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THE ONLY
PRIZE MEDAL AWARDED
FOR
REGISTERING
Meteorological Instruments.

LIST, WITH NOTES,

OF

STANDARD METEOROLOGICAL

AND OTHER

INSTRUMENTS

FOR

OBSERVATORIES,

TRAVELLERS AND EXPLORERS,

AND

THE ARMY AND NAVY,

MANUFACTURED BY

L. CASELLA,

SCIENTIFIC INSTRUMENT MAKER
MECHANICAL AND ELECTRICAL ENGINEER

TO

H.R.H. the Prince of Wales,

TO THE ADMIRALTY AND ORDNANCE, THE BOARD OF TRADE, THE ARMY MEDICAL AND WAR DEPARTMENTS: THE GOVERNMENTS OF INDIA, RUSSIA, GERMANY, FRANCE, ITALY, SPAIN, PORTUGAL, THE UNITED STATES AND BRAZILS, CHINA AND JAPAN; THE UNIVERSITIES OF OXFORD, CAMBRIDGE, AND LONDON; THE METEOROLOGICAL AND THE ROYAL GEOGRAPHICAL SOCIETIES; THE LEADING HOSPITALS AND INFIRMARIES; AND THE OBSERVATORIES OF GREENWICH, KEW, ARMAGH, CAPE OF GOOD HOPE, WASHINGTON, VICTORIA, TORONTO, CALCUTTA, THE MAURITIUS, ETC. ETC.

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PART I.

NOTES AND INSTRUCTIONS
ON
METEOROLOGICAL INSTRUMENTS.

IN compiling the following pages, L. CASELLA has endeavoured to combine the recommendations of the highest authorities in the rapidly advancing science of meteorology, with the practical experience gained by himself during upwards of a quarter of a century devoted to the construction of an almost endless variety of experimental and other instruments:—

BAROMETERS.

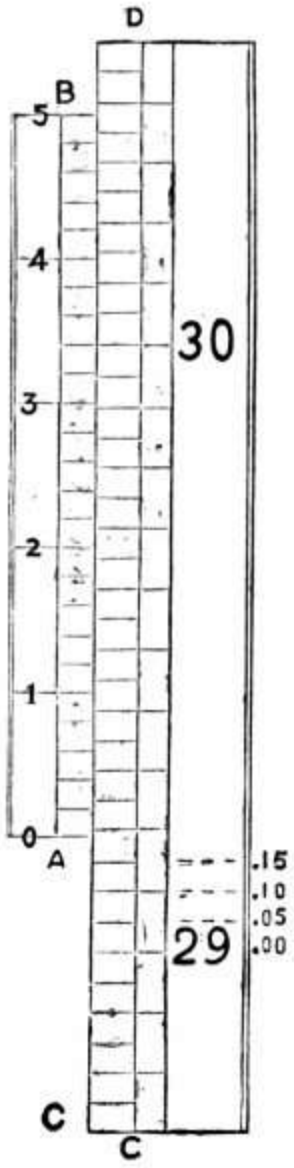
Barometers on Fortin's principle are on the whole the most convenient, and they are very trustworthy. The error index can suffer no change from lapse of time, because it is independent of the loss of mercury from oxidation, &c.; and should any air find its way into the tube, it can be easily known and readily removed. To ascertain if air has entered the tube, take down the barometer and incline it gently till the mercury reaches the top, when if air be present a soft dull tap will be heard; but if there is no air present a sharp clear click will be elicited. To remove air from the tube, incline the instrument gently as above, and invert it, so as to allow the air to pass slowly into the cistern. If the quantity be very small, the head may be tapped slightly on the ground, to facilitate the exit of the air; but when great accuracy is desired it will be necessary to have the mercury reboiled in the tube. An accident of this kind with this form of barometer is, however, almost impossible.

Instructions.—When sent into the country or abroad the barometer is packed apart from the mahogany board, in some soft elastic material, the mercury being screwed up so as to fill the tube and cistern. It should be unpacked carefully, but not handled until a position has been selected for it. The barometer may be placed in any convenient room where it is not near a fire or exposed to the sun's rays. It should be in a good light, with the scale about five feet from the ground, so that the zero point in the cistern, and the vernier on the scale, may be easily seen First fasten the board to the wall, then put the lower part of the cistern into the bottom bracket, and suspend the instrument as in *fig.* 1, page 12. When the barometer is thus suspended, turn the bottom-screw down till the mercury falls in the cistern below the level of the ivory point.

To Set the Barometer.—First read the attached thermometer, then adjust the mercury, by means of the bottom-screw, so that it barely touches the ivory point in the cistern, which, with its reflection, will then appear as a double cone; the height of the column is then taken by adjusting the lower edge of the vernier, so that it shall exactly form a tangent to the convex surface of the mercury in the tube, just excluding the light from the apex when the eye is in the same plane with the back and front lower edges of the vernier. Every care should be taken to

avoid influencing the temperature whilst making the observation. In adjusting the level in the cistern, the mercury should always be *screwed up* to the cone, and if the point of the cone is submerged the screw must be turned down until it is quite clear of the surface before the final adjustment is made. This precaution is necessary in order to preserve the same form of surface of mercury in the tube at different readings.

How to read the Vernier.—By means of the annexed diagram, the use of the vernier in ensuring accurate measurement is readily understood. C D represents part of the fixed scale of the barometer, and A B is the sliding scale or vernier. The scale C D is divided into inches, tenths, and half-tenths of an inch, so that each division of the scale is ·05; A B is made equal to 24 divisions of the scale, and is divided into 25 equal parts. It follows, therefore, that each division of the vernier is smaller than each division of the scale by the 25th part of ·05; which is ·002 inch. The lower edge of the vernier, A, is set to the top of the barometrical column, and hence we have to find the height of A. First we read on the scale, say, 29·15; next we look along the vernier until we find one of its lines which lies evenly with a line of the scale. As shown in the figure, this line is the second above 3. Now each of the figures engraved on the vernier count as hundredths, and each intermediate division counts as *two* thousandths (·002); hence the vernier shows ·034, and this added to the scale reading 29·15, gives the reading sought, 29·184.



In the Kew pattern barometers the inches on the scale are not really inches, but are so contracted as to thoroughly correct for the variation of the level of the mercury in the cistern.

In the old barometers this was effected by calculating the so-called "capacity correction"; in the Fortin barometers it is done by raising or lowering the mercury to the fiducial ivory point, and in the Observatory standard by moving the scales to the mercury.

The instructions given above for using the Fortin barometer apply equally to the Kew pattern, except that the cistern adjustment is unnecessary.

CORRECTION OF BAROMETER READINGS.

In order to ascertain the true pressure of the atmosphere, and to render comparable observations made in different localities, it is usual to reduce all barometric observations to what they would have been had the instrument been at the temperature of melting ice, and the barometer itself at the mean level of the sea. These corrections are fully explained, and all necessary tables are given in Marriott's "*Hints to Meteorological Observers*," and in Scott's "*Instructions for the use of Meteorological Instruments*," and in many other meteorological books, but some formulæ are given below which may be useful to those who may happen to be without a set of tables or text book when they wish to reduce their observations.

A special correction for temperature must be made in the case of barometers of the Kew pattern, a full account of which appears in the "*Philosophical Magazine*" for 1861.

These formulæ assume that the scale is brass, and also that the expansion of mercury is uniform for the range of temperature employed, which latter assumption, though not absolutely true, will give no appreciable error.

It is usual for the scale of *inches* to be so graduated as to be true only at 62° F. while if the *metrical* scale be employed the scales are made true only at the freezing point of water. This causes the correction for the inch scale to be of a more complicated nature than that for the metrical scale, an inconvenience which is further increased by the use of the Fahrenheit instead of the Centigrade thermometer.

The correction for the sea level is only roughly approximate, and suitable for very moderate elevations, the complete formulæ being far too complicated to commit to memory.

(A.) Formula for the reduction of the ENGLISH BAROMETER to the freezing point and sea level.

$$H = h\left(1 - \frac{9\,t - 256}{100000}\right) + \frac{E}{812{\cdot}86 - 1{\cdot}945\,t}$$

Where H is the corrected reading in inches.
h is the observed reading in inches.
t is the temperature in degrees Fahrenheit.
E is the elevation of the station above the sea level in feet.

(B.) Formula for the reduction of the METRICAL BAROMETER to the freezing point and sea level.

$$H = h\left(\frac{1 - t}{6196}\right) + \frac{E}{10{\cdot}54 + {\cdot}041\,t}$$

Where H is the corrected reading in millimetres,
h is the observed reading in millimetres,
t is temperature in degrees centigrade,
E is the elevation of the station above the sea level in metres.

When there is much difference in the latitude of two stations whose barometric pressures are to be compared, an allowance must be made for the variations in the force of gravity.

Another correction has still to be applied when the diameter of the tube is less than $\frac{3}{4}$ of an inch, namely, that for capillarity; this, however, can be determined once for all from tables, when the diameter of the tube is known, and must be added to the unreduced reading. It is, however, included in the instrumental error given in the certificate issued from the Kew Observatory, and in the case of the syphon barometer, of Gay-Lussac, the correction is unnecessary altogether.

ANEROID BAROMETERS.

These ingenious and elegant instruments are most useful to all who take interest in the weather, whilst, to travellers in particular, they present advantages which hitherto they could not obtain. Before the introduction of the aneroid, limited indeed were the means of those who, moving from place to place, desired in their progress to take reliable notice of meteorological phenomena; whilst the measurement of heights by any simple and portable arrangement was quite out of the question. Action is here obtained by means of a thin, flat, metallic box, which is deeply corrugated to increase its elasticity, and from the interior of which the air has been carefully removed; the upper and lower surfaces of this are held in a state of tension or separation from each other by means of a strong spring;

the atmosphere, pressing with varying force on these surfaces, conveys action to smaller springs, and thus shows by hands on the dial the variation of heights, or changes of the weather. In the measurement of small differences of height, as well as great elevations, the improved aneroid is most valuable; not only does it show with precision the differences in height between one room and another, or the varying gradients in travelling on a railway, but it is now so improved as to show with precision elevations up to twenty-four thousand feet. Besides portability, the aneroid has another great advantage over a mercurial barometer, namely, that it is possible so to construct it as to be independent of any correction for temperature of the instrument.

One of the chief uses of aneroid barometers is for measuring differences of elevation by means of the diminution which takes place in the atmospheric pressure as we ascend to a higher level. This diminution is not equal for equal differences of altitude, in consequence of the elasticity of the air, which allows the lower strata to be pressed more closely together than those above them; but it follows known laws, and hence altitude scales have been computed, taking the varying ratio between pressure and altitude into account.

There is, however, a second cause of variation, which (though included in the recognized formulæ for reducing barometrical determinations of altitude) has not been included in any altitude scale yet published. This cause is the variable temperature of the air,* which will evidently affect the result by affecting the density of the air, and therefore the ratio of pressure to altitude. In the "Engineering Aneroid," invented by Mr. Rogers Field, B.A., Assoc. Inst. C.E., F.M.S. (of which L. CASELLA is appointed sole maker), this variation is for the first time taken into account by the scale being made adjustable for temperature. The principle of adjustment is that of shifting the altitude scale according to the temperature of the air. There is nothing novel in movable scales themselves, as they are frequently used with aneroids for the purpose of shifting the zero of the scale to correspond with the varying position of the hand. This method of using them is, however, radically wrong, as the shifting of the scale makes it inaccurate, and the novelty consists in taking advantage of this inaccuracy to obtain a valuable means of adjustment. The scale that is inaccurate for one temperature is practically accurate for another, so that we have only to shift the scale into certain different fixed positions to obtain a series of different scales suitable for different temperatures of the air.

The altitude scale adopted in this aneroid is that of the late Astronomer Royal (which has been compared with the formulæ of Laplace, Guyot, Baily, Plantamour and other authorities, and found to give results lying between them), and as the instrument is intended for the accurate measurement of moderate altitudes, the range is purposely limited so as to give an open graduation. The adjustment for

* This must not be confounded with the changes produced by alterations in the temperature of the instrument itself, which may be neglected, as the compensation for temperature is as nearly perfect as possible, and under all ordinary circumstances the temperature of the instrument will be so nearly identical at the various stations as not to affect the result.

the temperature of the air, is applied by shifting the scale in accordance with the figures engraved on the outside of the instrument. The rim which holds the glass should be slightly raised, so as to be free from the locking-pin, and then turned until the figures corresponding to the air temperature are opposite to the pin, when the glass should be depressed so as to re-lock it.

The process of observation is extremely simple. The first thing is to determine, either by observation or estimation, the air temperature likely to prevail during the series of observations: if this is done within 5° it will be sufficiently accurate (within about 1 per cent.). The scale must then be set to this temperature in the manner above explained. Subsequently the readings must be taken from the outer scale of feet, and the *difference* will give the difference of elevation. The following example of actual observations taken between Hampstead and London will explain the proceeding:—

Temperature of 40° *and scale set accordingly.*

	Feet.
Journey to London:—	
Reading at Jack's Straw's Castle, Hampstead. . .	1640
,, ,, "Horse Guards," London	1200
Difference	——440
Journey from London:—	
Reading at "Horse Guards," London	1215
,, ,, Jack Straw's Castle, Hampstead . . .	1640
Difference	——425
	2)865
	432 Feet

The true difference of altitude, according to the Ordnance levels, is 428 feet, showing an error of only four feet. The accuracy of the result will be further increased if the observations are repeated more than once, and the average of the results taken.

It should be mentioned that the above principle of adjustment can only be correctly applied to aneroids in which the graduation is nearly uniform, and therefore extreme care is taken in the selection of suitable instruments for this purpose.

THERMOMETERS.

Mercurial thermometers are much the best, and the general accuracy of the better class is sufficiently indicated by the fact that the errors of L. Casella's instruments, when determined at the Kew observatory, are often *nil* and rarely exceed 0°·2. This is partly due to the great care in their manufacture, and partly also to the tubes being filled with mercury some years before the divisions are marked upon them. The reason for filling the tubes so long beforehand is the singular one that, after the glass has been heated in the manufacture, and subsequently a vacuum has been created within it, the bulb for some years very gradually becomes smaller, and consequently after a time the thermometer reads higher than it should do. This error is carefully guarded against in L. Casella's

best instruments. Other points essential to good and durable thermometers, are an indelible black for the degree marks, and an imperishable material for the slabs to which they are fastened—and in both respects it is believed that success has been attained. The porcelain employed in all these instruments is of an improved kind, expressly made for L. CASELLA, warranted indestructible by frost, and unaffected by changes of weather; and the graduations on the tube itself are by a new process rendered indelible.

CASELLA'S STANDARD MAXIMUM THERMOMETERS.

These instruments are made on the principle applied by the late Professor Phillips, F.R.S., and were first employed for meteorological purposes by Mr. John Welsh at the Kew Observatory in 1851. Next to its able inventor, L. CASELLA claims the exclusive merit of the introduction and arrangement of these most perfect maximum thermometers. In the report of the Kew Committee of the British Association for the Advancement of Science, in 1856, they are described as "valuable for their extreme simplicity," "capable of greater accuracy than any others," "the most convenient form of all maximum thermometers." In 1862 they were amongst the chief causes of the decision of the jury in awarding to L. CASELLA *the only prize medal* for registering meteorological instruments, and since then their adoption may be called universal, both in the British Empire and on the Continent, as well as recently in the United States. They are extensively used by travellers, as well as for mines, deep wells, on board ship, and indeed in any position in which portability and a true reliable registration of temperature is required. The great advantage of this arrangement consists in the index being formed of a small portion of the mercury itself, which is detached from the rest and made of any required length, according to the purpose to which it is to be applied; thus, for stationary instruments, it is kept sufficiently long to be set by merely lowering the bulb, whilst in others it is made so short as to retain its indication in whatever position the thermometer may have to be used, whether erect or inverted. As a medical thermometer for clinical investigations, its delicacy is unequalled by any other arrangement; but as many very bad imitations are offered to the public, L. CASELLA would request that he be not held responsible for any thermometers which do not bear his name and consecutive number on the tube. The respectability of the agent should also be considered, as most flagrant cases of useless imitation are frequently detected. For safety of transit this principle leaves nothing to be desired.

The Directions for using the Maximum Thermometer vary slightly according to the purpose for which the instrument has been designed; but the difference is only in the degree of force requisite to bring the detached portion of the mercurial column almost into contact with the continuous column. For fixed observatories a much longer detached column is desirable than for travellers, a still shorter one is used for clinical thermometers, while the shortest of all is employed for observations on underground temperature. Suspend the instrument by means of the brass loops attached to the back, so as to keep it fairly horizontal, as shown on page 21. To set the index, disengage and lower the bulb end, to allow the detached portion of mercury to approach the rest, which it will do within about one quarter of a degree. On an increase of temperature the

mercury will rise as in an ordinary thermometer, and continue to do so as long as the heat increases, propelling the detached portion to whatever extreme the heat may attain. On a decrease of temperature the mercury will contract and recede in the usual manner, leaving the end of the detached portion furthest from the bulb to indicate the highest temperature.

Directions for using the Rutherford Minimum Thermometer.—Suspend or lay it in a horizontal position, with the bulb an inch lower than the opposite end. To set the index, raise the bulb end until the index flows to its place in the spirit, viz., to the extreme end. Then place the thermometer as before, and as the temperature decreases the spirit will contract and recede, taking the index back with it; but on an increase of temperature the spirit will advance, leaving the index to mark whatever extreme of cold may have occured. This it does by the end furthest from the bulb, whilst the spirit itself indicates the temperature at the time. If in transit the spirit becomes separated, or the index shaken out, it is easily united or replaced by a brisk swing or two of the arm, holding the bulb downwards; and when thus put right the thermometer should hang for about ten minutes with the bulb down, to allow the fluid fully to settle. A fault attaching to *all* spirit thermometers is the liability of the column to evaporate, and of the vapour to condense at the extreme end of the tube. L. CASELLA believes that those made by him rarely fail in this respect, but he thinks it best to call the attention of observers to its *possible* occurrence. The wonderfully low temperatures occasionally mentioned in the newspapers are frequently traceable to this fault. It can be easily corrected by the method just described. These instruments can also be arranged so as to be set by means of a pulley and cord when it is desired to place them outside a window or in a position difficult of access.

SOLAR RADIATION.

Considerable attention has lately been devoted to this subject, both in England and in France. In this country the observations have been systematized and collected by the Rev. F. W. Stow, who has issued the following rules for observers:—

1.—Place the instrument four feet above the ground, in an open space, with its bulb directed towards the S.E. It is necessary that the globular part of the external glass should not be placed in contact with, or very near to, any substance, but that the air should circulate around it freely. Thus placed, its readings will be affected only by direct sunshine and by the temperature of the air.

2.—One of the most convenient ways of fixing the instrument will be to allow its stem to fit into, and rest upon, two little wooden collars, fastened across the ends of a narrow slip of board, which is nailed in its centre upon a post steadied by lateral supports.

3.—The maximum temperature of the air in shade should be taken by a thermometer placed on a stand in an open situation. Any stand which thoroughly screens it from the sun, and exposes it to a free circulation of air, will do for the purpose.

4.—The difference between the maxima in sun and shade thus taken is a measure of the amount of solar radiation.

Quite recently, and partly following the practice of the French *savans*, a bright bulb thermometer in vacuo and, except as to blackness, identical with the black bulb, has been substituted for the shade temperature referred to in rule 3, and a double support, represented in *fig.* 28, for the simple one formerly employed.

An important addition to this branch of meteorology has recently been made by Mr. T. F. Campbell's invention of an instrument for recording the daily amount of sunshine. The instrument as at first arranged being suitable only for the particular locality for which it was made, L. CASELLA has, in conjunction with Mr. Whipple, of the Kew Observatory, effected an improvement in the mechanical details of the instrument, and produced a more convenient form, suitable for every latitude, whereby a complete record for every day in the year can be readily kept.

HYGROMETERS.

The wet and dry bulb thermometers variously called Mason's hygrometer, or August's psychrometer, up to the present time may be fairly said to have supplanted the use of all others as an easy and practical means of indicating the humidity of the air. It consists of two thermometers placed parallel, about three inches apart, with their graduations as nearly as possible identical. The bulb of one is covered with thin muslin, from which trail a few threads of lamp cotton; these, being first wetted, are passed into a small attached vessel of water, two or three inches distant. The bulb is thus kept continually moist, which causes this thermometer to indicate a temperature lower in proportion to the rate of evaporation, whilst the dry bulb shows the temperature of the air. From the readings of the wet bulb thermometer the temperature of evaporation is at once obtained, and the dew point and other hygrometric data can easily be ascertained by reference to the tables. During frost, when the capillary action of the cotton is stopped, the bulb should be wetted by means of a camel hair brush, with water as cold as possible. In such cases it is not necessary to remove the ice from the bulb, but merely to remove the drop which first forms from the water; the temperature will then speedily settle so as to indicate the point of evaporation. In placing fresh covering on the bulb, it should be made loose, and care taken not to restrict capillary action by tying it beneath the bulb.

