.

The object aimed at by meteorological observations is a regular record of the readings of trustworthy instruments and of associated phenomena. The observations, whether made several times a day, once a day, or even once a week, should always be made at the same hours. At normal stations observations are made three times a day—at 7 a.m., 2 p.m., and 9 p.m. *Local* mean time should be adopted for the observations and noted as being so adopted in the register. Where normal observations cannot be provided for, observations may be made once daily, preferably at 9 a.m.

Regular daily observations of maximum and minimum temperature and of rainfall at auxiliary stations, or of rainfall alone, are valuable. Irregular observations are of little practical value; observations with untrustworthy instruments are of no value whatever.

EQUIPMENT.

A normal outfit of meteorological instruments and accessories is as follows:—

1. A mercury barometer with vernier reading to ·002 inch.
2. A dry-bulb thermometer.
3. A wet-bulb thermometer with muslin, wick, and a vessel to hold water for moistening the wick.
4. A maximum thermometer.
5. A minimum thermometer.
6. A cage of galvanised iron, with padlock, to contain the thermometers.
7. A rain gauge and measuring glass.
8. A book of detailed instructions in the use of instruments, with a cloud-atlas, and tables for the reduction of barometer readings and dry-and-wet-bulb readings, suitable for tropical countries.
9. A rough note book ruled for the observations.
10. Register sheets for a fair copy of the observations.

To these may be added, if desired, a grass minimum thermometer for recording the effect of terrestrial radiation, a black bulb thermometer *in vacuo*, and a similar instrument with bright bulb, for recording the maximum effect of solar radiation, a barograph, a thermograph, an anemometer, earth thermometers at depths of 1 ft. and 4 ft.—for recording the temperature underground, and a percolation gauge. A sunshine recorder is generally unnecessary.

Observations of the direction of wind require a properly-mounted wind vane or some other means of identifying the direction. Observations of wind force, amount and kind of cloud, and other items for normal observations can be made without instruments.

The Meteorological Council will supply trustworthy instruments at 5 per cent. above the contract prices to those observers who undertake to send a copy of their observations to the Meteorological Office either directly or through the Foreign or Colonial Office. They will also supply suitable note books and forms of register.

SELECTION OF INSTRUMENTS.

Barometer.—In tropical countries the variations of the barometric pressure from day to day are as a rule very small. The diurnal variation, with two maxima in the day, is the most conspicuous feature of a tropical record, whereas in temperate latitudes it is marked by large fluctuations which do not occur in the tropics except in storms. Special care and accuracy, as well as punctuality in observing, are necessary on that account. The barometer must be so graduated that the reading may be estimated to ·001 inch. For this purpose the Fortin barometer or the Kew pattern barometer may be employed. For skilled observers the Fortin barometer is to be preferred. It requires two settings—one for the cistern, the other for the vernier. An observer who is not well practised in the use of delicate instruments may easily introduce errors by faulty setting, and from that point of view the Kew pattern barometer, which only requires one setting for an observation, is to be preferred.

Thermometers of ordinary pattern may be employed, care being taken that the range of temperature on the scale is sufficient. The maximum and minimum thermometers in the Meteorological Office equipment are of the "Negretti and Zambra" pattern and the "Rutherford" pattern respectively.

Alcohol thermometers are liable to get out of order by the alcohol distilling and condensing in the upper part of the tube. If it does so, the detached alcohol can generally be shaken back by holding the thermometer in the hand, bulb downwards, and jarring the hand.

Both barometer and thermometers should be specified to have "Kew certificates."

Rain Gauge.—The rain gauge may be either five inches or eight inches in diameter, but care must be taken that the measuring glass corresponds with the gauge.

MOUNTING AND EXPOSURE OF THE INSTRUMENTS.