It is desirable to use either distilled or rain water, as hard water soon coats the bulb of the thermometer with lime.

In frosty weather the water receptacle should not be left full, or it may burst.

The muslin should be washed or renewed frequently, as it is essential for accurate results that it and the wick be kept clean.

Glaisher's hygrometrical tables are expressly adapted for these instruments.

Lately, however, Mr. G. Dines, of the Council of the Meteorological Society, has invented a form of Dew Point Hygrometer which leaves nothing to be desired for either convenience or accuracy. It requires no ether, but simply cold water, and the thermometer is well protected. A description of it will be found on page 29.

RAIN GAUGES.

Mainly through the efforts of Mr. G. J. Symons, F.R.S. the great practical importance of an accurate knowledge of the amount of rain falling in different localities has been increasingly recognized during the last twenty-five years. Great attention has consequently been given to the form and size of gauge best adapted for general use, and the best mode of fixing the gauges when made. In order to determine these points, elaborate and costly experiments were made at Calne by Colonel Ward, with the personal assistance of Mr. Symons; and similar experiments on a lesser scale have since been made in various other parts of the country. The general result has been to show that the size of the gauge is not very important, but that practically from 3 to 8 inches in diameter is the most expedient. Mr. Glaisher, F.R.S. is also understood to have made experiments

which led him to recommend a diameter of 8 inches. In exposed positions 5 inch gauges collect rather too little; for such stations 8 inch gauges are therefore preferable. If the orifice of a gauge be nearly level with the ground it will collect an undue amount, as the water will splash in off surrounding grass, leaves, or soil; on the other hand, if the gauge be raised above the ground it will collect less the higher it is raised. It has therefore been decided that the orifice should in all cases be one foot above the surface of the ground.

L. CASELLA has the pleasure of adding (by permission of Mr. Symons) a reprint of the rules, as to placing rain gauges, issued by him.

Rules for Observers.—A rain gauge should not be set on a slope or terrace, but on a level piece of ground, at a distance from shrubs, trees, walls, and buildings—at the very least as many feet from their base as they are in height. Tall-growing flowers, vegetables, and bushes must be kept away from the gauge. If a thoroughly clear site cannot be obtained, shelter is most endurable from N.W., N., and E., less so from S., S.E., and W., and not at all from S.W. or N.E.

The funnel of a rain gauge must be set quite level, one foot above ground, and so fixed by three or four pegs, that it will remain firm in spite of any gale of wind or ordinary circumstances.

The gauge should be emptied regularly each day, at 9 a.m., and the amount then measured entered to the day before that of measurement.

The measurement simply consists in emptying the contents of the bottle into the glass measure, which must be held upright, and noting the number of the division to which the water rises. Each division equals 100th of an inch; the fifty divisions, therefore, equal half an inch—that is to say, one division should be entered as ·01; 25, as ·25; and 50, or half an inch, as ·50; of course, if there is more than that, it must be measured separately; for instance, twice full up to the 50 and once to the 6 would be

·50
·50
·06

1·06 or one inch and six hundredths.

The amount should always be written down before the water is thrown away.

All columns should be cast up *twice*. When there is no rain, a line should be drawn rather than cyphers inserted.

When very heavy rains occur, it is desirable to measure on their termination, and enter the particulars as remarks, and it will be found a safe plan after measuring to return the water to the gauge, so that the morning registration will not be interfered with. Of course if there is the slightest doubt as to the gauge holding all that falls, it must be emptied, the amount being *previously* written down.

In snow, melt what is caught in the funnel and measure that as rain, and select a place where the snow has not drifted, measure with a rule the average depth, and enter it in the remarks.

A fall of rain measuring the tenth of an inch in depth, corresponds to the deposit of 2262 gallons, or about forty hogsheads, or ten tons weight of water per acre.

ANEMOMETERS.

The measurement of the force of the wind has been effected by two classes of instrument. In one class a resisting medium (either a column of water, as in Lind's, or a flat plate of metal backed by springs, as in Osler's) is opposed to the wind, and its force is ascertained by the *pressure* which it exerts. In the other class the *velocity* with which the wind travels is measured. Of this class are Whewell's (now rarely used) and Robinson's.

Robinson's Anemometer consists essentially of four hemispherical cups, having their diametrical planes exposed to a passing current of air. They are carried by four horizontal arms attached to a vertical shaft, which is caused to

rotate by the velocity of the wind. Dr. Robinson found that the cups, and consequently the axis to which they are attached, revolve with one-third of the wind's velocity, which is here measured by a simple arrangement of two wheels, working in endless screws, and by means of two indices shows, on inspection of the dial, the velocity of the wind. The outer, or front wheel, which revolves once for every five miles, is furnished with two graduated circles, the interior circle being sub-divided to miles and tenths of miles, whilst the outer circle is divided into 101 parts, each part being equivalent to five miles, so that it measures 505 miles of wind. The stationary index at the top of the dial marks on the *inner* circle the number of miles (UNDER FIVE) and tenths that the wind has traversed, in addition to the miles shown by the traversing index, or hand, which revolves with the dial and indicates on the *outer* circle the transit of every five miles. This anemometer is rendered extremely portable by the arms which carry the cups being made to take off. For use it may be screwed on a shaft or ordinary piece of iron pipe which accompanies it, and may be fixed in any desirable position, its construction being such as to adapt it to withstand the most violent storms, whilst the simplicity of its make enables the observer to clean and lubricate it at pleasure, twice or three times a year being sufficient.

Instructions for Reading.—If after placing the instrument the hands are at 0, the next observation will show the distance travelled by the wind during the interval; but if the hands stand otherwise, read them as they are, by noting down the divisions and figures indicated by the traversing hand and stationary index at the top. Thus, say that the former points to between 125 and 130, and the latter to 2·6, making together 127·6, this will now be the starting-point: on the next observation the traversing hand will point to an increased number on the outer circle, say between 375 and 380, and the stationary index to 3·6; these two numbers added together give the true reading, *i.e.* 378·6 miles. From this reading subtract the previous reading of the instrument, viz. 127·6, and the difference, 251 miles, is the distance traversed by the wind during the interval.

THERMOMETER STANDS.

A very large amount of time and labour has been wasted, or rather, worse than wasted, in reading, recording, and even printing, observations from good thermometers badly placed. Latterly, however, it has been very generally agreed that the pattern of thermometer screen recommended by Mr. Stevenson, of Edinburgh, should be generally adopted. An engraving of it will be found on page 30, and it is only necessary to add here, that the observer should see that the posts on which he fixes it are very strong, and of such a length that the bottom of the stand is 3ft. 6in. above grass. It is desirable that the door and the path leading to it should be to the north of the stand.

TIME OF MAKING OBSERVATIONS.

Although special circumstances may induce some persons to adopt other times, it may be well to mention here that the vast majority of British observers have adopted 9 A.M. and 9 P.M. as their hours of observation, and uniformity in this respect is evidently desirable. The self-registering thermometers are in that case read and reset at the night observations.

METEOROLOGICAL REGISTERS.

There are several forms published, as will be seen by referring to the list of meteorological books at page 41 ; but whichever the observer may select, it is very desirable that he should enter in it full particulars respecting the instruments he uses, and the locality at which the observations are made.

VERIFICATION OF INSTRUMENTS.

The Kew committee of the Royal Society have for many years rendered an important service to meteorology by undertaking the comparison of properly constructed instruments with the standards in their observatory. Although it is usual for the verification to show that the errors of L. CASELLA'S best instruments are scarcely perceptible, he strongly recommends that purchasers should obtain verified instruments.

The cost of verification, including expenses of sending and fetching instruments to and from Kew Observatory and risk of breakage, are as follows:—

Barometer (Fortin's) with attached thermometer	10*s.*	6*d.*	
Ditto Kew pattern . .	15*s.*	0*d.*	
Thermometers .	1*s.* 6*d.*	to 15*s.*	0*d.**
Rain Gauges	2*s.*	6*d.*	
Anemometer, small . . .	10*s.*	6*d.*	

The majority of the rain gauges have, however, for many years been sent to Mr. Symons for verification, upon the same terms as at Kew.

SPECTROSCOPES.

The classical researches of the Astronomer Royal for Scotland, Professor Piazzi Smyth, have opened out a new field of interest and enquiry for meteorologists in the rainband of the spectrum, which is observed almost universally to precede and accompany wet weather, when the light of the sky is examined. The phenomenon is remarkably certain in its indications, and has been noticed frequently to have given warning of a coming shower or storm when both barometer and hygrometer have entirely failed. This no doubt arises mainly from the fact that the latter instruments have a less extended sphere of action than the former ; they indicate the meteorological condition of the exact spot in which they are, while the spectroscope gathers its light from great distances, and gives as it were a general average of the condition of the atmosphere through which the light has passed. This makes it an invaluable instrument for tourists, for whom a pocket instrument has been expressly constructed.

Directions for using the Rainband-Spectroscope.—Having first adjusted the slit and focussed the eye piece, so that the dark vertical lines crossing the spectrum (Fraunhofer's lines) shall be quite sharp, the instrument is turned to the sky, a little above the horizon, with the blue and red ends of the spectrum to the right and left respectively. The rain-band, if it is present, will appear as a shading immediately on the left hand side of the line D in the yellow part of the spectrum, the depth and breadth of the shading depending on the excess of moisture in the atmosphere. A small illustrated pamphlet on the subject by L. CASELLA, F.R.A.S. gives more detailed information on the subject.

* For general meteorological purposes this charge seldom exceeds 2*s.* 6*d.*

PART II.

METEOROLOGICAL INSTRUMENTS,

FOR

OBSERVATORIES & FIXED STATIONS.

BAROMETERS.

The following forms of standard barometers are all of the highest excellence, the mercury being boiled in the tubes of each by a simple and improved method, and every care taken in their construction and graduation to render their indications absolutely correct, and therefore accordant with each other :—

In the official report for the year 1873 to the Government of Bengal, by H. F. Blandford, Esq., it is said of these barometers :—

"The best in every respect that I have tried are CASELLA's Standards, with tubes of uniform bore. They bear transport admirably; and, although they have been in use at some stations for three years, no instance has occurred of leakage or any other injury to them."

1. **Observatory Standard Barometer,** as designed for the Kew Committee of the Royal Society, and supplied to many of the leading foreign observatories. A scale on each side of the tube is adjusted to the level of the mercury in the cistern by a rack and pinion motion, and the vernier reads to 0·002 of an inch, or, by estimation to 0·001 inch. The instrument revolves on a cast iron pedestal, and the mounting is of great strength and stability. The internal diameter of the tube is 0·80 inch (*fig.* 1.)
£35 0 0

2. **Observatory Standard Barometer,** with extra large column of mercury in neat skeleton iron frame, arranged to revolve in brackets from a wall, or on a pedestal, precisely as the Kew standard, for reading off by means of a cathetometer . £33 0 0

For **Cathetometers,** see page 16.

3. **Standard Barometer** (Fortin's). In this construction the mercury in the cistern is adjusted at each observation to a fixed ivory point, which thus forms the zero of the scale. The mercury is boiled in

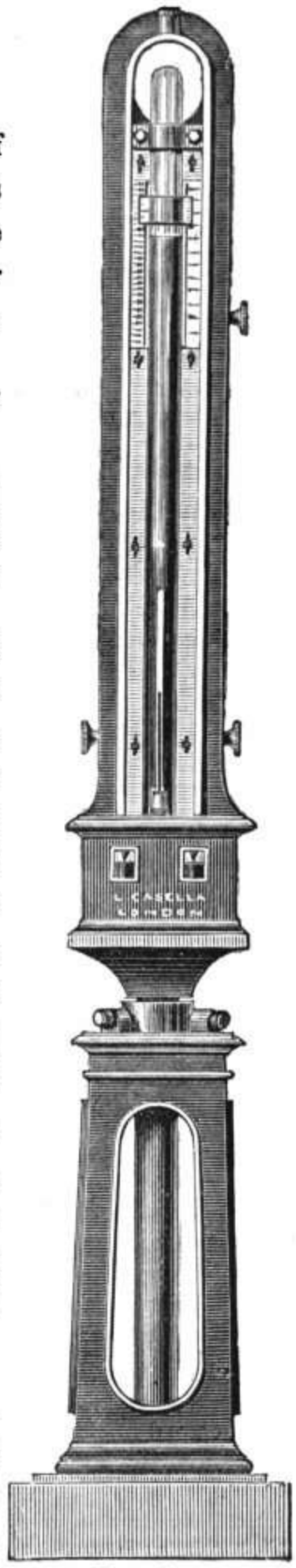


FIG. 1.

the tube, which is 0·45 in. internal diameter. The cistern is made partly of glass, to admit of the zero of the scale being visible, and the mercury is adjustable to the zero or ivory point by means of a thumb-screw acting upon the flexible base. The vernier reads to 0·002 of an inch, or, by estimation, to 0·001 inch, and is adjusted by a rack and pinion motion. In front of the barometer a thermometer is attached, in contact with the tube, with divisions etched on the stem. For facility of reading, a slab of white porcelain is placed behind the scale. The barometer is mounted in a brass frame, and suspended from a bracket at the top of a mahogany board, so as to insure perpendicularity. At the bottom of the board is a socket, with clamping screws for steadying the barometer in a vertical position, when an observation is made. The instrument is so mounted that it can be turned at pleasure to any source of light (*fig.* 3) . £10 0 0

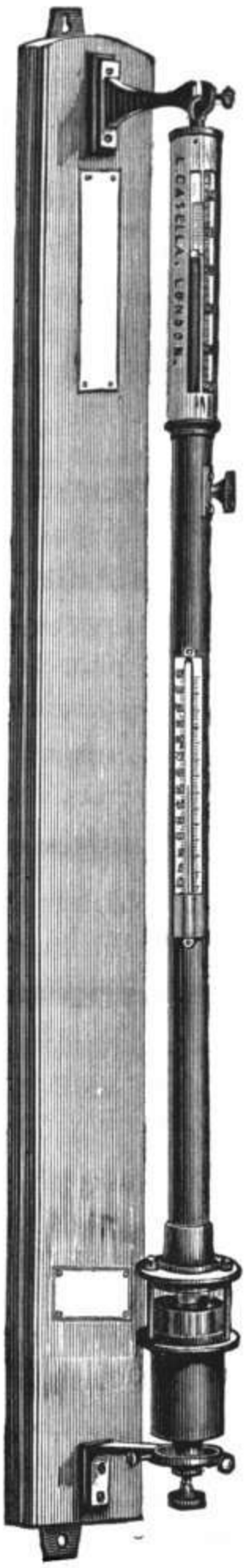


FIG. 3.

4. **Standard Barometer,** precisely as above, but not so highly finished, internal diameter of tube, 0·40 in. £8 10 0

5. **Fortin's Standard Barometer of extra large size,** specially suited for public observatories, tube 0·70 in. internal diameter, with (at the side) a thermometer immersed in a tube of mercury of the same diameter as the barometer tube . £22 0 0

6. **Standard Barometer, on the Kew Principle,** in which the graduations of the scale are arranged to compensate for the rise and fall of mercury in the cistern, by which the necessity of stooping to read from a point in the cistern is obviated. The mounting, &c., the same in every respect as No. 3 standard barometer £8 10 0

7. **Standard Barometer,** as No. 6, in plainer mounting £6 0 0

8. **Standard Barometer,** on the Kew principle, as No. 6, but with handsome and bold ivory, porcelain, or metal scales, with plain and broad graduations for easy reading, revolving in brackets on oak or mahogany board £6 0 0

9. **The Student's Standard Barometer,** on the Kew principle, as No. 6, with similar compensation, &c., but smaller in size, for those who do not at first desire a more expensive standard . . £4 15 0

10 **Standard Marine Barometer,** on the Kew principle, as recommended by the Brussels Conference for making correct meteorological observations at sea, and used by the Admiralty and Meteorological Office. The cistern is made of bronzed polished iron. The frame is brass bronzed, and revolves in gimbals, having a stout spring arm for suspension. The scale reads to 0·002 of an inch, and the tube is contracted to prevent oscillations during the heaviest rolling of the ship (*fig.* 10) £4 5 0

Millimetre scale added to either of the above, £1 extra.

FIG. 10.

11. **The Fisherman's or Storm Barometer,** as expressly approved by Admiral FitzRoy, Board of Trade, &c., for lifeboat stations. It consists of a strong tube with a large bore, and very correct and bold thermometer, mounted in a solid oak frame, firmly screwed together. The scales are of porcelain, distinctly engraved, and impervious to any injury from the weather; the vernier reading is to 0·01 inch. It is strongly recommended as a sound and excellent instrument, admirably adapted for the sea coast and public institutions £4 15 0

12 **Miner's Barometer.** The numerous accidents occuring in coal mines in particular, and the close connection of these with diminished atmospheric pressure, as shown by a low state of the barometer, has induced L. CASELLA to arrange an economic and highly portable form of instrument for this purpose; it is plain, handy, sensitive, and adapted alike for all climates . . £1 17 6

13. **Miner's Barometer,** more elaborately finished . . £2 5 0

The instruments, Nos. 11, 12, and 13, can be fitted with an electric apparatus to give warning of a sudden fall by ringing a bell, either on the instrument or at a distance, at a small extra cost.

14. **Wallis's Barometer Adjunct,** for facilitating the adjustment of the zero of the scale. It can be clamped to any of the instruments on the Fortin principle (*fig* 14) . 10*s*. 6*d*.

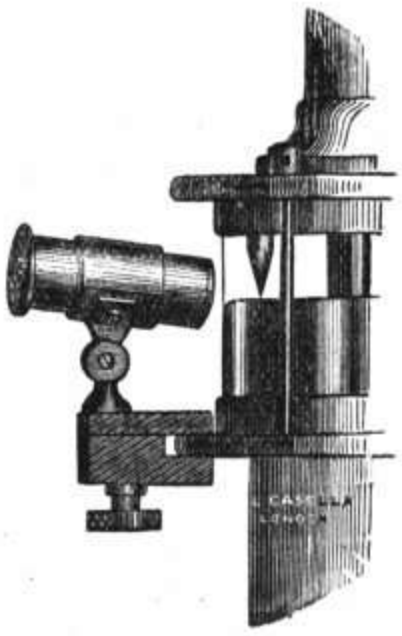


FIG. 14.

15. **Glass Case for Standard Barometer,** of black polished wood, with plate-glass sides and front, forming a neat and elegant protection against dust, &c. for either of the standard barometers . £2 10 0 to £4 0 0

For Mountain Barometers, Mercurial Mariotte, and Aneroid, see Travelling Instruments, Part III.

L. CASELLA also supplies the ordinary upright barometers for halls, cottages, &c. in a great variety of forms and mountings, at various prices, from 12*s*. 6*d*. to £25.

SELF-RECORDING MERCURIAL BAROMETERS.

16. **King's Barograph,** or Self-recording Barometer, as designed by the late William King, Esq. C.E. of Liverpool. In this arrangement the tube is partly supported by the mercury in the cistern, which as it rises and falls raises and depresses the tube. A delicate mechanical contrivance records this change of level continuously on a revolving drum. About 130lbs. of mercury are employed, and the effects of friction are entirely overcome by the most sensitive mechanical arrangements. The barometric column is made to show nearly six inches for each inch of the ordinary barometer, and to indicate in this extended form the atmospheric pressure on a vertical scale, as well as to record continuously on a diagram the exact time and character of the smallest, as well as the greatest, fluctuations which occur in the pressure of the atmosphere. The lofty and elegant form of this instrument, as well as the extreme delicacy of its indications, eminently adapt it for first-class observatories . . . ~~£260 0 0~~ 230 0 0

Or with suitable Glass Case, extra £40.