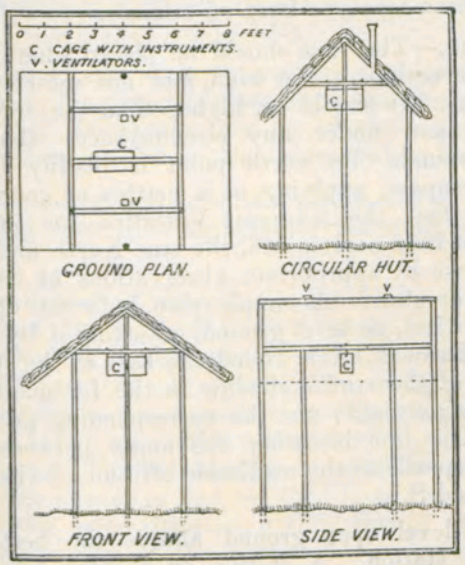
The Barometer should not be exposed to the weather. It may be kept indoors and should be suspended in a vertical

position in a good light, not exposed to the sun. The room should not be subject to sudden changes of temperature. The instrument should be fixed at such a height that the observer can read the vernier comfortably when standing upright. The height of the cistern above sea level should be accurately noted in the register.

Barometers should be *carefully* handled. Before moving a Fortin barometer to a new position first turn the screw below the cistern until the mercury fills the tube, then turn the barometer carefully over, and carry it with the cistern end upwards. A Kew pattern barometer may be gradually inclined until the mercury fills the tube. It also must be transported cistern-end upwards.

Thermometers.—The thermometers require a perfectly free exposure to the moving air but protection from the sun and rain. They are placed within an iron cage, which should at all times be kept locked, so as to prevent interference with the instruments. This cage is suspended under a thatched shelter, which should be situated in an open spot at some distance from buildings, must be well ventilated, and guard the instruments from being exposed to sunshine or rain, or to radiation from the ground. A simple hut,

FIG. 1.



made of materials available on the spot, would answer this purpose. The accompanying drawings (Fig. 1) give some particulars of suitable huts. A gabled roof with broad eaves, the ridge of which runs from north to south, is fixed upon four posts, standing four feet apart. Two additional posts may be introduced to support the ends of the ridge beam. The roof, at each end, projects about 18 inches. In it are two ventilating holes. The tops of the posts are connected by bars or rails, and on a cross-bar is suspended

the cage with the instruments. These will then be at a height of six feet above the ground. The gable ends may be permanently covered in with mats or louvre work, not interfering with the free circulation of the air, or the hut may be circular. The roof may be covered with palm-fronds, grass, or any other material locally used by the natives as building material. The floor should not be bare, but covered with grass or low shrubs.

Care should be taken to fix the cage firmly, so that the maximum and minimum thermometers may not be disturbed by vibration.

The solar radiation thermometers should be supported horizontally on a stand at 4 feet from the ground with the bulbs exposed to the full sun. The grass minimum should also be placed horizontally, with a free exposure to the sky, and should be supported with the bulb free from the ground but as near to it as is consistent with free exposure.

Rain Gauge.—The rain gauge must be fully exposed in an open space. It should be firmly fixed in the ground with the top of the rim one foot, or, if on bare soil, one foot three inches, above it, and perfectly horizontal. It will probably be found expedient to surround the rain-gauge, at a distance of at least 10 feet, by a fence, to keep off animals.

Wind Vane.—The vane should be placed where it is freely exposed to the action of the wind, and not interfered with by local conditions. It should be higher than the trees or buildings near it, and under any circumstances about 25 feet above the ground. Its north point is readily obtained by means of a compass, applying, as a matter of course, the local variation. In case the Magnetic Variation for the particular locality has not been ascertained, the true North and South line should be set out by appropriate observations of Sun shadows, or of the sun or stars. A simple plan is to set up a straight stick in the vertical, on level ground, adjusting it by means of a plumb line. Draw a circle round the base of the stick through the extremity of the stick's shadow in the forenoon; mark the position of this extremity and the corresponding position at the afternoon. The line bisecting the angle between these two positions corresponds to the maximum altitude of the sun and is therefore N. and S.

Moderately level open ground affords the best site for a meteorological station. A station on a steep hill slope gives records which are not comparable with those of a station on level ground.

INSTRUCTIONS FOR TAKING THE OBSERVATIONS.

Register.—All the original observations should be written down at the time in a properly ruled note book, which should

be preserved for reference in case any question should arise about them afterwards. The entries in the book should *under no circumstances* be altered or erased, errors should be noted in the margin.

In entering the observations in the register it is absolutely essential that they be correctly copied from the original note book, and carefully checked.

The first Monthly Register should be accompanied by a description of the station and of its environs, as also an account of the situation, &c., of the instruments. Any subsequent changes in the latter should be duly noted.