17. **King's Barograph,** of simpler form than the above . £150 0 0

18. **Self-Recording Mercurial Barometer,** or Barograph, for recording the barometric variation on ruled metallic paper. In this arrangement a vertical cylinder of about four inches diameter is made to revolve once every seven days by means of clock-work. A metallic pencil, rising and falling with the mercury, marks this paper at every hour. The paper being changed once a week, the date, time, &c. of every change of pressure is correctly indicated; and the marks, being connected by lines drawn from point to point, give a continuous diagram of the changes which have occurred. The mercurial column and timepiece are also observable

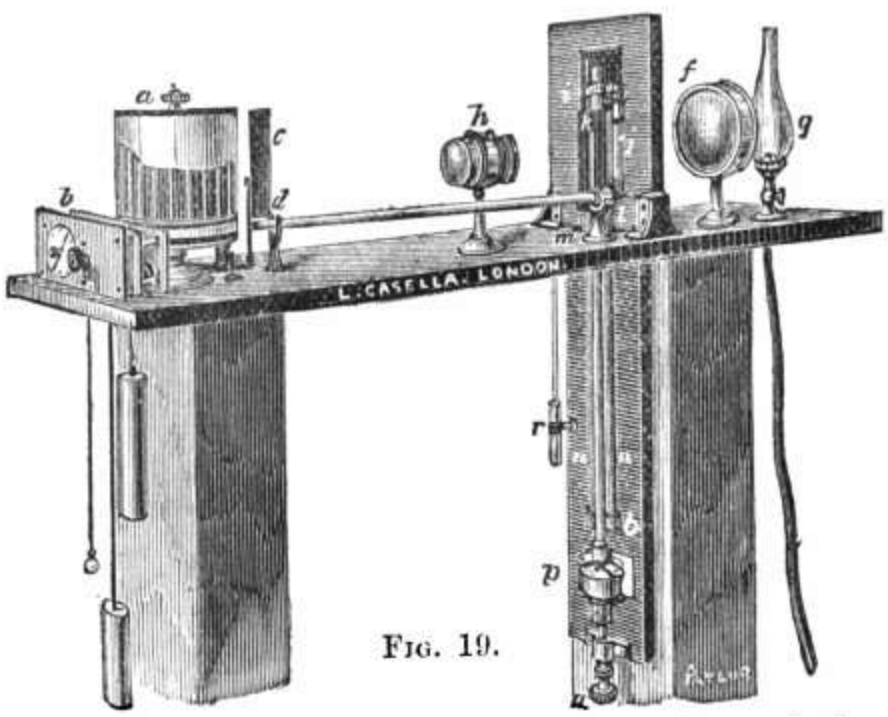


Fig. 19.

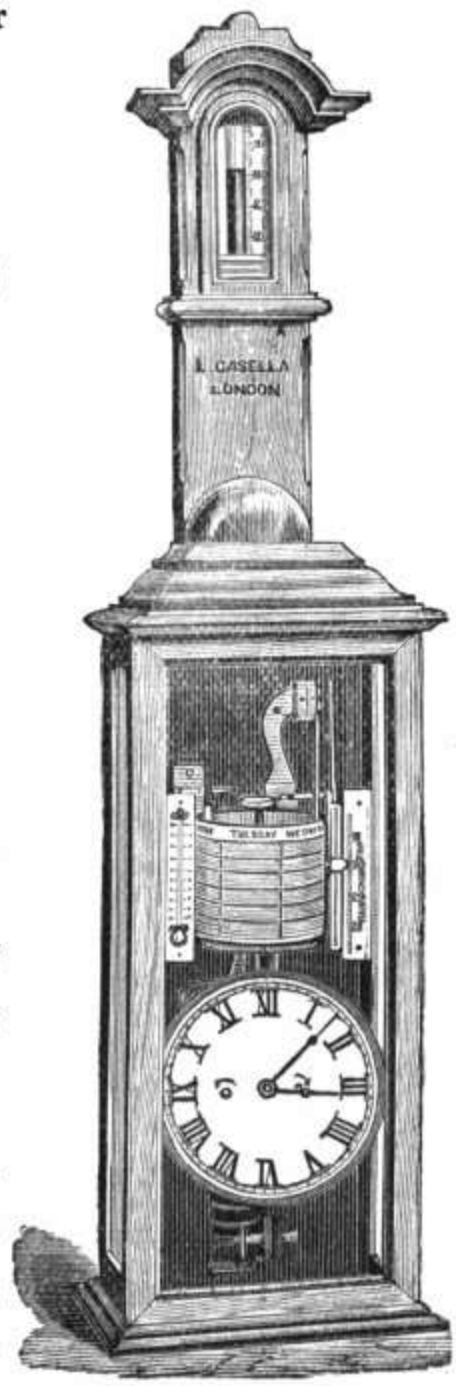


Fig. 18.

at any moment, the instrument thus forming an ordinary, as well as a self-recording barometer, with the addition of an excellent eight-day clock (*fig.* 18, p. 15). The size is about 13 inches wide, 8 inches deep, and 36 inches high £30 0 0

19. **Beckley's Kew Observatory Barograph,** as made by L. CASELLA for the Government Observatories, permanently records the various changes of barometric pressure by means of photography, with barometer, standard thermometer, and all appliances complete, and ample instructions for use (*fig.* 19, p. 15) . £92 10 0

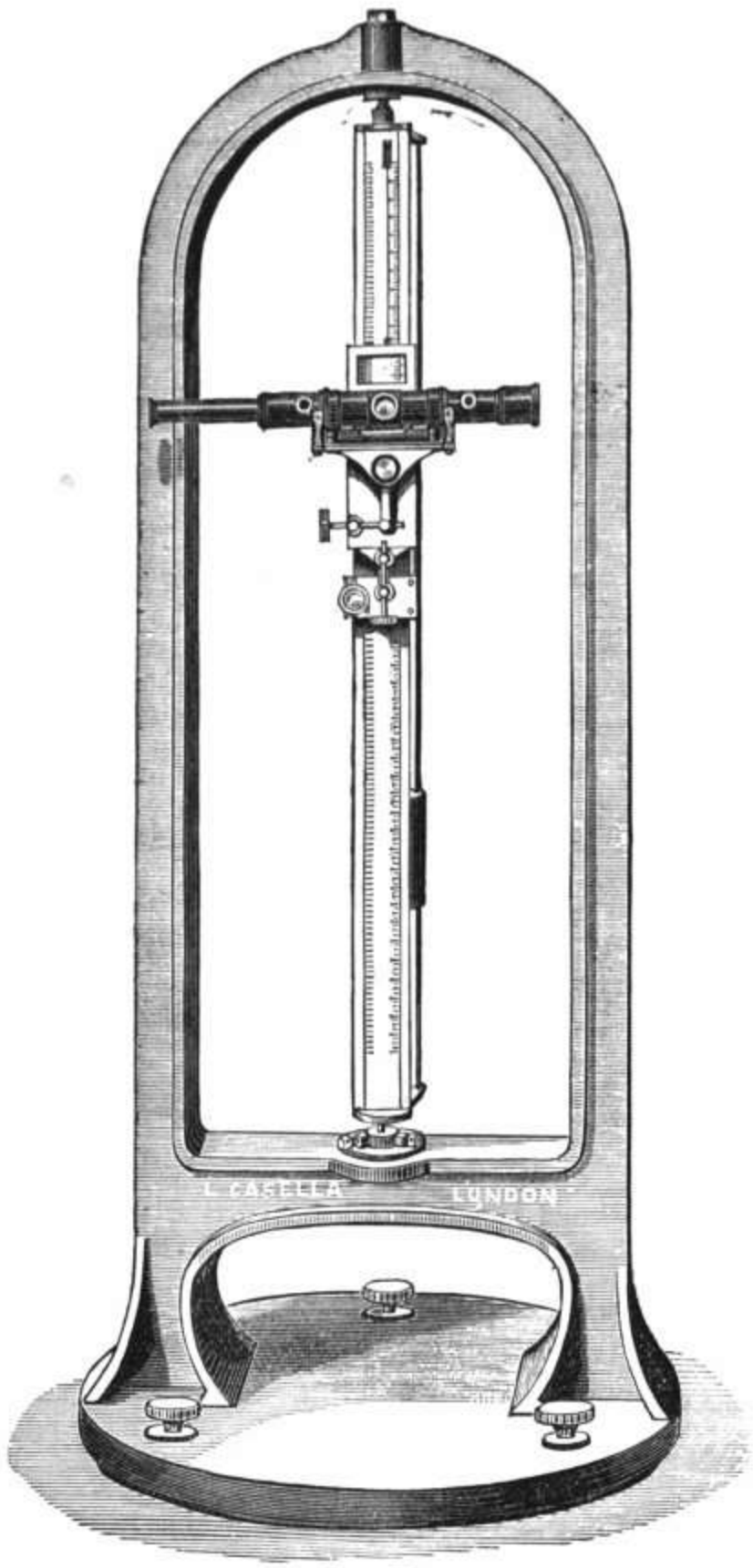


FIG. 20.

20. **Cathetometer,** as constructed by L. CASELLA for the Indian Government, with triangular brass bar divided to 0·1 inches, reading to ·001 inches by a vernier. It is furnished with a superior telescope, carrying cross wires and level, rack motion, clamp, erecting and inverting eye-pieces, and fine adjustment to both vernier and telescope. The whole revolves on adjustable centres in a painted arched iron frame, the base of which is furnished with three levelling screws (*fig.* 20) . £53 0 0

21. **Cathetometer,** as used at the Kew Observatory, with metal scale divided to millimeters, reading to 0·1 m. m. by vernier; telescope and attached level, fine adjustments to level and vernier, and clamp to fix telescope at any height; with extra firm stand carrying three levelling screws (*fig.* 21, p. 17) £28 and £28

22. **Cathetometer,** 6½ feet high, with telescope, surmounted by an adjustable level, erecting eye-piece, tangent screw adjustment, vertical slide motion, with clamp and rack adjustment. Brass pillar stand with folding claws and levelling screws (*fig.* 22) £12 15 0

This instrument can be had with rod divided to ·5 decimeters, together with vernier reading to ·1 m. m. £14 15 0

Cathetometers in great variety at higher prices, from £60 upwards can be had on application, or see larger catalogue.

Fig. 21.

Fig. 24.

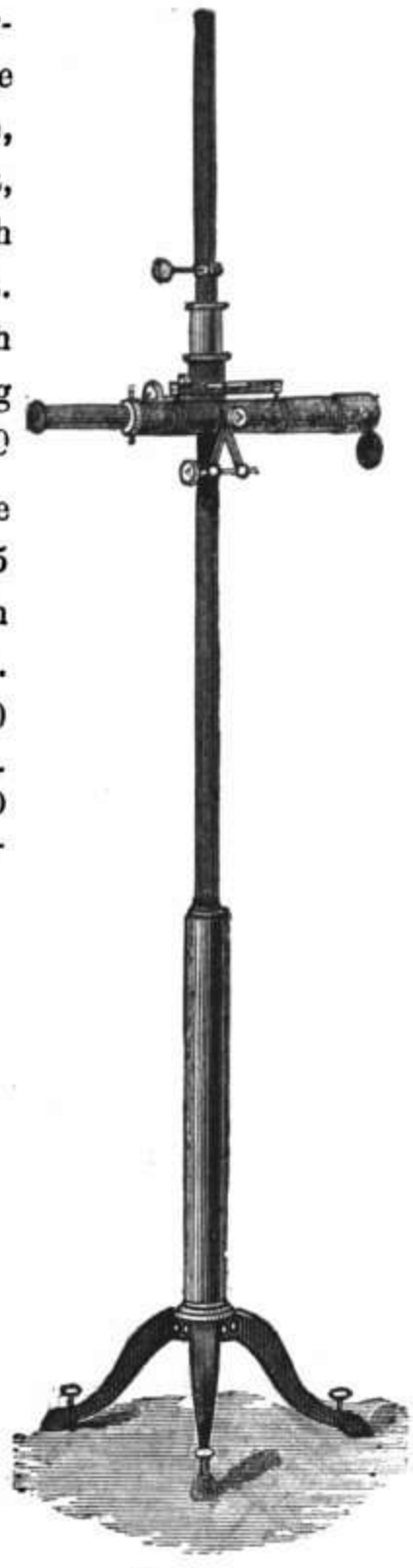


Fig. 22.

ANEROID BAROMETERS.

23. **Aneroid Barometer,** bold and very handsome, in ebonized, bronzed, or gilt metal frame, 18 inches diameter, for halls and public institutions £15 0 0

Larger sizes, in various mountings, made to order.
For smaller sizes see page 45.

Four-and-a-half inches diameter, in neat cases.

24. **Aneroid Barometer,** highly finished, carefully compensated for temperature, extra sensitive, with greatly expanded graduations, divided to ·10 inch, each barometric inch being represented by nearly four inches of scale, with circular thermometer and richly engraved ornamental dial (*fig.* 24) £5 10 0

25. **Aneroid Barometer,** of superior finish, carefully compensated, in best cylindrical case, with revolving index and neat plain engraved dial, without words or thermometer, as in the best standard instruments . £5 10 0

26. **Aneroid Barometer,** of superior finish, carefully compensated, in best cylindrical case, with revolving index. Ordnance pattern, for measuring heights up to about 15,000 feet or more . . . £5 10 0

27. **Aneroid Barometer,** for measuring heights up to about 8000 to 10,000 feet £5 0 0

28. **Aneroid Barometer,** for measuring heights up to about 6000 to 8000 feet £4 15 0

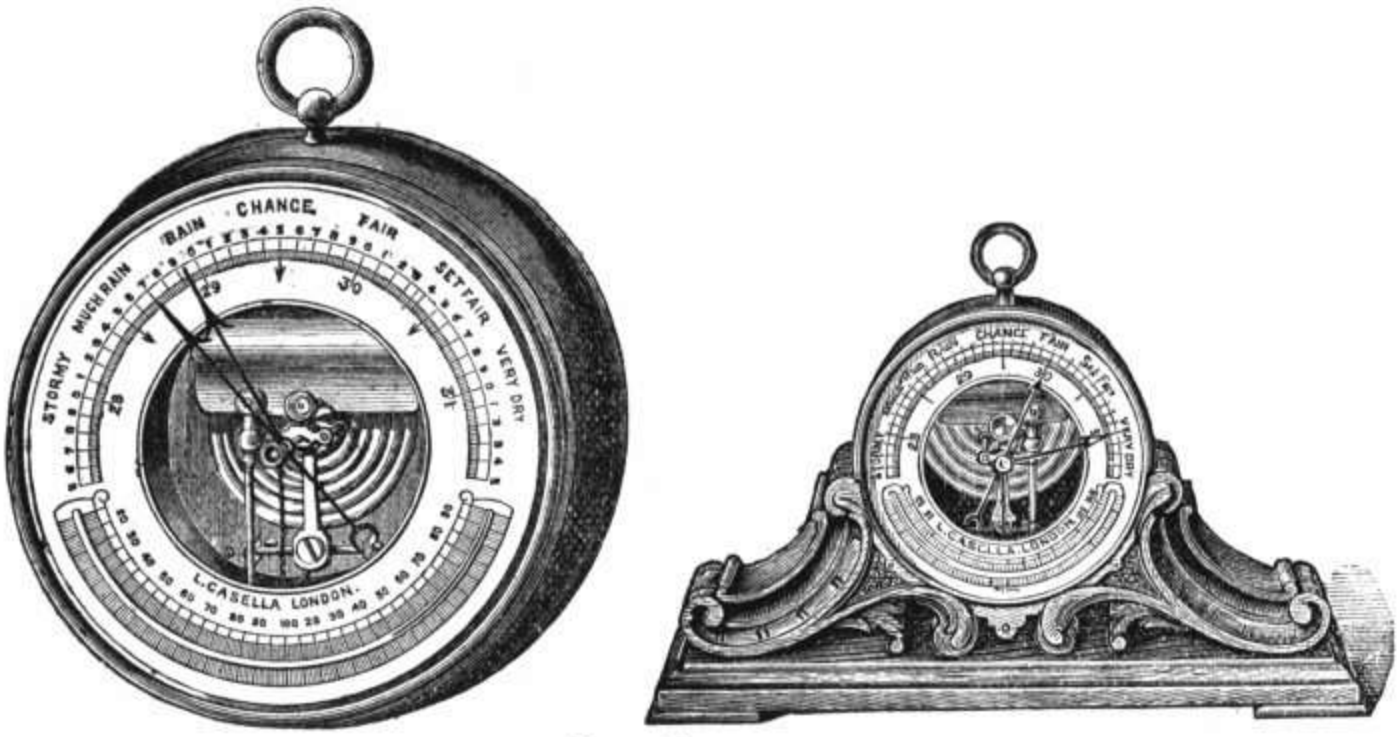
29. **Aneroid Barometer,** for measuring moderate heights, with richly engraved raised circle, revolving index, and with or without thermometer £5 0 0

30. **Aneroid Barometer,** cylindrical form, carefully compensated for temperature, with extended scale, available for measuring heights to about 6000 feet £4 4 0

31. **Aneroid Barometer,** available for measuring heights, as used in Her Majesty's Navy, with thermometer . . . £4 4 0

32. **Aneroid Barometer,** open engraved metal dial to show the interior mechanism, with thermometer (*figs.* 32) . . . £2 10 0

For moist climates a gold band is occasionally substituted for the ordinary steel chain, and may be put to any of the above, at an extra charge of 10*s*.



FIGS. 32.

33. **Aneroid Barometer,** open enamel card dial, to show the interior mechanism, with thermometer £2 10 0

34. **Aneroid Barometer,** ornamental gilt or coloured dial, with circular thermometer £2 12 0

35. **Aneroid Barometer,** best engraved . . . £2 10 0

36. **Aneroid Barometer,** metal dial, with or without thermometer £1 0 0

37. **Aneroid Barometer,** card dial, with or without thermometer £0 15 0

The best Aneroids can have self-registering indices added, by which the highest and lowest point during absence may be registered, at £1 1*s.* extra.

A scale of altitudes can be had with most of the above gratis, or may be engraved on their dials at an extra charge of 10*s.*

Leather Sling Case, with strap for portability, to any of the above, 10*s.* extra.

38. **Self-Recording Aneroid Barometer.** In this arrangement a vertical cylinder is caused to revolve by means of clockwork, and the barometric variations are accurately marked at every hour on ruled metallic paper by the action of a large and strongly-made aneroid barometer, the paper being changed once a week. By drawing a line through the dots an accurate barometric diagram, showing dates and times of changes, is obtained, whilst the clock and aneroid respectively form excellent instruments for showing exact time, as well as the constant changes in the barometric pressure (*fig.* 38)

£25 10 0

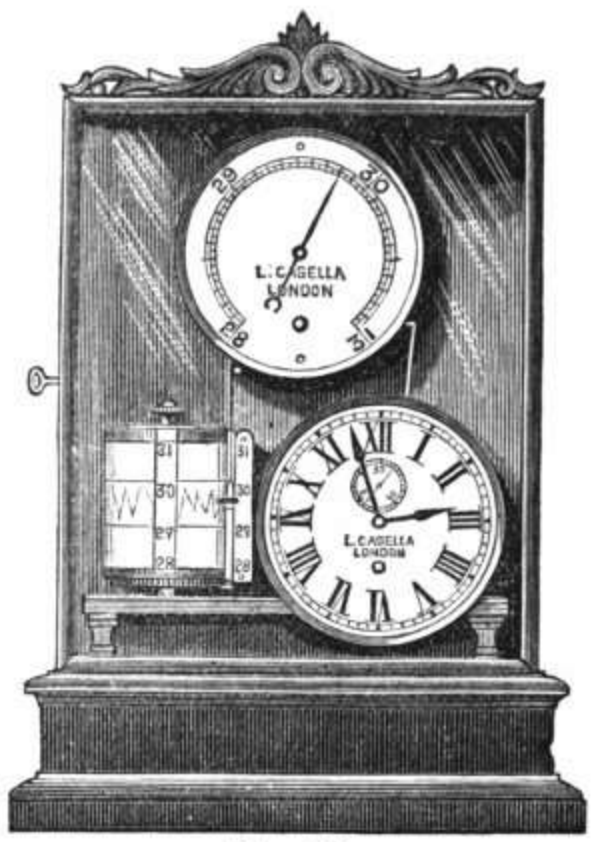


FIG. 38.

THERMOMETERS.

39. **Independent or Natural Standard Thermometer.** This is the highest class of thermometer which can be made; the bore is carefully calibrated, the freezing and boiling points of water are determined with the utmost precision, and the greatest care is taken to minimise the "displacement of the zero"; it is engine-divided and figured on the stem

£5 5 0

40. **Standard Thermometer, Comparative,** carefully tested in all its parts, the tube 15 inches long, engine divided on the stem, and figured on raised metal or porcelain scale, 0° to 212° Fahrenheit or – 20° to 100° Centigrade, in maroon case, with verification from Kew Observatory (*fig.* 40, p. 20) £2 5 0

41. **Standard Thermometer, Comparative,** as No. 40, with porcelain scale on mahogany, for out-door use, range about 0° to 130°, as made by L. CASELLA for various departments of the Government (*fig.* 41, p. 20)

£2 5 0

42. **Kew Observatory Thermometer** (*Meteorological Office and Admiralty pattern*), 12 inches long, with divisions etched on the stem, and the figures indelibly burned on the porcelain scale, range about 0° to 120° ; as arranged at the Brussels' Conference, for taking reliable observations at sea. This is an excellent instrument, with which others may at any time be compared, and is, moreover, the only kind of thermometer, which can be used at sea without deteriorating from the corrosive action of salt water and damp. In copper case (*fig.* 42), with verification from Kew Observatory 15*s.* 6*d.*

43. The same thermometer less expensively mounted, and without verification 10*s.* 6*d.*

N.B —A set of six thermometers, as No. 43, with two copper cases, in a neat box, as supplied by L. CASELLA to the Board of Trade and Admiralty . . . £3 3 0

FIG. 40.

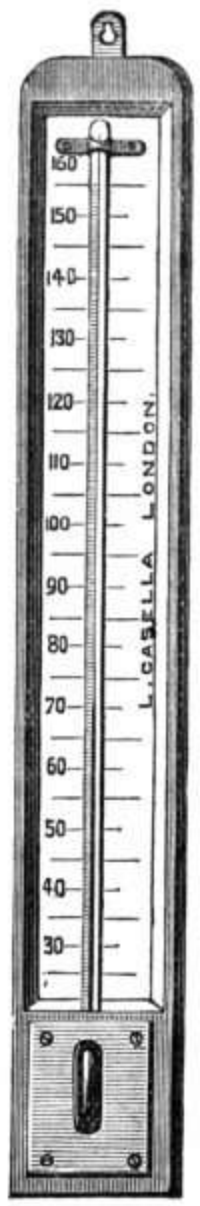


FIG. 41.

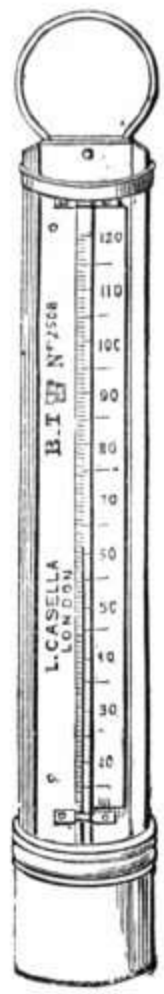


FIG. 42.

44. **Babinet's Apparatus,** with two highly sensitive thermometers, for taking the exact temperature of the air (*fig.* 44) £2 10 0

The slow and unequal transmission of heat by air and water is well known, the temperature of a body of the latter being only obtainable by its constant agitation. The above arrangement gives the same means of agitating the air in order to ascertain its true temperature as well as the effects of its friction on the thermometer bulb.

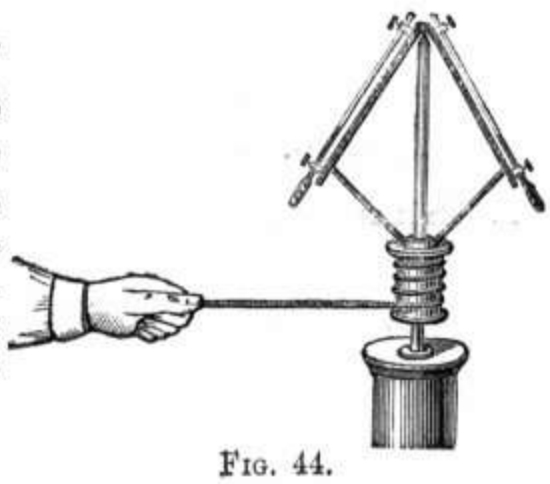


FIG. 44.

45. **Thermomètre Fronde,** in brass case for pocket, as designed by M. Renou, for ascertaining the true temperature of the air without a thermometer stand . . . . . 10*s.* 6*d.*

This thermometer is arranged to be rapidly swung round above the head by means of the silk cord about six times, when it will be found to show almost precisely the same temperature as that of a thermometer in the best constructed thermometer stand.

46. **Maximum Thermometer,** for registration of temperature in shade; engine divided on the stem, and indelibly figured on CASELLA'S improved porcelain scale, *which effectually resists frost and all effects of weather* (*fig.* 46) £1 0 0

(Plainer kinds of this instrument are made at 12*s.* 6*d.* and 8*s.* 6*d.*)

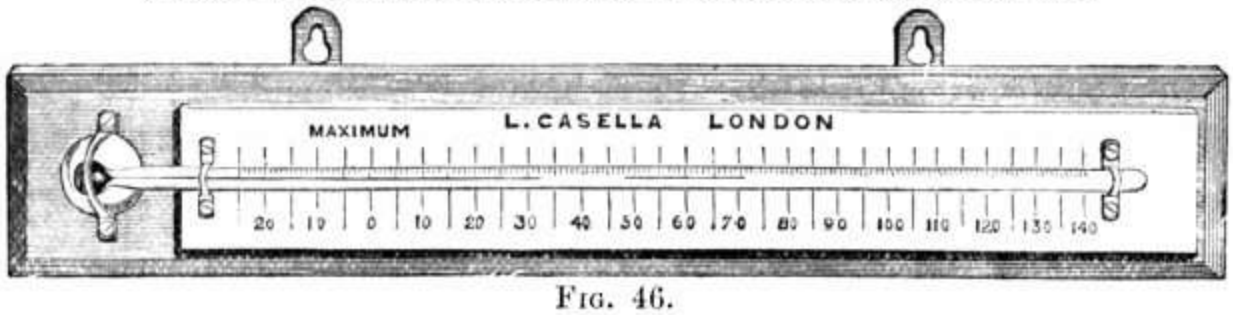


FIG. 46.

47. **Casella's Mercurial Minimum Thermometer** (for temperature in shade), on porcelain scale, with hardwood back, and divided on the stem (*fig.* 47) £2 10 0

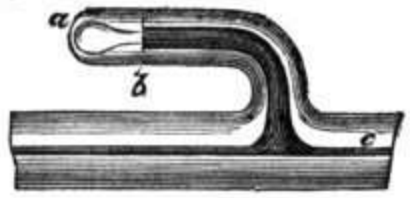


FIG. 47.

This is the only practical *mercurial* minimum thermometer hitherto invented. The bulb and column are of the same size as in the standard maximum thermometers; and cold is thus registered under precisely the same conditions as heat; no steel or other index is employed, whilst the annoyance arising from vaporization and breakage of the column, as in the spirit minimum thermometer, is entirely avoided. In this arrangement advantage is taken of the tendency of fluids to recede first from the smaller bore and rise in the larger, whilst the return of the mercury from any point to which it may descend is prevented by capillary action.

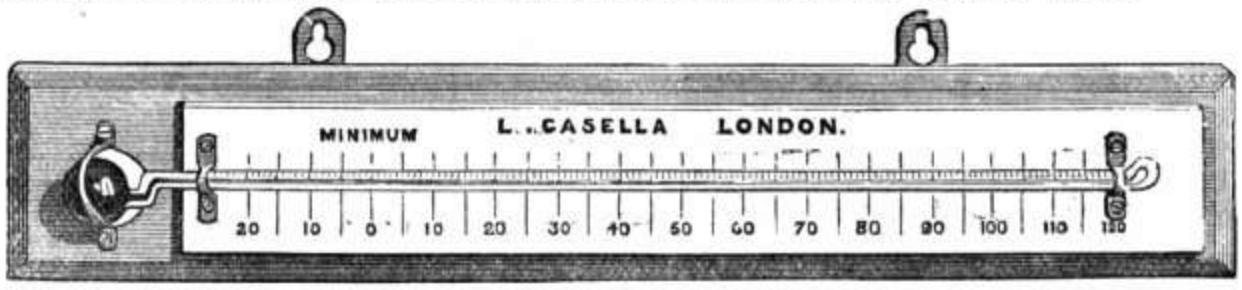


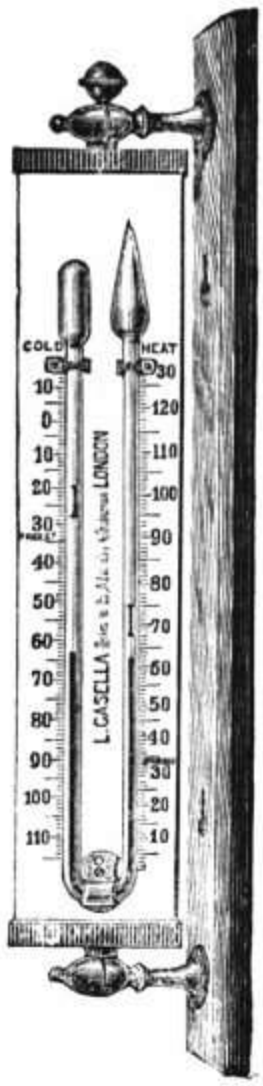
FIG. 48.

48. **Minimum Thermometer,** filled with pure alcohol for ordinary registration, engine divided on the stem, and mounted to correspond with the standard maximum No. 46 (*fig.* 48) £1 0 0

(Plainer qualities at various prices down to **4***s.* 6*d.* each.)

49. Casella's Extra Sensitive Minimum Thermometer, forked as *fig.* 62, p. 24, on porcelain scale, with hardwood back . £1 5 0

50. Sixe's Self Registering Thermometer (CASELLA's Improved). This instrument shows accurately the present temperature, and registers the extremes of heat and cold during the absence of the observer. It is the only instrument that registers cold in a vertical position, or that does not require handling or removal from its place in setting the indices, and is certainly the most convenient form of all double self-registering thermometers. For dull or defective sight it is deservedly appreciated, as its plain bold indications are so easily seen that, placed outside the window, it can be turned to any angle, as shown in the figure, and read off without opening the window. In the garden, greenhouse, dairy, or wine cellar, its indications are equally valuable, whilst for manufacturing purposes, as malting, brewing, &c. &c. where unknown or sudden changes of temperature are often serious, the indications of this instrument are of the utmost importance.



The great improvements effected of late in this thermometer, together with its convenient form and extensive application, have caused it to be adopted as a means of ascertaining the temperature of the sea. For this purpose, however, considerable modifications were required, not only to adapt it for the rough usage to which it must thus be exposed, but also to protect the bulb from the effects of the great pressure of the sea; with these changes it was at once adopted by the ADMIRALTY and the ROYAL SOCIETY for the late investigations conducted on board Her Majesty's Ships ***Porcupine*** and ***Challenger***, as well as by the leading Governments of the world; and with it, under the well-known name of the "Casella-Miller Deep-Sea Thermometer," the able men at the head of these expeditions have successfully determined the temperature of the sea, even at its greatest depth, and thereby obtained a better knowledge of the laws which govern the circulation of the waters of the ocean (See No. 156, page 46).

PRICES:—No. 1. Improved self-registering thermometer, as above, on mahogany board, with bronzed bracket for outside of windows, with clear black figures and divisions on opal or porcelain, impervious to all the influences of weather, 10-in. £1 15*s.*; 12 or 14-in. £2.

No. 2. Improved self-registering thermometer, on opal, as above, for gardens, greenhouses, &c. &c. in Japan case, 10-in. £1 1*s.*; 12-in. £1 6*s.*; 14-in. £1 10*s.*

No. 3. Improved thermometer, as above, on polished boxwood scale, in Japan case, 10-in. 15*s.* 6*d.*; 12 or 14-in. £1.

51. Casella's Electrical Sixe's Self Registering Thermometer. This instrument, made at the suggestion of W. T. Goolden, Esq., M.A., F.C.S., &c., is well adapted for *forcing-houses*, *hospital wards*, or for the

ventilation of *theatres* and *public buildings*. The indices can be *set at any desired range of temperature*, and if the temperature either rises above or falls below these limits, a bell is sounded at any convenient distance from the instrument, for instance, in the gardener's cottage, or in the room of the medical officer or man in charge of the heating or ventilating apparatus. It can also be used as an ordinary Sixe's Thermometer . £3. 3. 0

52. **Cripp's Self-Recording Thermometer.** This instrument records thermometric changes on a vertical cylinder carrying a ruled metallic paper, and revolving once in seven days. A flat spiral thermometer, balanced on a horizontal axis, is caused to rotate through a small arc of a circle by the disturbance of its equilibrium when the mercurial column advances or recedes. Connected and moving concentrically with the thermometer is a grooved sector, to which a chain and metallic pencil are attached. As the thermometer revolves the pencil rises and falls, and impinging on the metallic scale records the temperature at intervals of an hour. The whole is mounted in a black cabinet with glass door, and also shews the time on a good clock £20 0 0

53. **Earth Thermometer,** for ascertaining the temperature below the soil, or the heat developed in hay-stacks, pine and melon pits, &c. with pointed brass or copper tube (according to length), from 4*s*. 6*d*. to £1 5 0

54. **Well or Earth Thermometer,** self-registering; for immersion to any depth in the earth or wells, and showing the maximum and minimum temperature for any interval of time . £1 10 0

55. **Well Thermometer,** Sir William Thomson's self-registering 7-inch maximum, in stout glass shield, as supplied to the Underground Temperature Committee of the British Association £1 1 0

FIG. 55.

Symons's New Earth Thermometer, to lower into an iron pipe to any depth, expressly arranged to obviate all the difficulties hitherto felt in obtaining ground temperature (*fig*. 55).

56.	Thermometer with tube for showing temperature	6 in.	below	the surface	£1	1 0
57.	Do.	do.	do.	1 foot	do.	1 1 0
58.	Do.	do.	do.	2 feet	do.	1 5 0
59.	Do.	do.	do.	4 feet	do.	1 10 0
60.	Do.	do.	do.	10 feet	do.	2 5 0

The tubes for these thermometers are intended to project six inches above ground, and the length supplied is therefore that much more than the depth at which the thermometer is to indicate.

TERRESTRIAL HEAT AND RADIATION.

61. **Minimum Thermometer,** for terrestrial radiation, divided and figured on the stem, which is enclosed in a glass cylinder for protection (*fig.* 61) £1 0 0

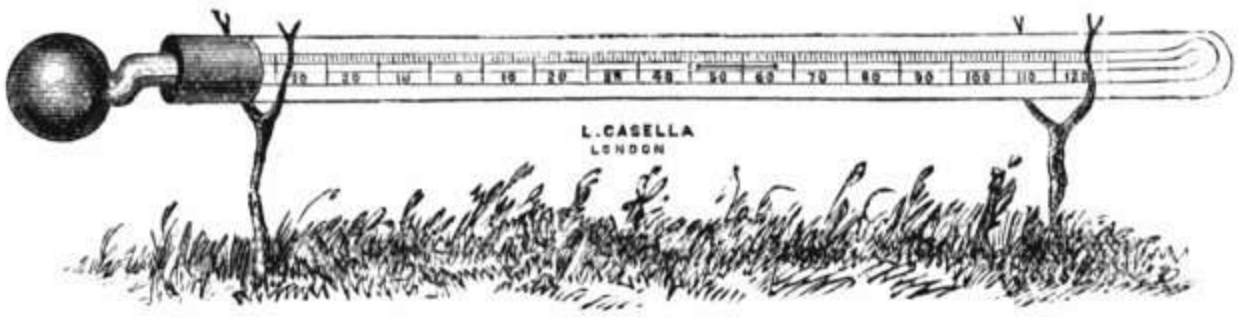


FIG. 61.

62. **Casella's Extra Sensitive Minimum Thermometer** for terrestrial radiation. The unavoidably high price of CASELLA's Mercurial Minimum Thermometer, as well as the care required in using it, have induced him to design the one shown in *fig.* 62, in which the bulb, being extended in the forked form there shown, exposes a greatly increased surface to the air, and thus renders it little, if at all, less sensitive than the mercurial one. It is really interesting to note the increased sensitiveness of this over even the best instruments of the usual construction . . . £1 5 0

[See paper on this subject by Mr. G. J. Symons, in "Quarterly Journal of Meteorological Society" for July 1874.]

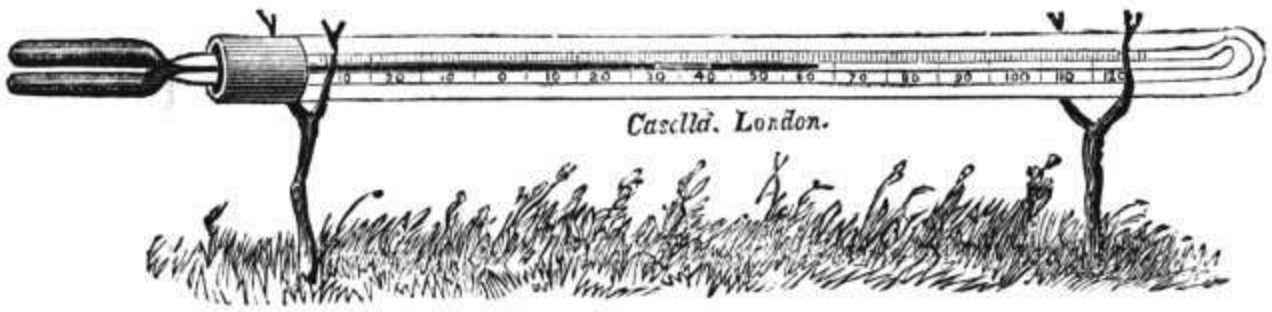


FIG. 62.

63. **Casella's Newly-designed Sensitive Minimum Thermometer,** Registered £1 5 0

The flat side of this thermometer being turned to the sky, greatly increases its power of indicating the effect of radiation.

SOLAR RADIATION THERMOMETER & APPARATUS.

64. **Solar Radiation Thermometer,** maximum, with black bulb, tube divided and figured on the stem, and enclosed in glass shield for protection £1 5 0

65. **Casella's Insulated Solar Radiation Thermometer,** as first made by him, at the suggestion of Sir J. Herschel (see *Admiralty Manual of Scientific Enquiry*). In this arrangement, the thermometer

being in a nearly perfect vacuum, the maximum registration of the heat of the sun's rays is obtained, divested of the influence of vapour or passing currents of air (*fig.* 67) £1 5 0

An important improvement also is that effected by the Rev. F. W. Stow, who from close observation found that a certain amount of dull black covering on the bulb and stem, as well as general uniformity in size and state of exhaustion, was indispensable. Besides the careful observance of these conditions, L. CASELLA is prepared to demonstrate at any time the complete state of vacuum obtained in the outer shield of each of these thermometers.

66. **Vacuum Radiation Thermometer,** bright bulb, as arranged for the observatories of the Meteorological Society £1 5 0

FIG. 67.

67. **Stand** for the above, it being essential for strict comparison, that all instruments of this kind should be similarly placed (*fig.* 67) ~~£1 1 0~~ 0. 7. 6

68. **Pouillet's Pyrheliometer,** for ascertaining the effect of the sun's heat upon a given area by the number of degrees of heat imparted to a given quantity of mercury in five minutes, as described in Dr. Tyndall's "Heat Considered as a Mode of Motion" . . £4 4 0

In a paper in the "Quarterly Journal of the Meteorological Society" for 1875, the Rev. Fenwick W. Stow says:—

"An improvement on this instrument (being made by Mr. CASELLA), on Pouillet's original water principle, is in process of manufacture."

And in a note at the end he says:—

"It is now completed and, so far as it has yet been tried, seems likely to act well."

69. **Solar Intensity Apparatus,** invented by Padre Secchi, for measuring the comparative heat of the sun's rays. Two thermometers are here kept immersed in a fluid at any temperature, and a third surrounded by the same conditions, but not immersed, is exposed to the rays of the sun. The increase of temperature thus obtained is found to be the same irrespective of the temperature of the fluid which surrounds it. Cylindrical form, about 3 × 10 in. Price, with the requisite three thermometers £3 18 0

70. **Tripod Stand** with universal joint, by which the above may be kept in any position at any temperature £1 5 0

71. **Helio-Pyrometer,** as arranged by T. Southall, Esq., by which the following extraordinary results were obtained :—

July 11th 1859, maximum temperature of air 87°·0, in the sun of 216°·0
,, 12th ,, ,, ,, 89°·1 ,, 231°·5
,, 13th ,, ,, ,, 80°·5 ,, 217°·0
£2 5 0

For further details see large catalogue.

72. **Actinometer** (Sir John Herschel's), for ascertaining the absolute heating effect of the solar rays, time being considered one of the elements of observation £7 0 0

To take an observation the actinometer is placed in the shade for one minute and read off; it is then exposed for one minute to the sun's rays, and its indication taken; it is finally restored to the shade, and its reading also taken. The mean of the two readings in the shade subtracted from that in the sun gives the actual amount of expansion of the liquid produced by the sun's rays in one minute of time. (See Report of the Royal Society on Physics and Meteorology.)