Barometer :—

1. Note (to nearest degree) the reading of attached thermometer.

2. If the instrument is a Fortin barometer, bring the surface of mercury in the cistern into contact with the ivory point which forms the extremity or zero of the scale by turning the screw at the bottom of the cistern. The ivory point and its reflected image in the mercury should appear just to touch each other and form a double cone.

If the instrument is a Kew pattern barometer this adjustment is not required, nor is that numbered 5.

3. Adjust the vernier scale so that its two lower edges shall form a tangent to the *convex* surface of the mercury. The front and back edges of the vernier, the *top* of the mercury, and the eye of the observer are then in the same straight line.

4. Take the reading, and *enter the observation as read* without either correcting it to freezing-point or reducing it to the sea-level.

Note on the method of reading the Barometer.—The mode of reading off may be learned from a study of the following diagrams, in which A B represents part of the scale, and C D the vernier, the *lower* edge D denoting the position of the top of the mercurial column. The scale is readily understood; B is 29·000 inches; the first line above B is 29·050; the second line 29·100, and so on. The first thing is to note the scale line just below D, and the next is to find out the line of the vernier which is in one and the same direction with a line of the scale. In Fig. (2), the lower edge of the vernier, D, is supposed to be in exact coincidence with scale line 29·5; the barometer therefore reads 29·500 inches. Studying it attentively in this position it will be perceived that the vernier line *a* is ·002 inch below the next line of the scale. If, therefore, the vernier be moved so as to place *a* in a line with *z*, the edge D. would read 29·502. In like manner it is seen that *b* is ·004 inch away from the line next above it *on the scale*; *c*, ·006 inch apart from that next above it; *d*, ·008 inch from that next above it; and 1, on the vernier, is

·010 below *y*. Hence, if 1 be moved into line with *y*, D would read 29·510. Thus the numbers 1, 2, 3, 4, 5, on the vernier, indicate hundredths, and the intermediate lines the even thousandths of an inch. Referring now to Fig. (3), the scale line next below D is 29·650. Looking carefully up the vernier, if the third line above the figure 3 had coincided with a line on the scale, the reading would have been estimated as follows :— The number 3 indicates ·030, and the third subdivision ·006; thus we should get—

Reading on scale ...	...	29·650
Reading on vernier	...	·030
		·006
Actual reading ...	...	29·686 inches.

In Fig. 3, however, two pairs of lines appear to be almost coincident, and in this case the intermediate thousandth of an inch should be set down as the reading. Thus the reading appears to be 29·684 or 29·686, and the mean 29·685 should be adopted.

Fig. 2.

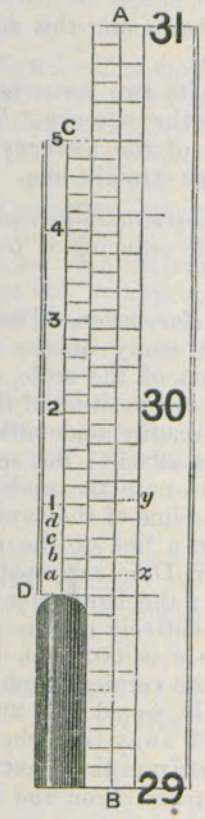
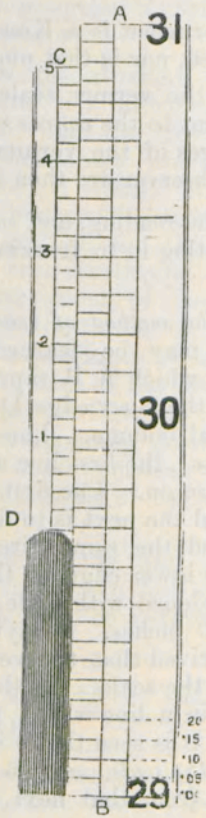


Fig. 3.



5. Lower the mercury in the cistern by turning the screw at the bottom until the surface is well below the ivory point ; this is done to prevent the collection of impurities.

Dry-Bulb and Wet-Bulb Thermometers.—Readings should be entered without applying any corrections for the errors of the instruments. They should be stated in degrees and tenths of degrees.

Five, or preferably, ten minutes before reading the Dry-Bulb Thermometer in damp weather it is to be wiped dry.