73. **Beckley's Thermograph** as made by L. CASELLA for the Government observatories. This instrument is designed to show changes of atmospheric temperature and moisture, by means of photography. When in use the top is covered by a mahogany box, for the exclusion of light in the same way as the barograph; in this case, however, the artificial light is only admitted to the paper through an air-speck in each thermometer, which separates the mercury in the same manner as that arranged by L. CASELLA to detach the index in his maximum registering thermometer. An ingenious arrangement is made to support the thermometer bulbs in the open air; they project about one foot from the wall, upon the edge of which the slabs rest, the general arrangement being as in *fig.* 73. With bent thermometers, two standard thermometers and all appliances complete . £120 0 0

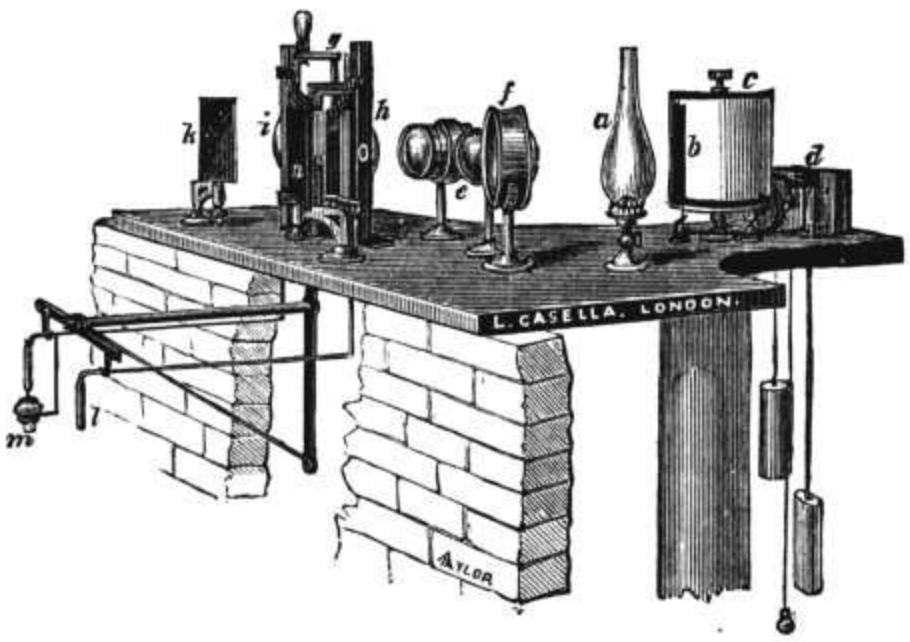


FIG. 73.

74. **The Whipple-Casella Universal Sunshine Recorder,** for ascertaining and recording the daily amount of direct sunshine. A strip of

cardboard is arranged so that the sun's rays, concentrated to a focus by a large spherical lens, shall trace a charred line on it when they are unobscured by cloud or mist. The instrument is universal, having divided latitude and diurnal circles, and thus can be easily set for any locality and for any day in the year (*fig.* 74) £17 0 0

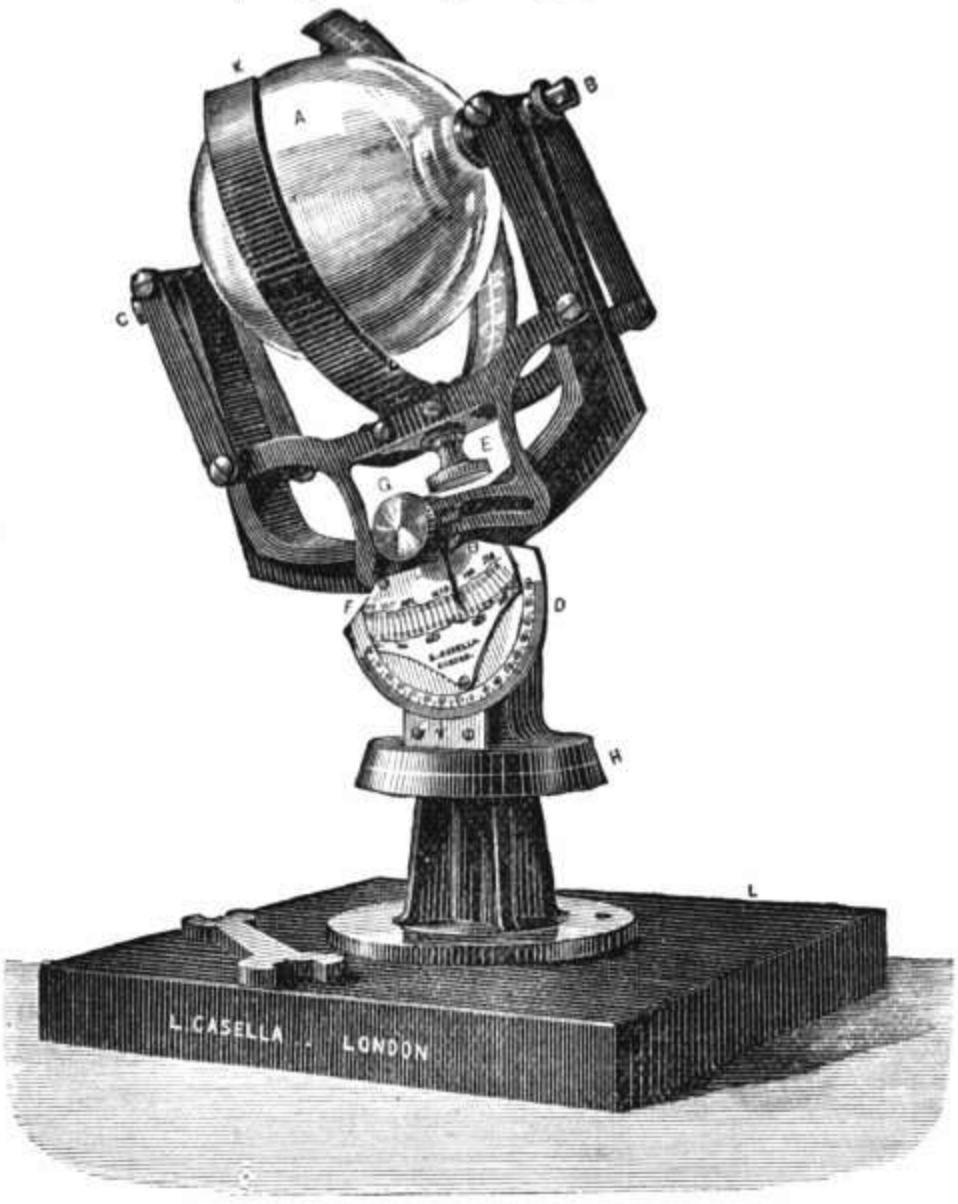


Fig. 74.

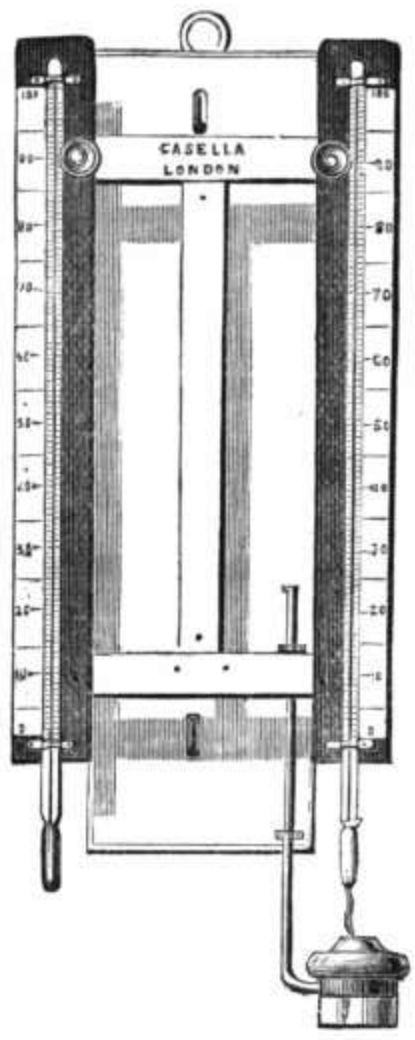


Fig. 77.

HYGROMETERS.

75. **Mason's Hygrometer,** or August's Psychrometer, extra large size, with 18-inch tubes, divided to fifths of degrees, for delicate investigations £5 5 0

76. **Mason's Hygrometer,** large size, 15-in. tubes, divided to 0°·2 £3 10 0

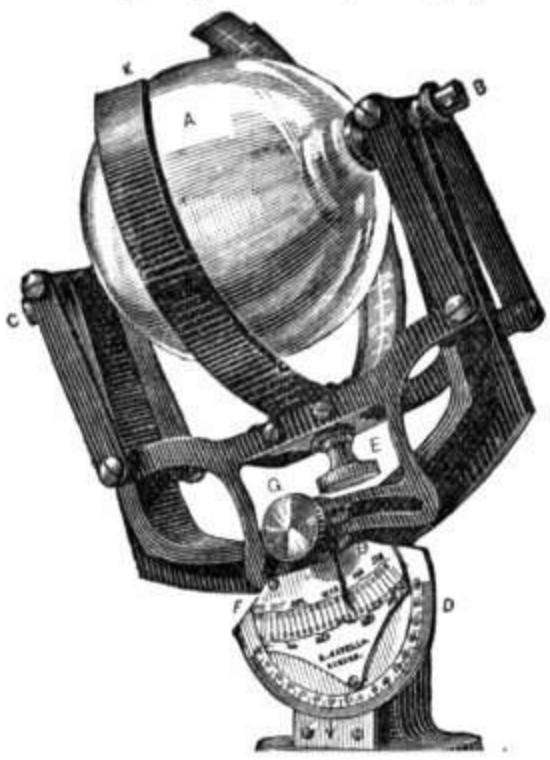
77. **Mason's Hygrometer,** with metal scales, mounted on mahogany board for suspension. The thermometers are divided on the stem, and the figures indelibly burnt in on porcelain slips at the side, as supplied by L. Casella to the various Government Departments and to the Fellows of the Meteorological Society (*fig.* 77) . . . £2 5 0

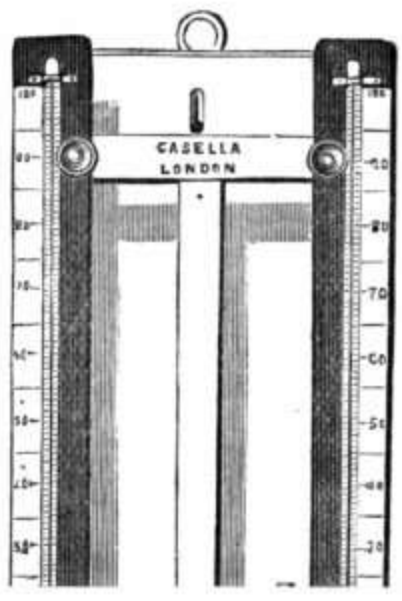
78. **Mason's Hygrometer,** like *fig.* 77, but mounted on porcelain scales £1 15 0

79. **Mason's Hygrometer,** mounted on brass pedestal (*fig.* 79 p. 28) £2 2 0

L. Casella has instruments of this pattern, but not so strictly accurate, at various prices, down to 13*s.* 6*d.*

cardboard is arranged so that the sun's rays, concentrated to a focus by a large spherical lens, shall trace a charred line on it when they are unobscured by cloud or mist. The instrument is universal, having divided latitude and diurnal circles, and thus can be easily set for any locality and for any day in the year (*fig.* 74) £17 0 0





Sunshine Recorder for fixed stations as used by the Meteorological Office . . . . . £9 : 9 : 0

Curves for Do. for one year . . . . . £1 : 15 : 0

Blue Strips of Card ruled and figured for one year, for use with the Universal Sunshine Recorder . . . . . £1 : 4 : 0

HYGROMETERS.

75. **Mason's Hygrometer,** or August's Psychrometer, extra large size, with 18-inch tubes, divided to fifths of degrees, for delicate investigations £5 5 0

76. **Mason's Hygrometer,** large size, 15-in. tubes, divided to 0°·2 £3 10 0

77. **Mason's Hygrometer,** with metal scales, mounted on mahogany board for suspension. The thermometers are divided on the stem, and the figures indelibly burnt in on porcelain slips at the side, as supplied by L. CASELLA to the various Government Departments and to the Fellows of the Meteorological Society (*fig.* 77) . . . £2 5 0

78. **Mason's Hygrometer,** like *fig.* 77, but mounted on porcelain scales £1 15 0

79. **Mason's Hygrometer,** mounted on brass pedestal (*fig.* 79 p. 28) £2 2 0

L. CASELLA has instruments of this pattern, but not so strictly accurate, at various prices, down to 13*s.* 6*d.*

80. **Daniel's Hygrometer**; the thermometers divided on the stems, with ether test-jar, bottle, &c. complete in mahogany case (*fig.* 80) £3 10 0

This elegant instrument consists chiefly of two bulbs, a black one and a white one, about one-fourth filled with the highest rectified ether, and united by a bent glass tube. The stem encloses a sensitive thermometer, with its bulb placed rather below the centre of the black ball. The white bulb is covered with thin muslin. The interior of the tube is thoroughly deprived of air, and the greatest care is taken not to over-boil or impoverish the ether.

To use this instrument, turn it over so that all the ether is in the black bulb, drop ether on the white bulb until a ring of dew is deposited on the black one, then instantly read both thermometers, watch for the disappearance of the dew from the black bulb, and then read both thermometers again. The mean of the readings of each thermometer gives respectively that of the air and that of the dew point.

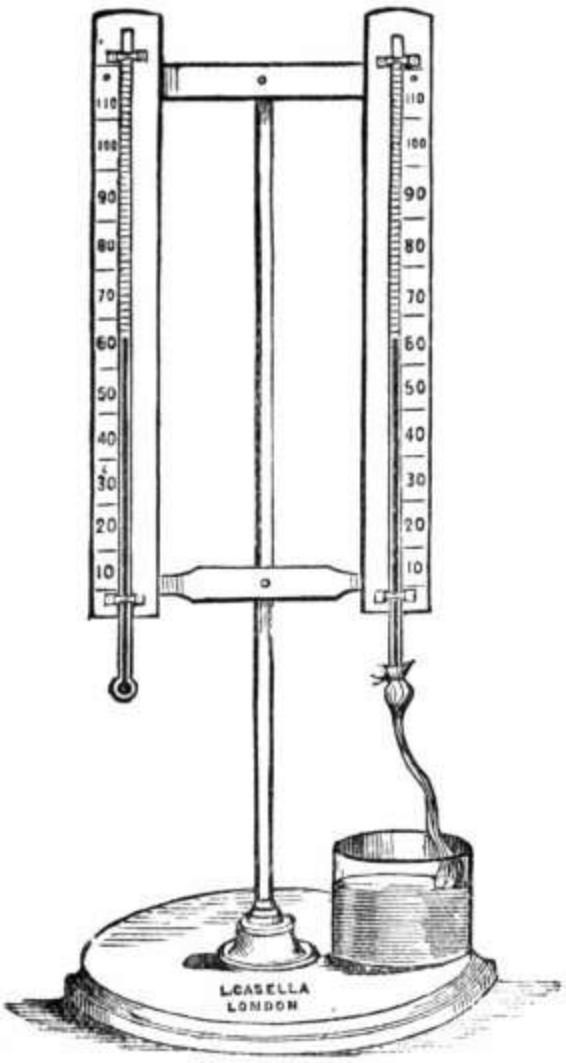


Fig. 79.

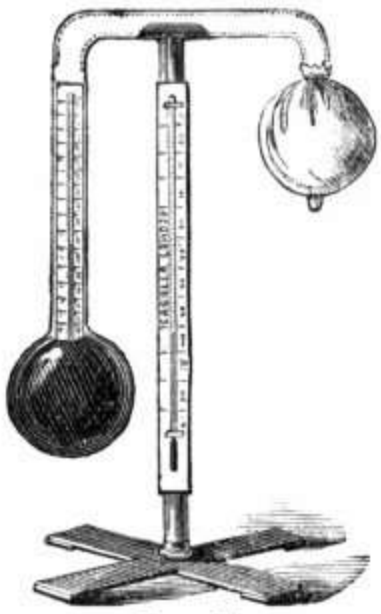


Fig. 80.

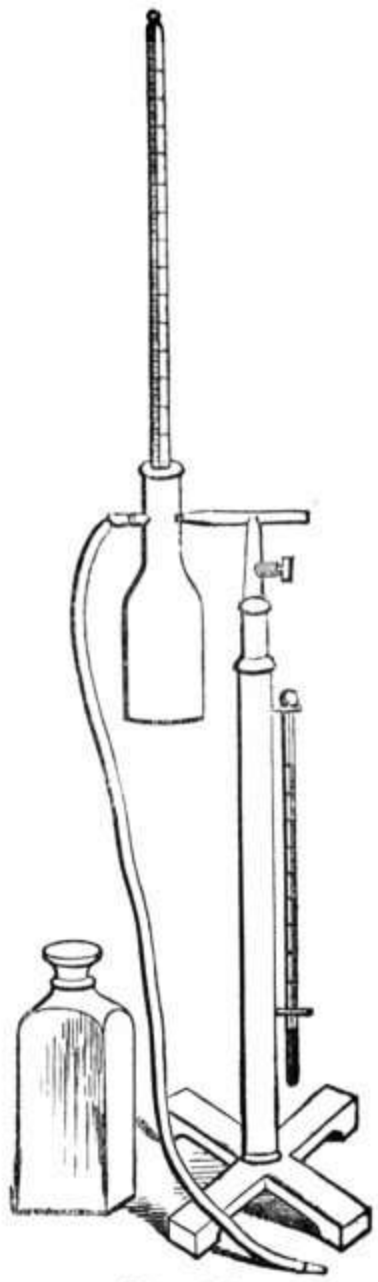


Fig. 81.

81. **Regnault's Condensing Dew-Point Hygrometer** (Casella's Improved), with ether bottle, &c. can be used either with an aspirator or by blowing air through, complete in mahogany case (*fig.* 81) . £4 4 0

*** At the suggestion of Colonel Sykes, F.R.S. and Dr. Miller, F.R.S. L. Casella has adapted to this instrument a black glass bottle, with silver neck and tube, which may be had instead of the silver bottle, or (at an extra charge of 20*s.*) as an additional chamber.

Although Mason's hygrometer has for some time been in general use, Regnault's is still often preferred for taking direct observations of the dew-point. It consists chiefly of two sensitive thermometers, one exposed to the action of the atmosphere, and the other to the influence of a current of air passing through ether. An important part of this instrument is the

small polished silver bottle into which, through a stopper, one of the thermometers is inserted. On one side of the bottle is a small silver tube which descends nearly to the bottom, to which a flexible tube can be attached and air blown through it; on the other side is another tube which enters the top only, for the escape of the air, or which can, by means of a caoutchouc tube, be connected to an aspirator, as in Regnault's original instrument.

82. **Dines's Sensitive Hygrometer.** This ingenious arrangement is the result of prolonged investigations on moisture and the dew-point, by George Dines, Esq., of the Council of the Meteorological Society. Its indications are obtained with unusual facility by means of a little water and ice, or cold water only. This is put into the cup A, and allowed to flow gently through the small chamber D, whence it rises through a perforated diaphragm into the space above. In this space rests the bulb of a sensitive thermometer, the space being covered water-tight by a thin smooth piece of silver or black glass. By turning the tap B the water will flow gently from the spout, as shown, thus cooling the cover E; when the temperature reaches the dew-point, a strong film of vapour or dew will be visible, the temperature being shown on the graduated stem of the thermometer (*figs.* 82*a* and 82*b*), either horizontal or vertical form . . £3 10 0

In the vertical form of this hygrometer (*fig.* 82*b*) ether may be employed, and a constant supply of it kept in the instrument for use whenever required.

FIGS. 82*a*.

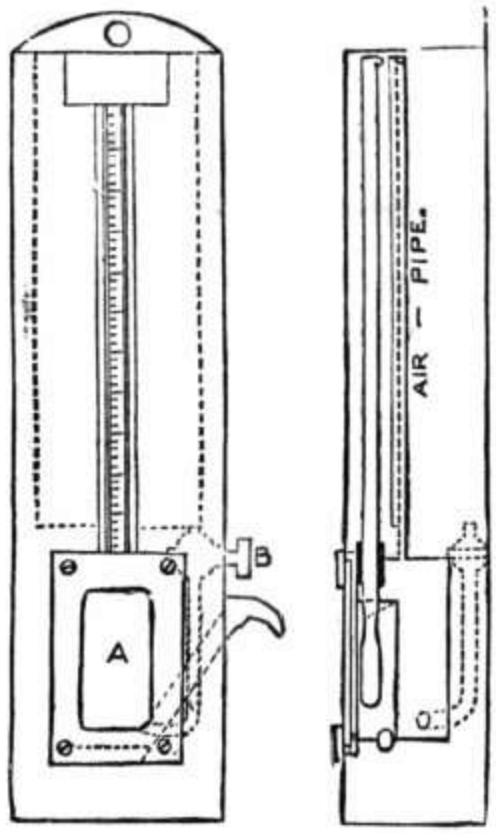


FIG. 82*b*.

83. **Sir Henry James's Thermometer Stand,** as described in his *Instructions for Meteorological Observations* . . . £3 3 0

84. **Stevenson's Thermometer Stand,** to be placed four feet above grass (*fig.* 84 p. 30) £1 15 0

The pattern adopted by the English and Scottish Meteorological Societies.

For convenience of transport this stand is usually supplied with merely dwarf legs, which can be attached to posts by any village carpenter, of such length as to bring the thermometer bulbs to the proper height.

85. **Louvre Board Case** for Hygrometer, out of doors, or on board ship 15*s*.

RAIN GAUGES.

EIGHT-INCH GAUGES.

86. **Mountain Rain Gauge.** This is the pattern (*fig.* 86) adopted by Mr. Symons (see British "Rainfall," 1867, p. 16), for rough mountain work, and for waterworks purposes in wet districts. It is capable of containing 48 inches of rain, and may be read off to tenths of an inch. It is constructed with much care, and all known sources of error (such as frost, evaporation, insplashing, &c.,) are guarded against. *The rod is detached* (*to avoid error from its intercepting the rain*), *and only dropped into the cup when an observation has to be made.* The cross-piece enables the reading to be taken very accurately. The instrument is double throughout, to guard against frost and to facilitate emptying. Zinc . £2 15 0
Copper . £5 10 0

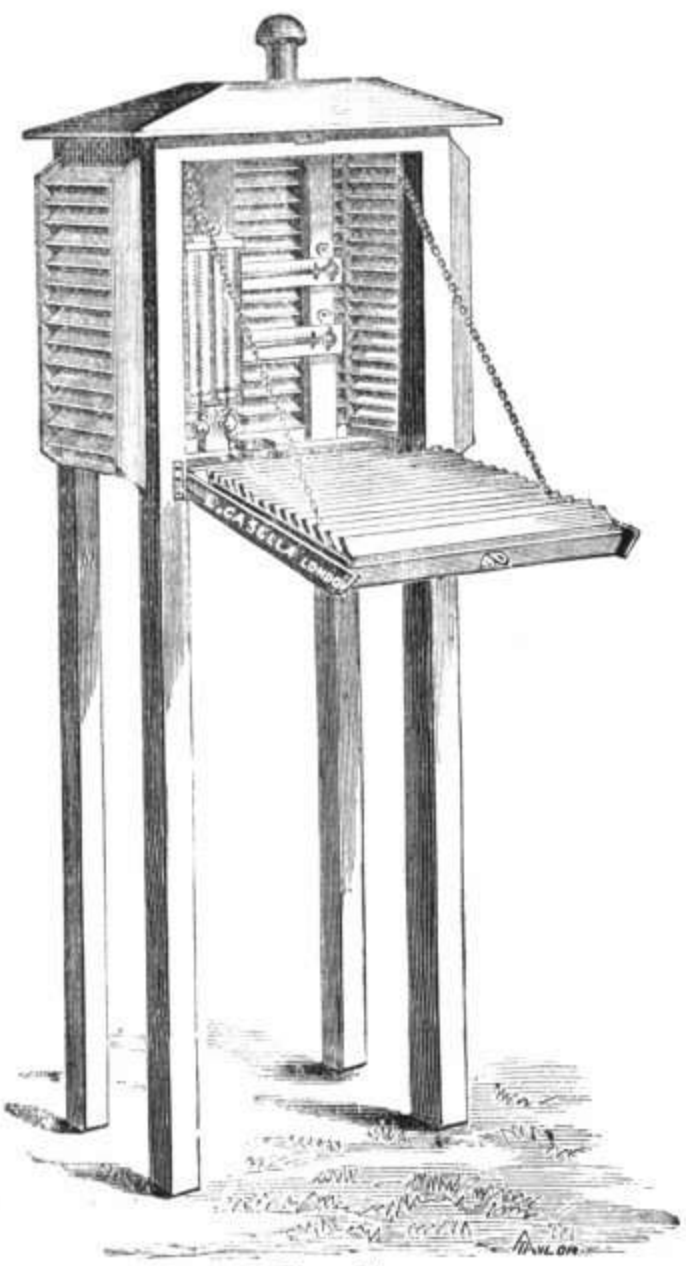


Fig. 84.

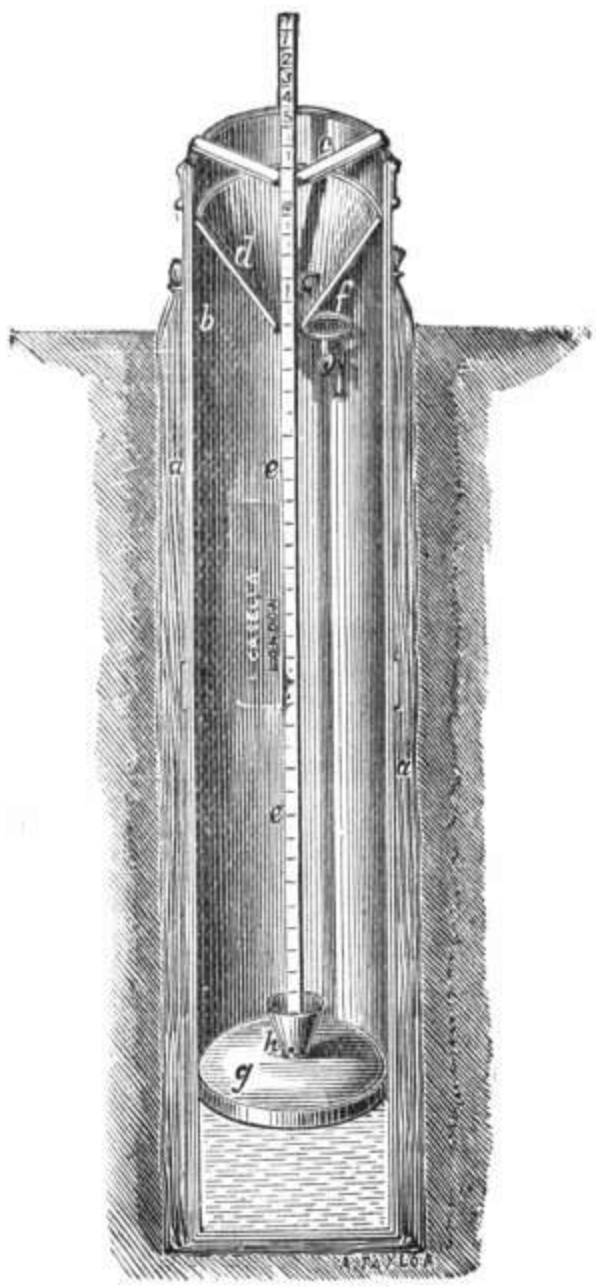


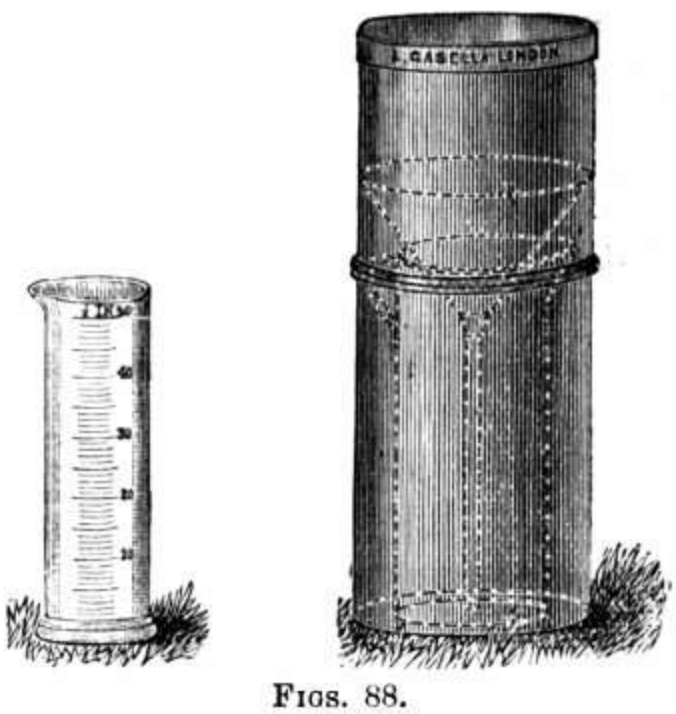
Fig. 86.

87. **Engineers' or Waterworks Rain Gauge.** This is identical in principle with the above, but modified to render it suitable for districts of which the mean annual rain-fall does not exceed 40 inches. The inner vessel (*b*) is only 5·658 inches in diameter, while the receiving surface is 8 inches, therefore the float rises two inches for each inch of rain—thus

giving an open scale, which can be read to a hundredth of an inch, if desired. It will hold about 12 inches. Zinc . . £2 15 0
Copper . . £3 15 0

The gauges Nos. 86, 87, and 92 are intended for weekly or monthly observation, but can be read at any time, daily or otherwise.

88. **Meteorological Office Rain Gauge,** with a high rim to secure the more correct measurement of snow (*fig.* 88). Japanned zinc £2 0 0
Copper . . £2 15 0



FIGS. 88.

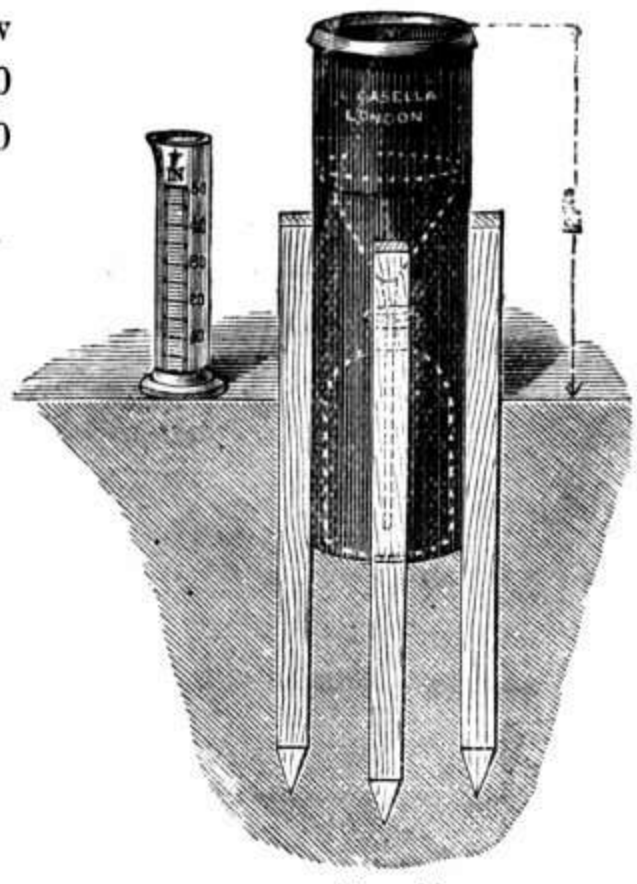


FIG 93.

89. Ditto, cheaper form, with glass bottle receiver and cylinder for overflow. Total capacity, 11 inches. Japanned zinc . . £1 10 0
Copper . . . £2 5 0

90. **Ordinary Japanned Gauge,** without Snowdon rim . £1 1 0

91. **Large Tropical Rain Gauge,**—cylindrical form, with deep brass rim and inside receiving-can and bottle, by which large or small quantities are measured while efficient protection is secured against evaporation, or frost, or overflow during the heaviest rains. Japanned zinc . £2 10 0
Stout copper . £3 5 0

5-INCH GAUGES.

92. **Bradford Water Works Rain Gauge.** A cylindrical gauge, total height 24 in., with inside copper pail holding 17 inches of rain, Snowdon funnel, and measuring jar to hold 1.00 in. Japanned zinc . £2 0 0
Copper . . £2 8 0

93. **Symons's Snowdon Rain Gauge,** with cylinder prolonged beyond the funnel to secure accurate measurement of snow as well as rain, with measuring jar and foot to same (*fig.* 93). Japanned zinc . £0 17 0
Copper . . £1 4 0

94. Ditto, but jar without foot. Japanned zinc . £0 15 6
Copper . . £1 0 0

95. **Rain Gauge,** improved cylindrical, with receiving bottle and graduated jar.
Japanned tin . . . £0 15 6
Copper £1 1 0

96. Cheapest form of ditto £0 10 6

97. **Howard's Rain Gauge.** Stone bottle, copper funnel, and glass measuring jar (*fig.* 97) £0 15 6

Fig. 97.

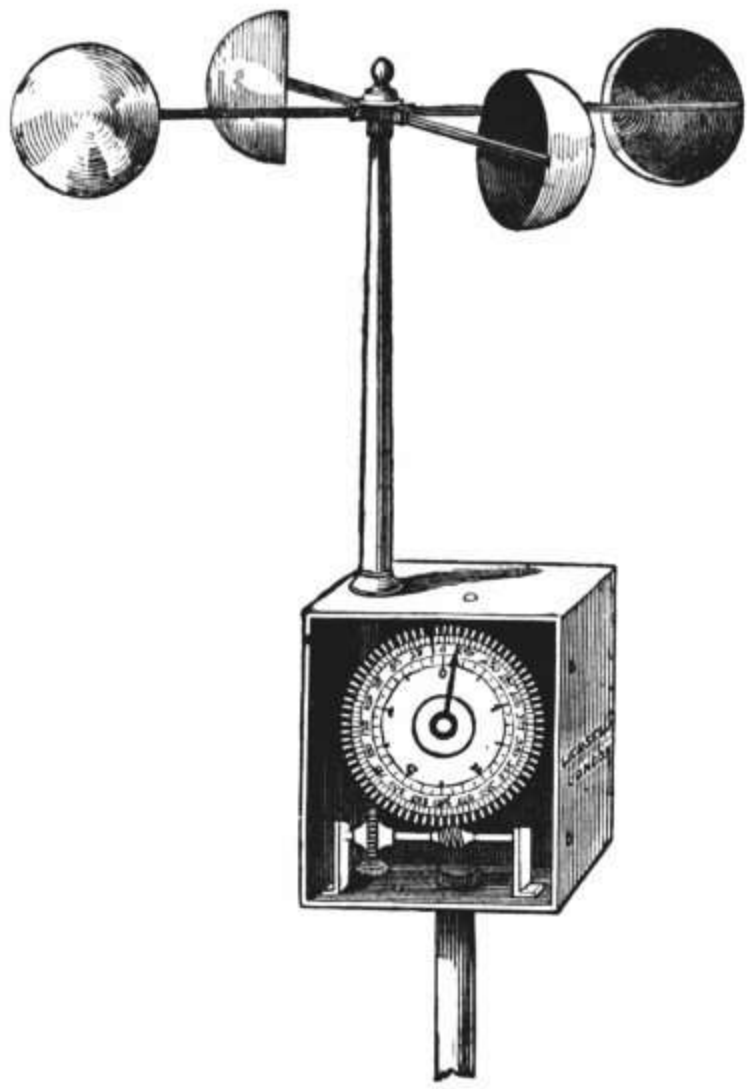


Fig. 103.

98. **Small Tropical Rain Gauge** (4½ in. diam.), to measure up to 4 inches of rain in 100ths of inches, with brass rim. Japanned Tin . £1 10 0
Copper . . £2 10 0

SELF-RECORDING RAIN GAUGES.

99. **Self-Recording Rain Gauge** (Casella's), simple and efficient, in stout metal case, 15 by 15, adapted for every position and climate. In this arrangement the amount of rain to the hundredth of an inch and the time of its fall is shown on a continuous diagram . . £50 0 0

100. **Crossley's Self-Recording Rain Gauge** (Casella's improved). Specially arranged for the tropics. Shewing the amount of rain fall in hundredths of an inch on a dial £6 6 0

101. **Casella's Electrical Recording Rain Gauge,** on Crossley's system, to record on a dial at any distance from the instrument. This will be found

a great advantage in wet weather, or in time of illness, avoiding wet feet, and enabling a complete meteorological record to be kept without going out of doors to read the instrument . . . . . £

For rain-band spectroscopes, see page 63.

ANEMOMETERS AND WIND VANES.

102. **Anemometer** (Lind's), in which the pressure or force of the wind is shown by the depression and elevation of a column of water below and above the zero of the scale £2 2 0

102*a*. **Anemometer** (Lind's), improved by Sir W. Snow Harris £2 5 0

103. **Anemometer** (Robinson's improved), for registering the velocity of the wind in miles and tenths, up to 505 miles, as *originally* made by L. CASELLA for the Royal Engineers, and described by Sir Henry James, R.E., F.R.S., in his *Instructions for taking Meteorological Observations* (*fig.* 103, p. 32) £4 4 0

103*a*. The same instrument, but registering to 1010 miles . . £5 0 0

103*b*. **Robinson's Anemometer,** as No. 103, with extra dial extending the registration to 5050 miles £5 10 0

104. **Electrical Anemometer,** on the above principle, with simple apparatus, by means of which the anemometer may be placed at any distance or height, whilst the indicating dial is kept for observation in any part of the house £10 10 0

105. **The "Blythswood" Electrical Wind Vane,** invented by Sir Archibald Campbell of Blythswood, Bart., in which, by a simple arrangement, the direction of the wind is indicated instantaneously on a dial in any room in the house £23 0 0

106. **Electrical Anemometer and Blythswood Wind Vane combined,** as 104 and 105, anemometer and vane on the same shaft, and both dials in the same box . . . . . £

107. **Electrical Anemometer and Wind Vane combined** (Sir A. Campbell's), designed for cases where it is desired to separate the indicator from the instrument by a long distance of wire . . £

SELF-RECORDING ANEMOMETERS.

108. **Casella's Embossing Anemometer,** *for registering the velocity and direction of the wind and the time of its various changes.* The general principle of this instrument, is that just described. The registering parts of the instrument, however, and also the vane, *are entirely new*, and the result of the joint efforts of L. CASELLA and of Mr. Beckley, the late engineer of the Kew Observatory; many other important improvements have also been more recently added to the instrument. The principle of embossing is the means of registration herein adopted. The paper employed is a narrow strip, wrapped round a small attached roller, from which it is drawn, and

embossed on one edge by the action of the rollers, as shown in the sketch. The rollers are divided to represent miles, figured at every ten, and one revolution shows the wind to have travelled fifty miles. The clock (*a*) raises the small hammer (*b*), which falls once in every hour, impressing the other edge of the paper with a small arrow ⟶ whose movements correspond with the larger one driven by the wind, and thus show its exact direction at the time. The rate of speed during each preceding hour is also shown by the distance between successive imprints of the arrows. The paper is of sufficient length to last from four to six weeks without being changed, and the clock may be wound up daily, weekly, or even monthly, as may be desired. The projection (*c*) contains metal balls, which firmly support the top and aid in giving freedom of action. The square box (*d*) is of cast iron, and contains the stronger portion of the wheelwork; it has holes on the flange for screws or nails, by which means it is easily fixed to the roof of a house, or to a pole placed in a garden, or field, or by the seaside. The chains (*e e*) act on *improved rollers*, over which they *cannot pass* without turning them, and are brought into connection with the clockwork and registering parts placed in a

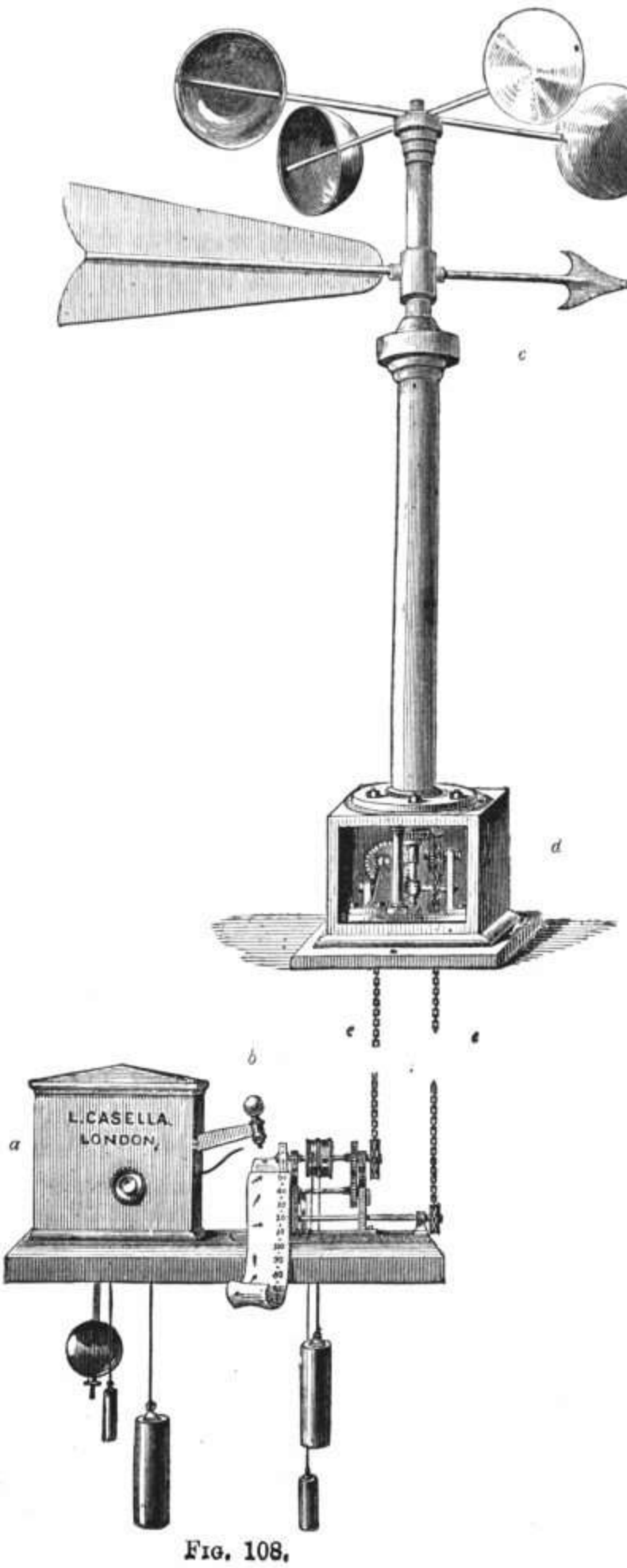


FIG. 108.