The Wet-Bulb Thermometer requires special attention. The bulb should be covered with a piece of thin muslin. Four threads of darning cotton, in the form of a noose, should be *loosely* tied round the neck of the bulb, and led through a small hole in the cover of the water receptacle or cup. Take care to have this cup at all times filled with clean rain or filtered fresh water. Hard water should not be used.

The muslin and the conducting threads must be quite free from grease. To remove grease they should be washed in boiling water, prior to use. They should be changed at least once a month, or whenever there is any appearance of dirt upon them.

When the temperature sinks below freezing point, wet the bulb with a camel hair brush about an hour before use. This is intended to ensure the bulb being covered with a thin coating of ice during the observation.

After a frost the water in the receptacle should be thawed, and the muslin and conductor washed, to restore proper action.

Maximum Thermometer (Negretti & Zambra's) :—

1. See that the end of the column nearest the bulb has not run away from it through vibration or otherwise. If it has, the Thermometer should be tilted *very* gently until the detached column comes in contact with the contraction in the tube.

2. Read at 7 a.m. or 9 a.m. by noting the point at which the end of the column of mercury is lying. *Enter to previous day.*

3. Set, by holding the Thermometer Bulb downwards and swinging it until the mercurial column becomes continuous throughout*. The end of the mercury should then indicate the same temperature as the Dry-Bulb Thermometer.

* If the Maximum thermometer be of the Phillips pattern the column should not become continuous, a portion remains detached by the air speck.

Minimum Thermometer (Rutherford's) :—

1. Read at 7 a.m. or 9 a.m. by noting position of the end of the index *furthest* from the bulb. *Enter to the day on which read.*

2. Set, by raising the bulb and allowing the index to slide to the end of the column of spirit. When set, the end of the index furthest from the bulb should indicate nearly the same temperature as the dry-bulb.

The Solar radiation and grass minimum thermometers must be set each day.

Rain Gauge.—The Gauge should be examined daily at 7 a.m. *or* at 9 a.m. During exceptionally heavy rains it may be necessary to measure the contents of the Gauge at more frequent intervals, but the total results should in all cases be inserted in the Register under the hours named.

The rain measured at 7 a.m. or 9 a.m. should be entered as having *fallen* on the *previous day*.

The measurement is effected by pouring the contents of the gauge (bottle or can) into a glass measure, each division of which represents 0·01 in. The reading to be taken midway between the two apparent surfaces of the water.

If hail or snow should be collected in the funnel, it is to be melted and measured as rain. If necessary this is done by adding to the hail or snow a measured quantity of hot water, and by afterwards deducting the quantity so added from the total measurement.

Wind.—*Direction of the wind* should be recorded from the True North. Note the *direction from* which the wind blows from the indications of a freely moving Vane, or by observing the drift of smoke, applying the correction for variation if a magnetic compass is used. Take care that no doubt attaches to the records on account of confusion between Magnetic North and True North.

The *Force of the wind* is to be noted according to Beaufort's Scale, which may be provisionally expressed in terms of the actual velocity of the wind, as follows :—

	Corresponding Velocity* in Miles per hour.
0. Calm	Under 1.
1. Light Air	1 to 10 inclusive.
2. Light Breeze	
3. Gentle „	

* The estimates of the velocities of the wind corresponding to the numbers of the Beaufort Scale are based upon a comparison by Mr. R. H Curtis (Quarterly Journal Royal Meteorological Society, vol. 23, p. 24, 1897) between the readings of anemometers reduced to actual velocities by the use of an appropriate factor and simultaneous estimates of the force on the Beaufort Scale.

4. Moderate Breeze ...	Above 10 and below 30.
5. Fresh „ ...	
6. Strong „ ...	
7. Moderate Gale	30 to 45 inclusive.
8. Fresh „	
9. Strong „	Above 45. The highest recorded velocities in the most destructive winds in the British Isles approximate to 100 miles per hour.
10. Whole „	
11. Storm	
12. Hurricane	

Clouds.—The *proportion* of the sky covered with cloud is to be estimated, the scale adopted being 0—10, 0 representing a perfectly cloudless sky, and 10 showing that the *whole* sky is clouded.

The *forms* of clouds should be described as defined by Howard, as follows :—

Cirrus (Ci.):—Parallel, wavy, or diverging fibres.

Cirro-cumulus (Ci.-Cu.):—Fleecy clouds arranged in groups or lines.

Cirro-stratus (Ci.-S.):—A thin veil of feathery or streaky cloud.