room or box for protection, at any vertical distance from the base (*d*), say from 3 to 25 feet. The height of the upper part is 3 feet 3 inches from the base of the box (*d*), the diameter over the cups is 2 feet, and its strength and general

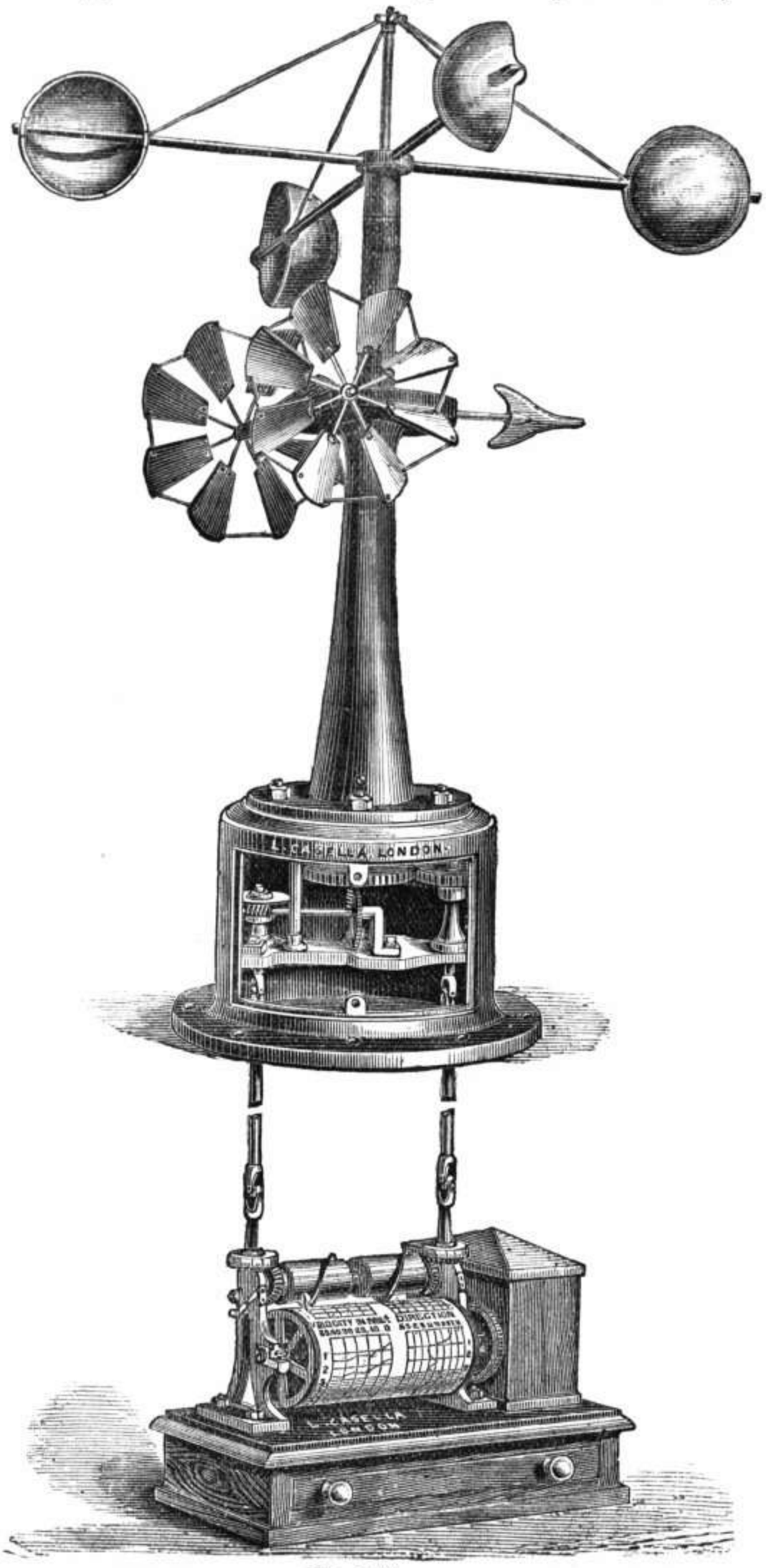


Fig. 109.

construction such as to bear the vicissitudes of the severest storm. Where frequent absence is requisite, or in places of difficult access, the advantage of the little attention required in using this instrument can hardly be over-estimated. A small dial showing time, and another the direction, is also attached to the self-recording apparatus in the room, so that the various conditions can be seen at a glance at any moment. The action of each instrument is tested and guaranteed to agree with that of the standard anemometers constructed by L. CASELLA for the Kew Committee and other Observatories belonging to the Government (*fig.* 108, p. 34) £65 to £70

Windmill Fans may be added to the wind vane as in *fig.* 109, (p. 35,) by which the mean direction is more accurately indicated at an extra charge of £12.

109. **Enlarged Anemometer, or Anemograph,** for harbours and public observatories, a much improved form of the instrument as originally constructed by L. CASELLA for the Kew Observatory and the other observatories of the Meteorological Office of the Government. In this arrangement the cups revolve in the same manner as in the smaller instrument, but the registration is obtained by means of a revolving cylinder to which paper is attached, and the direction as well as velocity is continuously shown for every minute of time by means of a clock which forms part of the instrument. The exposed portion of this anemometer may be placed at any height, whilst the registering part (as in No. 108) is kept in a room or other covered place for observation. For the purposes of comparison, the registering papers supplied with these anemometers are similar to those used with the Government instruments. With connecting shafts, patent self-lubricators, and all complete (*fig.* 109 p. 35) . £78 0 0

Enlarged Anemometer, or Anemograph, if made to register in a lower room of the building . . . £85 to £95 0 0

110. **Anemograph,** same as 109, but self-contained, as used in the principal observatories in Spain and Portugal £45 0 0

An Anemograph of simpler form is in course of arrangement.

111. **Casella's Air Meter, or Pocket Anemometer,** for mines, hospitals, and other public buildings. The object of this little instrument is to give correct means of measuring the velocity of currents of air passing through coal and other mines, and the ventilating spaces or shafts of hospitals and other public buildings. Although now generally copied by the trade, it was *origi-*

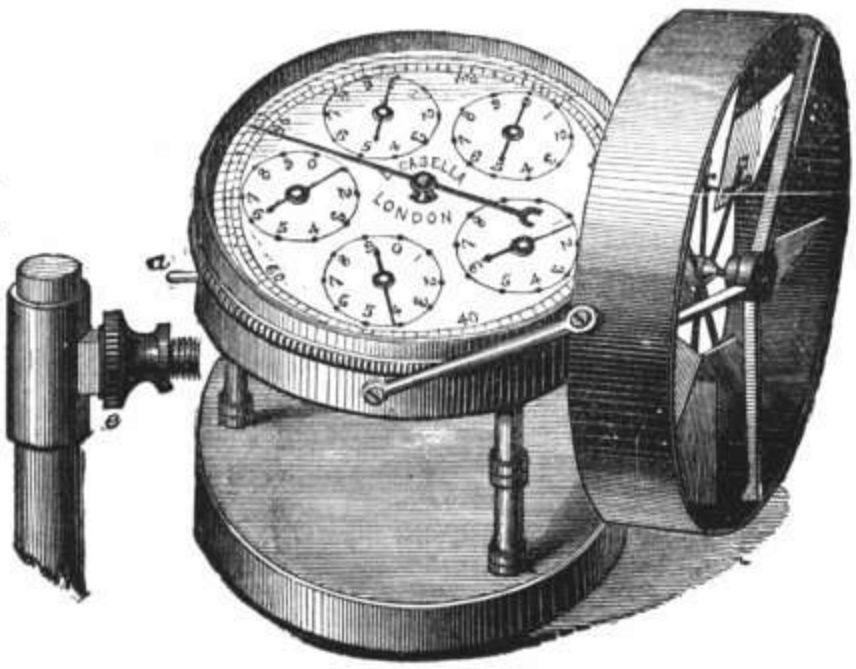


FIG. 111.

nally arranged and constructed by L. CASELLA for Dr. Parkes, F.R.S, of the Royal Victoria Hospital, Netley, for measuring the state of ventilation in that large military establishment, and declared to be the most perfect and sensitive instrument of the kind in use. Since then it has been adopted in our Houses of Parliament, the United States Senate, and many of the leading prisons and hospitals throughout the country, and ordered to be used in every coal mine. The graduations for each instrument are obtained by actual experiment by means of machinery made for the purpose, so that the indications of all are as comparable with each other as the weight or measure of ordinary substances. By means of the large dial the low velocity of fifty feet per minute may be measured, and by the smaller ones continuous registration is extended up to 10,000,000 feet, or 1894 miles, being practically beyond what most extended observations can require. It forms also an admirable pocket anemometer for travellers (*fig.* 111 p. 36) £4 4 0

OZONOMETERS.

112. **Ozonometer** (Dr. Schönbein's), consisting of strips of paper prepared with iodide of potassium and starch. The papers are to be suspended so as to be exposed to the free access of air, but sheltered from wet and the direct rays of the sun. When affected by ozone they become tinged, and the intensity is measured by a graduated scale of twelve tints, which accompanies the ozonometer. In case, to last one year . . 6*s*. 6*d*.

113. **Sedan's Ozonometer** . . . . . 8*s*. 6*d*.

114. **Ozone Cage** of fine wire, as recommended by Sir James Clark 12*s*. 6*d*.

115. Smaller size, ditto, for travellers . . . . 12*s*. 6*d*.

116. **Dr. Moffat's Ozonometer** . . . . 8*s*. 6*d*.

117. **Forms for Registering Ozonometer Indications** . 1*s*. 6*d*.

ATMOSPHERIC ELECTRICITY.

118. **Electrometer** (gold leaf), for atmospheric electricity, with 2-ft. brass connecting rod, clip for lighted fusee, and improved mode of insulation, with stand and book containing spare gold leaves . . . £1 1 0

To replace the gold leaves, unscrew the top brass plate which supports them, and moisten with the breath the flat brass piece to which they are to be attached: press this gently down on one end of a gold leaf, and the opposite side on another in the same way.

119. **Thomson's Quadrant Electrometer,** with lamp and scale, complete in mahogany box, with full directions for use . . £35 0 0

120. **Thomson's Quadrant Electrometer** (CASELLA's pattern), of simpler form than the above, sufficiently sensitive to shew the potential of a single cell, in case £9 0 0

Lamp and scale, in case, £1 15 0 extra.

121. **Thomson's Portable Electrometer** (attracted disc), complete, in mahogany box, fitted with electrophorus (*fig.* 121) . £11 11 0

122. **Peltier's Electrometer,** as used by Professor Palmieri in his observatory at Vesuvius. In pine case £3 3 0

123. **Thomson's Water Dropping Collector** to order.

124. **Collecting Fuze** to order.

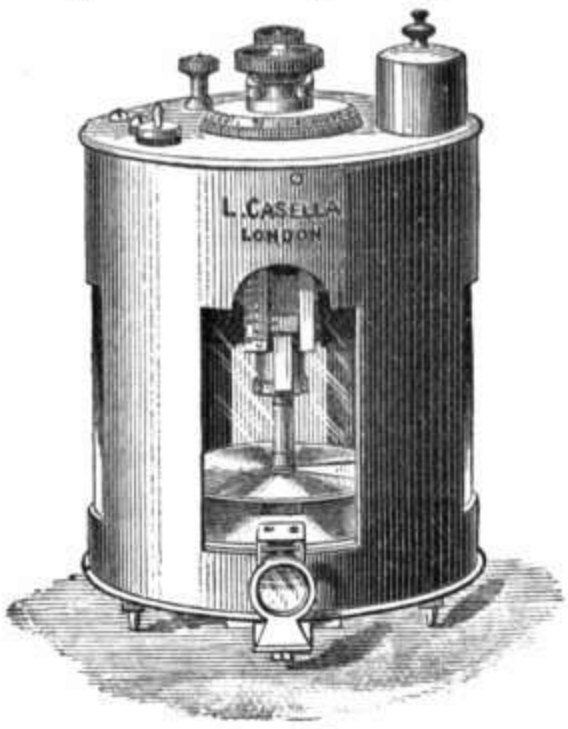


FIG. 121.

TERRESTRIAL MAGNETISM.

125. **Magnetograph,** as used at the Kew Observatory (*fig.* 125) £330 0 0

This instrument furnishes, by the aid of photography, a continuous record of the changes continually occurring in the magnetic force of the earth, both in direction and intensity,

For observations of declination made in a less refined manner azimuth compasses are usually employed, and CASELLA'S Dipping Needle Compass should also be mentioned. For prices see page 56.

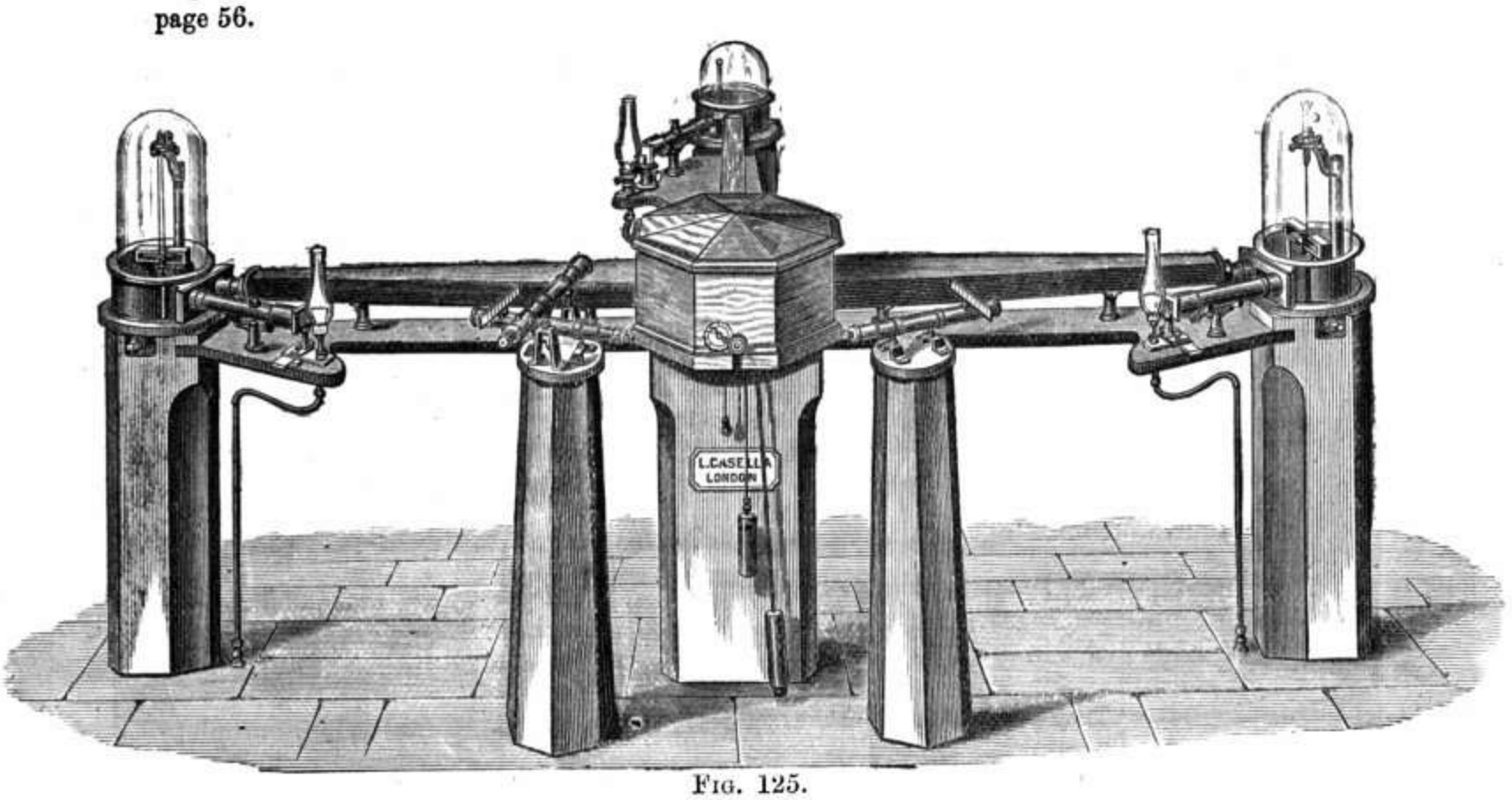


FIG. 125.

126. **Inclinometer or Dip Circle,** with all recent improvements. This instrument, known as the Kew Pattern Dip Circle, is an arrangement for delicately suspending a needle on a transverse axis resting on two agate

pillar, with cylindrical surfaces; a microscope, carried on a 4-in. circle divided on silver, enables the position of the needles to be observed with the greatest accuracy. It is furnished with LLOYD'S APPARATUS, by which the TOTAL FORCE can be measured at any place, if observations have been first taken at a base station to determine the constants . £36 10 0

Kew verification fee, £3.

The same without Lloyd's Total Force Apparatus £31 10 0

Kew verification fee, £1 10*s*.

Fox's Circle, see page 55.

127. **Kew Pattern Unifilar Magnetometer.** This instrument is the best known apparatus for determining accurately the horizontal component of the earth's magnetic force, and also the declination. The horizontal force is measured by observing the time of vibration of a delicately suspended magnet, and afterwards causing this to deflect a second magnet from the meridian; a combination of the two observations then gives the force, which can thus be accurately determined to the one thousandth of a British unit. For observing the declination a third magnet is provided, which, being hung on a torsionless silk fibre, takes up its position with its axis in the magnetic meridian. After reading this off upon the horizontally divided circle of the instrument, the telescope is directed by means of an accurately adjusted plane speculum to the sun or other celestial object, from which the true declination is obtained. The instrument is very compact and portable, occupying two cases respectively $10\frac{1}{2} \times 6 \times 13\frac{1}{2}$ in. and $11 \times 8\frac{1}{4} \times 10\frac{1}{4}$ in. £65 0 0

A table of constants, which are specially computed for each instrument, is supplied from the Kew Observatory at a charge of £5.

TIDE GAUGES.

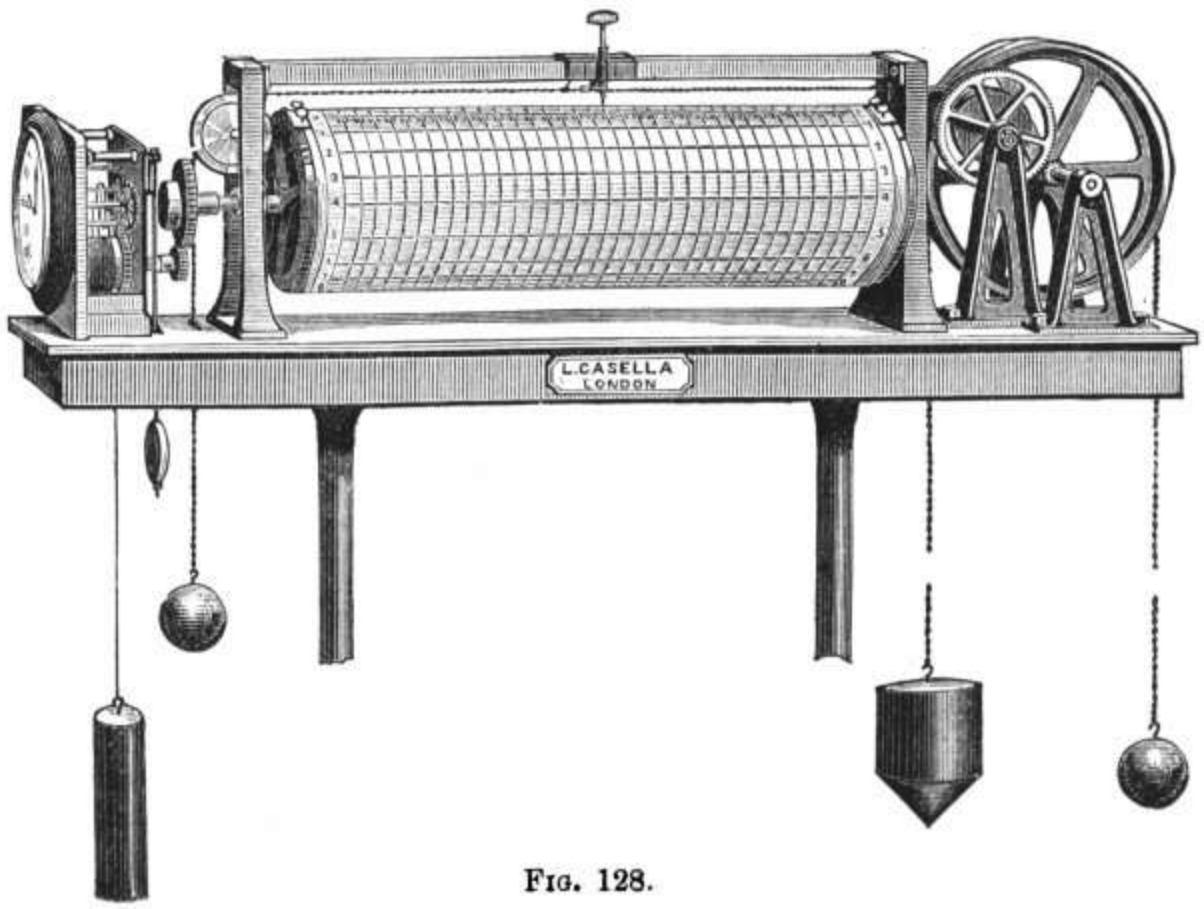


FIG. 128.