Cumulus (Cu.):—A cloud of a convex or well-rounded upper surface.

Cumulo-stratus (Cu.-S.):—A combination of Cirro-stratus with cumulus.

Stratus (S.):—Clouds in continuous horizontal sheets.

Nimbus or rain cloud (N.).

Under *motion* enter the direction whence the cloud is moving.

Weather.—Note any phenomena which may have occurred since the last observation.

Term-Days.—On the 1st, 11th, and 21st of each month hourly or two-hourly observations may, if possible, be taken, those of the 21st being the most important. This applies more especially to the barometer and its attached thermometer, the dry and wet bulb thermometers, and the direction and force of the wind.

Additional Observations.—If the station is favourably situated for measuring the height of a lake level or ascertaining the flooding of a river, this should be done. These observations should be made regularly daily, but if this is impracticable, once a week is much better than none. The water-gauge should be

divided into inches and tenths. The manner of fixing it must depend entirely upon local circumstances : its zero should coincide with the lowest level of the water, but in practice it will generally be necessary to accept an arbitrary zero, and to indicate all readings below it by a minus sign. It is desirable that the zero of the gauge should be referred to a bench mark cut in the face of a rock, or, failing that, in the trunk of a tree. Special instructions contributed by the Hydrographic Office for recording lake levels are appended.

Well-measurements may prove of interest. Measure the distance from the mouth of the well to the surface of the water in it, and *not* the depth of the well. At stations on the sea-shore, on lakes or rivers, the temperature of the water may likewise be recorded.

Phenological notes, *i.e.*, notes of the times of return of the seasons for example, *e.g.*, the flowering of plants, ripening of crops, migration of birds, and so forth, may be entered in the "Remarks" column of the meteorological register.

NOTES ON METHODS OF RECORDING LAKE LEVELS, WITH SPECIAL REFERENCE TO VICTORIA NYANZA.

CONTRIBUTED BY THE HYDROGRAPHIC OFFICE.

The only accurate method of keeping a complete record of the changes of lake levels, is by means of a self-registering gauge.

One of these instruments would furnish a more accurate record than several water gauges established at different places, and read once a day or even oftener.

If the extreme range of level is known, an instrument can be constructed to suit it, and on a scale of 2 inches to the foot would be of moderate dimensions, and would cost from £40 to £50.

If a long series of records is desired this will probably be the best course.

Automatic gauge.

The instrument would be worked by a float, and would record on a revolving drum.

The only drawback to such an instrument in Uganda would be the provision for necessary repairs to the clock.

A water-gauge clock is necessarily exposed to damp, is very liable to eccentricities in working, and requires periodical cleaning at no long intervals.

The instrument could either be erected on a pier as exists at Port Florence, or a well can be dug at some little distance back from the edge of the lake, with its bottom at a sufficient depth to allow for extreme low level of the lake, and connexion made by a large horizontal pipe also at a sufficient depth to allow for extreme fluctuations.

The latter is best for the clock, and a tray of chloride of calcium in the hut in which the gauge would be placed over the well, would go far to absorb damp, and help to keep the clock in order.

Eye observations.

If it is preferred to continue eye observations on tide gauges, the three stations already established should give a very close approximation of levels.

It would be necessary to construct gauges that will give results free from wave action. This is easily done by making wooden tubes, of square section, for a float to work in, and admitting the water by one or two small holes near the bottom.

The float can either carry a light rod (cane or bamboo), the level of the top of which can be read by a scale, on a flat wooden batten projecting above the tube (Diagram I.), or a fine copper wire can be led from the float, over a sheave or pulley at the top of the tube, to any inconsiderable horizontal distance required, over another sheave, and to a light bob weight, the evel of which can be read in a similar manner on a scale. (Diagram II.)

Such gauges could probably be easily constructed on the spot, but the float should not be of wood which is liable to become waterlogged, and sink deeper as time goes on, but of copper, hollow. Even then, care must be taken that there is no leak, or the same thing will happen.

In the diagrams the float is shown square in section, as being easier to make, but its diagonal dimension must be a couple of inches less than that of the side of the square tube, to prevent its jamming in the tube.

A circular section is much to be preferred.

Datum mark.

An important point in any case is to have the levels referred to some permanent mark on the land, by which the observations can be renewed in case of accidents to the gauge. This can only be done by levelling, and the difference of level between the fixed mark and some division of the water scale should be recorded.

Wind will, of course, cause considerable variations in level of the lake, and these will be different at different places on the shores, but for the purpose of recording the effective level of the outflow of the Nile, which it is presumed is the principal object, a gauge near the outlet should afford all the information required. If it is desired to ascertain the effect of wind as regards the level of the whole lake, or whether seiches occur, gauges on the German shore should also be established.

W. J. L. WHARTON.

October 29th, 1902.

DIAGRAM I.

GAUGE WITH ROD.

A. *Wooden Tube.*
B. *Copper Float.*
C. *Graduated Scale.*
D. *Light Rod*
E. *Four Stays to support tube.*

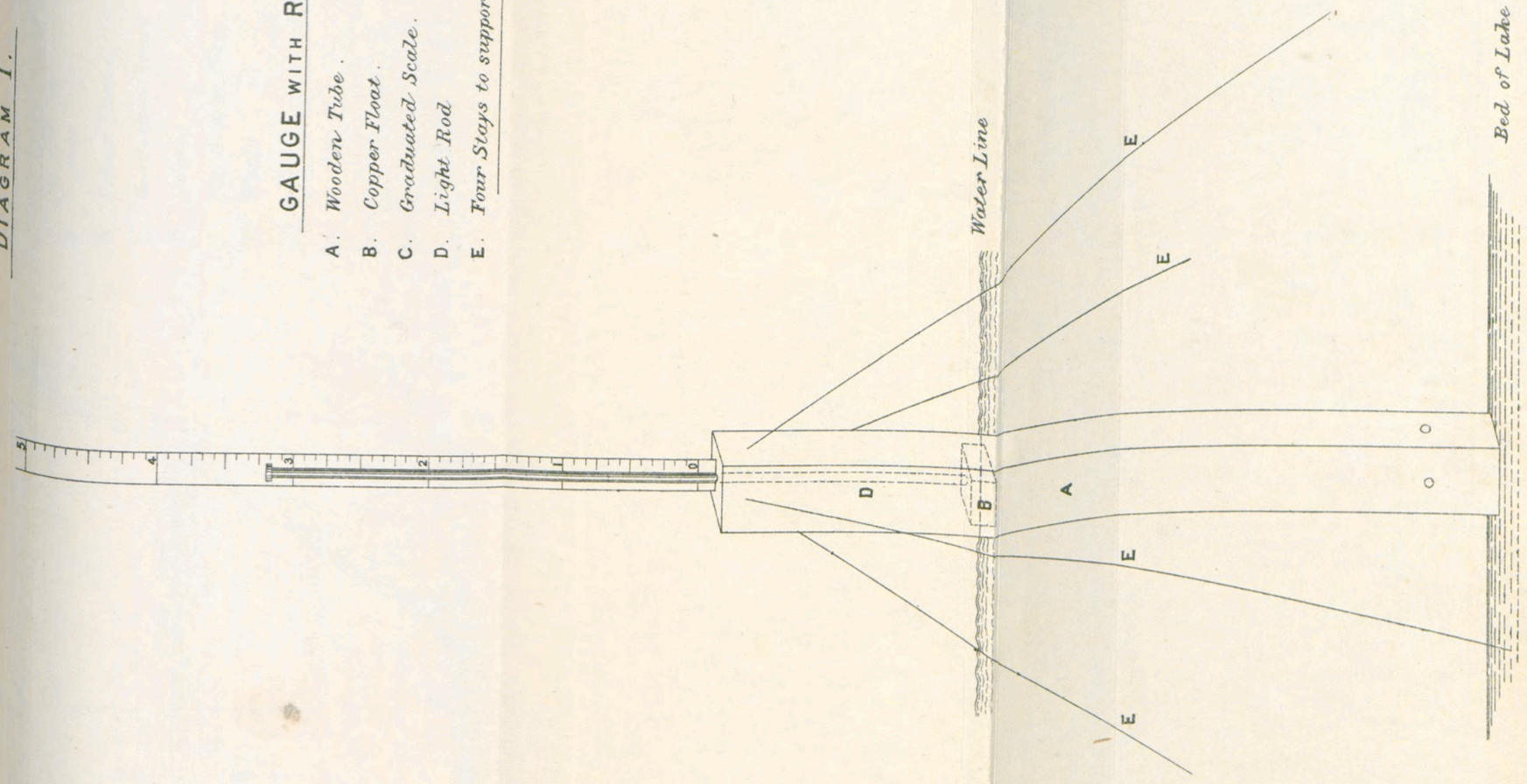
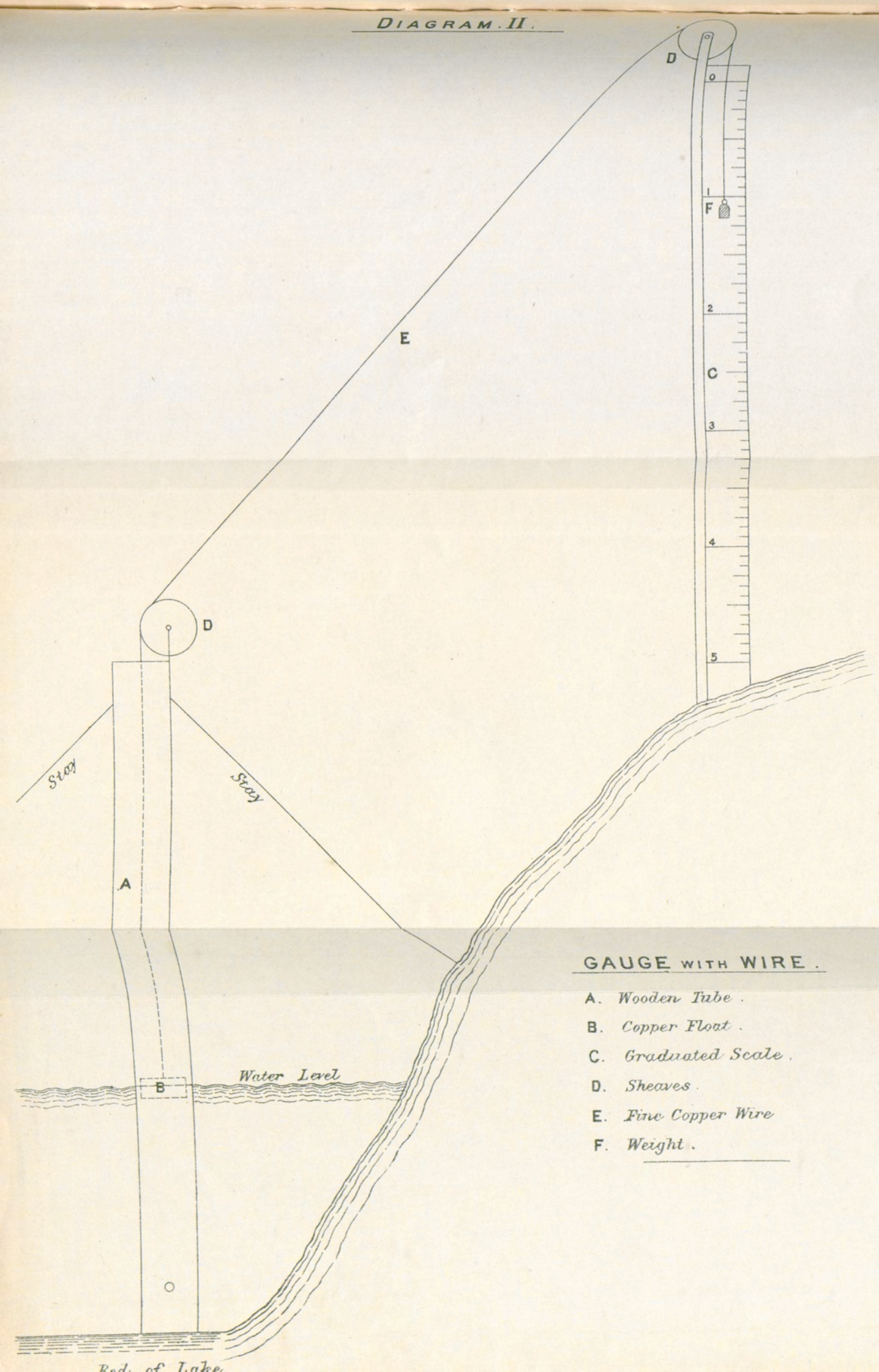


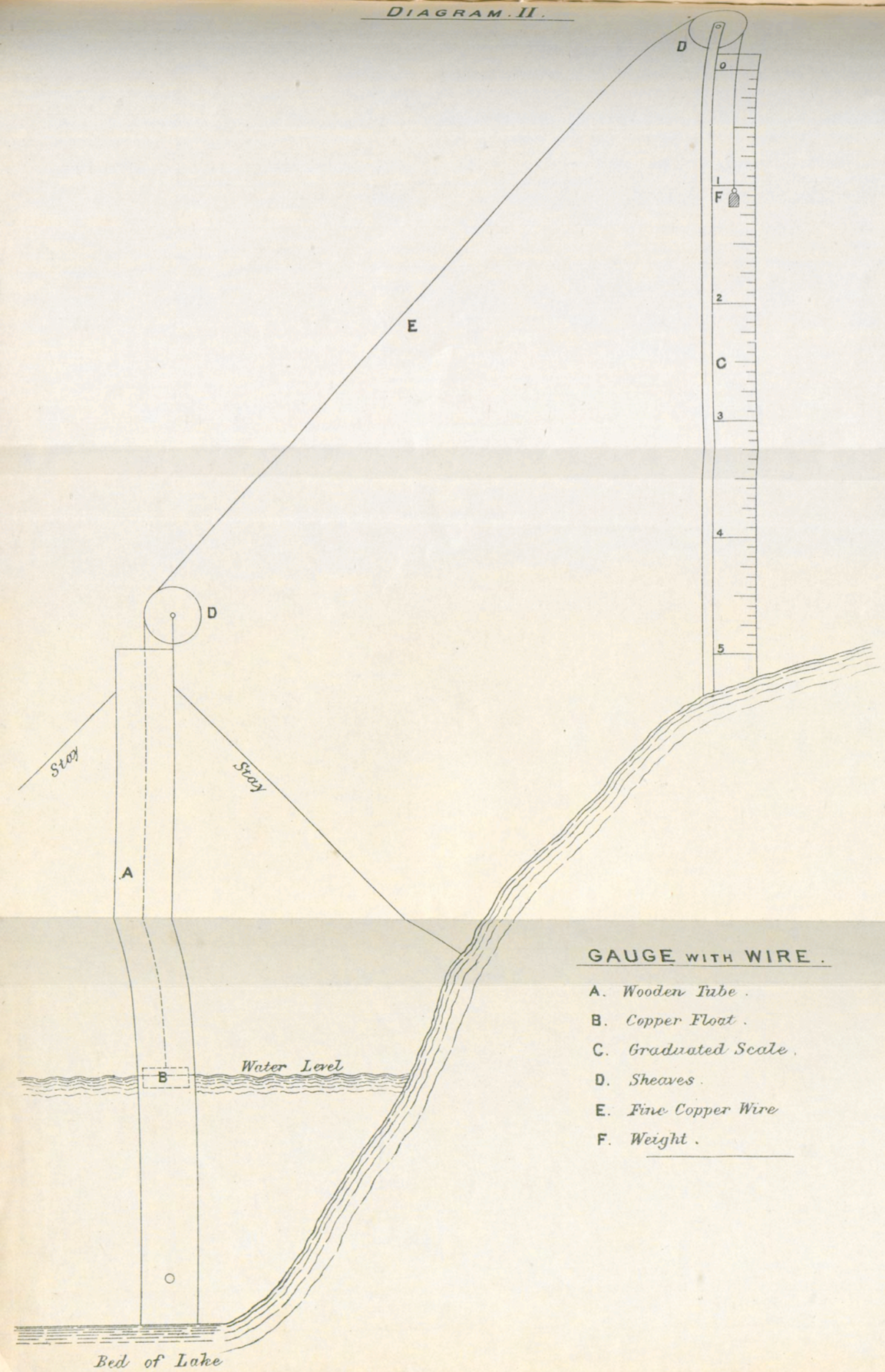
DIAGRAM. II.



GAUGE WITH WIRE.

A. *Wooden Tube.*
B. *Copper Float.*
C. *Graduated Scale.*
D. *Sheaves.*
E. *Fine Copper Wire*
F. *Weight.*

DIAGRAM. II.



GAUGE WITH WIRE.

A. *Wooden Tube.*
B. *Copper Float.*
C. *Graduated Scale.*
D. *Sheaves.*
E. *Fine Copper Wire*
F. *Weight.*

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