128. **Tide Gauge (Self Recording)**, for showing the rise and fall of water in harbours, rivers, canals, locks, &c. recording the exact time at which any increase or reduction may have occurred (*fig.* 128 p. 39) . £42 0 0

129. **Tide Gauge,** Sir William Thomson's, with notching apparatus to pencil, for registering from a mean level line drawn by the instrument itself on plain continuous paper, with an extra registering cylinder or barrel, and with best seven or fourteen day clock, as may be desired . £90 0 0

129*a*. **Tide Gauge,** as above, but registering on printed forms instead of continuous paper £85 0 0

130. **Van Rysselberghe's Universal Meteorograph.** This ingenious machine engraves by the aid of an electric current the readings of the various meteorological instruments selected for registration every quarter of an hour on a metallic sheet from which any number of copies may be printed. The same machine can be made to register the indications of any instrument whatever, even when placed at a considerable distance. The cost varies according to the nature and number of the instruments whose readings are to be recorded, but the price of the ordinary form, comprising barometer, hygrometer, rain gauge, anemometer, and wind vane, together with a supply of sheet zinc to last two years, batteries, and all complete is £230 0 0

Seismograph.—L. CASELLA is now arranging a greatly-improved and simplified instrument for measuring and recording earth tremors and the various disturbances in the earth's crust caused by volcanic and other subterranean agencies. All the recent improvements suggested by the experience of Professor Milne, of Tokio, and other observers will be embodied in the new design, and the cost will be very moderate. Particulars can be given at an early date on application, as soon as the instrument is completed.

BOOKS ON METEOROLOGY.

	£.	s.	d.
BUCHAN, A., Introductory Text Book of Meteorology . . .	0	4	6
CASELLA, L. P., "Forms for Registering Meteorological Observation," with concise remarks and instructions, in twelve monthly forms for one year . . .	0	4	0
,, ,, "The Rainband Spectroscope," with coloured diagrams, and notes on its use chiefly taken from the works of Professor PIAZZI SMYTH, Astronomer Royal for Scotland . .	0	0	6
DANIELL, PROFESSOR J. F., "Elements of Meteorology," 3rd edition, 2 vols.	0	16	0
DOVE, PROFESSOR, "The Law of Storms,' translated by SCOTT .	0	10	6
FITZROY, ADMIRAL R., "Weather Book"	0	12	6
GALTON, FRANCIS, "Art of Travel"	0	5	0
GALTON'S "Meteoragraphica"	0	9	0
GLAISHER, J., "Hygrometrical Tables"	0	2	6
,, "Daily Range Tables"	0	1	0
GUYOT, A., "Meteorological and Physical Tables" . . .	0	16	0
HARRIS, SIR W. SNOW, "On Thunder Storms" . . .	0	7	6
HERSCHEL, SIR J., "Meteorology"	0	5	0
JAMES, COLONEL SIR H., "Instructions for taking Meteorological Observations"	0	7	6
KAEMTZ, PROFESSOR, "Meteorology," translated by WALKER . .	0	12	6
MARRIOTT'S "Hints to Meteorological Observers, with instructions for taking Observations, and Tables for their Reduction" . .	0	1	0
MAURY, M. F., "Physical Geography of the Sea and its Meteorology"	0	5	0
REID COLONEL, "Law of Storms"	0	14	0
,, ,, "Variable Winds"	0	10	0
ROWELL on "The Cause of Rain"	0	2	0
SCOTT, R. H., "Instructions for the use of Meteorological Instruments"	0	1	6
SIMMONDS, G. H., "Meteorological Tables"	0	2	6
STEWART, BALFOUR, "Elementary Treatise on Heat" . . .	0	7	6
STRACHAN, R., "Weather-casts and Storm Prevision" . . .	0	2	0
,, Portable Meteorological Register and Note Book, with weather diagrams, tables, and instructions; second edition .	0	2	6
SYMONS, G. J., "British Rainfall," 1865, and subsequent years, per year	0	5	0
,, ,, "Monthly Meteorological Magazine," . per year	0	5	0
,, ,, "Pocket Altitude Tables," 3rd edition . . .	0	2	6
,, ,, "Meteorological Register with Instructions," paper cover, per year	0	2	0
,, ,, ditto, half bound, for five years	0	7	6
,, ,, "Barometer and Thermometer Diagrams," per year	0	1	0
,, ,, "Rainfall Register," single sheet folio, per year	0	0	3
WELLS, W. C., On Dew; new edition, by L. CASELLA, F.R.A.S., with appendix, by R. STRACHAN, F.M.S.	0	4	0

NOTE.—Several of the works above mentioned are now out of print, and some are scarce. L. CASELLA is however at all times ready to use his best efforts to obtain such as may be required.

PART III.

METEOROLOGICAL AND MISCELLANEOUS INSTRUMENTS

FOR

THE ARMY AND NAVY, TRAVELLERS AND EXPLORERS.

Most of the following instruments having been expressly designed or re-arranged for distinguished explorers and travellers, equipped by L. CASELLA, he can confidently recommend them as perfect and efficient for their respective purposes.

N.B.—Practical instruction and demonstrations can be given in the use of any of the instruments referred to in this list.

MERCURIAL BAROMETERS AND THEIR SUBSTITUTES.

Although the marine barometer has been nearly superseded by the aneroid, and the sympiesometer has been entirely supplanted by it, yet the marine barometer described at No. 10 (p. 14) is still employed by the Admiralty as a standard by which to compare the aneroid at sea, and, with slight modifications in its make, it is often used on land as a standard instrument.

131. **Standard Mountain Barometer,** the same as the Standard Fortin Barometer No. 3, (p. 12) but much reduced in size of frame, by which it is rendered so portable as to remove nearly every difficulty hitherto found by travellers in carrying a mercurial barometer. With inch and millimetre scale and tripod stand, complete, in CASELLA's improved leather-covered shield case (*figs.* 131A and 131B, p. 43) . . . £10 10 0

If without case 25*s.* less.

*** Kew verification, if required, at an extra charge of 10*s.* 6*d.* See p. 11.

132. **Mountain Barometer,** Gay Lussac's syphon tube, with vernier to each limb, reading to ·002 of an inch, the difference between the two readings giving the height of the barometer. In improved leather-covered shield case £6 10 0

If with tripod stand, similar to that for No. 131, £8.

133. **Mountain Measuring Tube,** sealed at one end and graduated on the glass tube, with small bottle of mercury for filling the tube when required. By this means the traveller can at any time measure mountain heights by the column of mercury, without the risk attending the carriage of the mountain barometer. With 32-in. tube, £2 2*s.*; 21-in. £1 18*s.*; 15-in £1 15*s.*

134. **The Boylean-Marriotte, or Mercurial Standard Pocket Barometer,** invented and patented by Telford Macneill, Esq. C.E. (*fig.* 134) £10 10 0

Full description and instructions will be sent on application.

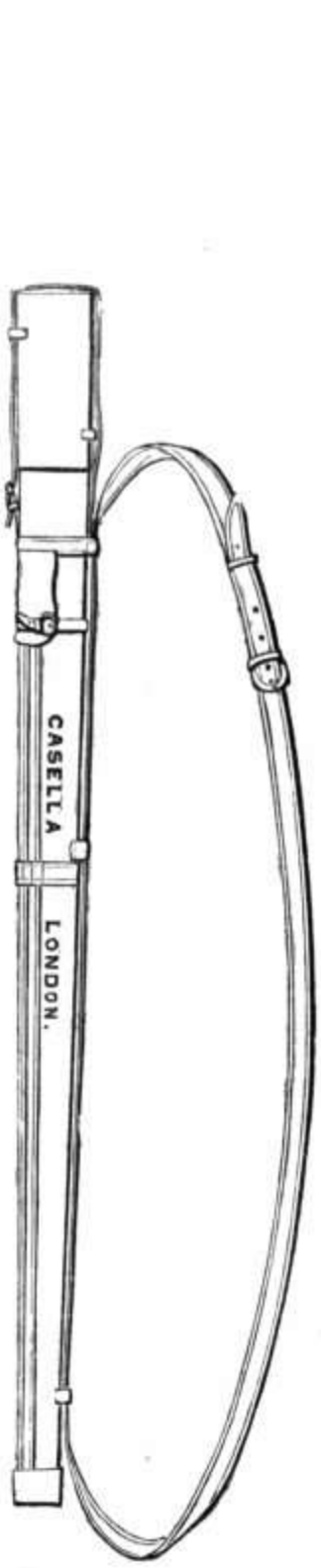


FIG. 131A.

FIG. 131B.

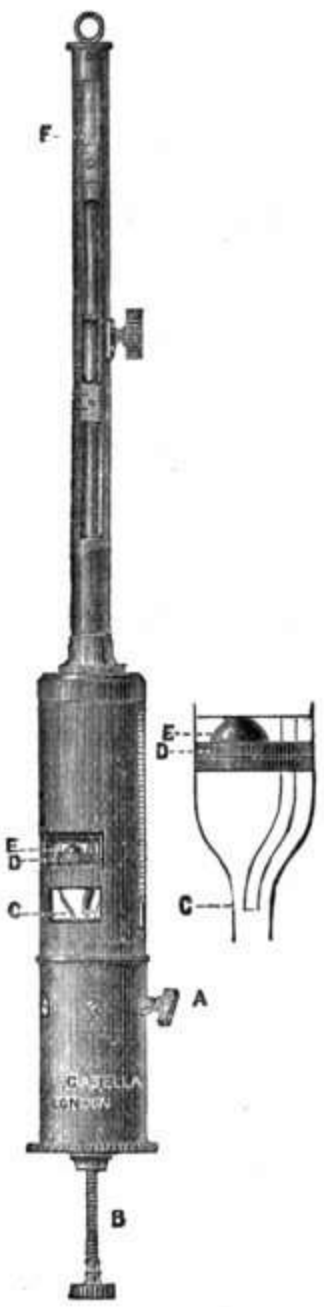


FIG. 134.

135. **Casella's Hypsometer,** for measuring mountain heights by the vapour of boiling water. The improvements effected in this instrument by L. CASELLA place it among the most certain and portable means of measuring great elevations. The thermometer, strong, with small bulb, is now indelibly divided and figured on the stem, and is sheltered from cold when in use by a double telescopic chamber, into which it is placed to any required depth through a loose piece of indiarubber which rests on the top. The proper depth is with the bulb not quite so near the water as is shown in the sketch. The chamber being filled with vapour from the boiling

water beneath, and the inner chamber and tube thus enveloped, the vapour descends in the outer chamber and escapes by the outlet. By this means the mercury both in the bulb and stem is immersed in pure vapour, whatever kind of water may be employed; less than a wine-glass full of water and half as much spirits in the lamp serve for several observations. The thermometer is kept in a light metallic case, lined with indiarubber. The portable leather case contains the whole when packed for travelling. Price, with one thermometer, divided to 0°·1, as arranged and made by L. CASELLA for the Government (*figs.* 135A and 135B) £4 15 0

Extra thermometers for the above, in brass case, each £1 5*s.*

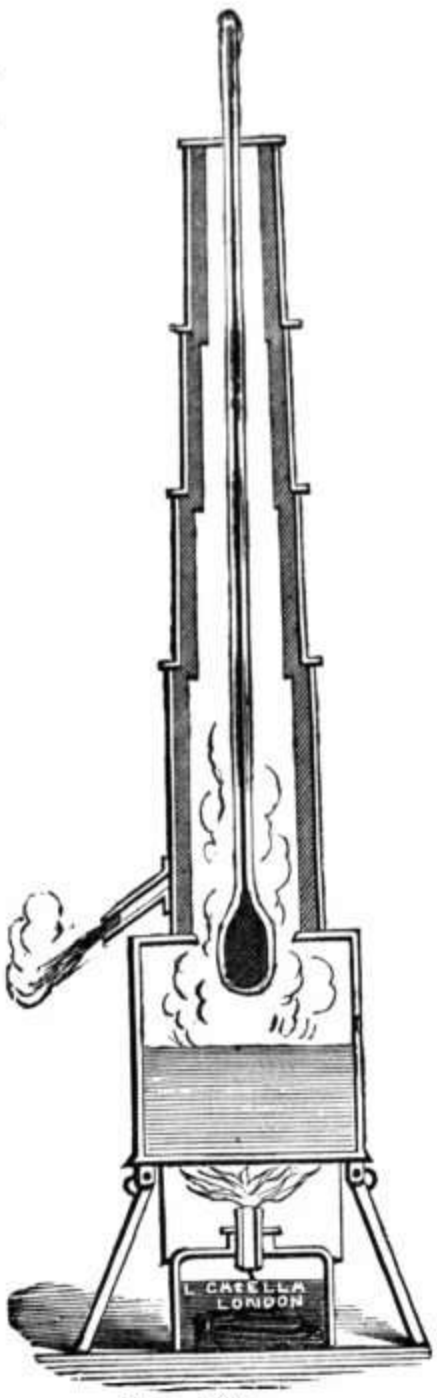


FIG. 135B.

136. **Pocket Hypsometer.** The success attending the above has induced L. CASELLA to construct a still smaller instrument on the same principle, which is much used by Alpine and other travellers. It may be carried with ease in the pocket; and by many is often preferred, for its simplicity and certainty, to the mountain barometer. With one thermometer, divided to 0°·2, as supplied to the Royal Geographical Society £2 10 0

Extra thermometers, in brass case, each £1 1*s.*

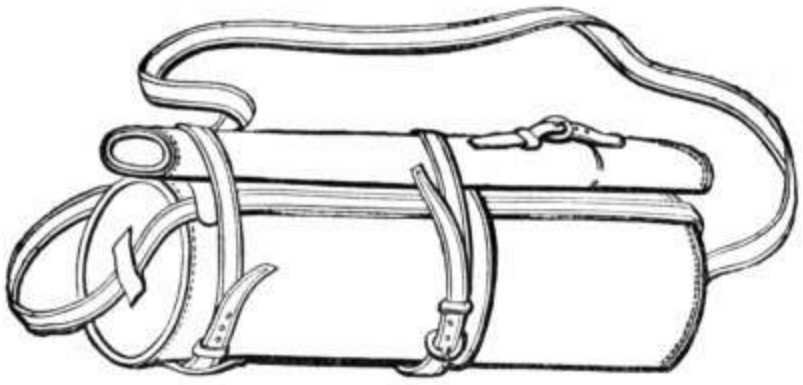


FIG. 135A.

The above Hypsometrical Thermometers may be had self-registering, if required.

137. **Casella's Tables,** with instructions for using the hypsometer, second edition . . . . . 1*s.*

Wherever the measurement of mountain heights is required to be taken by other means than the theodolite, or standard barometer, or where there may be danger of damage or breakage of either, without an easy means of comparing or replacing them, this cheap and simple means of measuring heights will be found both efficient and handy, and it is at all times a reliable test with which to compare an aneroid or any other similar instrument, which from time to time requires to be compared and adjusted.

"For the measurement of great mountain masses and continuously-elevated areas, I conceive that hypsometrical results are as good as barometrical ones. For the general purposes of botanical geography, the boiling point thermometer supersedes the barometer in point of practical utility; for under every advantage the transport of a glass tube full of mercury, nearly three feet long, and cased in metal, is a great drawback to the unrestrained motion of the traveller."—Dr. J. D. Hooker's "*Himalayan Journals*," Vol. II.

ANEROID BAROMETERS.

WATCH SIZE, FOR THE WAISTCOAT POCKET,

One and seven-eighths inches diameter, in maroon cases.

138. **Aneroid Barometer,** extra sensitive, with greatly expanded graduations, the circle divided to ·02 inch, from 28 to 31 inches, by which an extraordinary degree of sensitiveness is produced (*fig.* 138) £5 0 0

139. **Aneroid Barometer,** carefully compensated for temperature, for measuring heights up to about 15,000 to 19,000 feet £4 10 0

140. **Aneroid Barometer,** ditto 8,000 to 15,000 feet £4 4 0

141. **Aneroid Barometer,** ditto 5,000 to 8,000 feet £3 15 0

The above may be had, if required, with a raised circle for the barometric scale, so as to admit of a thermometer on the centre of the dial, at 10*s.* extra.

142. **Aneroid Barometer,** ditto, with circular thermometer, divided from 27.5 to 31-in. £3 10 0

143. **Aneroid Barometer,** ditto, without thermometer, measuring up to 6,000 feet £3 0 0

144. **Aneroid Barometer,** ditto, with revolving index . £2 0 0

An improved transparent compass, with crystal back and front, as **No. 216,** answering either as an excellent magnifier or burning glass, may be fitted into the lid of any of the above instrument cases, at 25*s.* extra.

145. **Aneroid Barometer,** in SILVER CASE, with double back, for measuring heights up to about 6,000 to 19,000 feet, as required £6 0 0 to £7 0 0

FIG. 138.

FIG. 146.

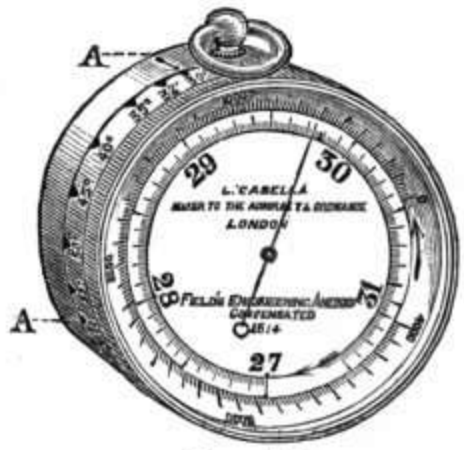


FIG. 148.

146. **Aneroid Barometer,** extra small, in SILVER CASE, with double back, $1\frac{5}{8}$ diameter, for measuring heights up to about 6,000 to 19,000 feet (*fig.* 146) . . . . . £6 0 0 to £7 0 0

147. **Aneroid Barometer,** in best GOLD CASE, 18-carat, for measuring heights up to about 6,000 to 19,000 feet £15 10 0

148. **Aneroid Barometer (Field's Engineering),** watch size, nickel plated, especially adapted for preliminary surveys of low levels (*fig.* 148) (see p. 4) £6 6 0

A scale of altitudes accompanies any of the above instruments gratis, or may be engraved on their dials at an extra charge of 10*s.*

Nos. 139—141 may be had of small size, as Nos. 146 and 147, if required, at 10*s.* extra.

POCKET SIZE.

Two and three-quarters inches in diameter, in Maroon Cases.

149. **Aneroid Barometer,** extra sensitive, with greatly expanded graduations, compensated for temperature, divided to ·02 inches, from 28 to 31 inches (*fig.* 149) £5 10 0

150. **Aneroid Barometer,** with revolving index, finely divided and compensated, for measuring heights up to about 10,000 to 19,000 feet . . £4 15 0

151. **Aneroid Barometer,** for measuring heights up to about 8000 to 10,000 feet . . £4 10 0

Fig. 149.

152. **Aneroid Barometer,** for measuring heights up to about 6000 to 8000 feet £4 4 0

Thermometers may be added to the above, with a raised circle for the barometric scale, at 10*s.* extra.

A compass, with pearl card, for showing in obscure light, may be added to the back of any of the above at £2 extra.

For moist climates a gold band may be substituted for the ordinary steel chain, at an average charge of 10*s.* extra.

153. **Aneroid Barometer,** (plain,) with revolving index, for indicating changes in the weather, or measuring heights up to about 6000 feet . £3 3 0

154. **Aneroid Barometer,** the same as above, but without revolving index £2 10 0

A scale of altitudes accompanies any of the above instruments gratis, or may be engraved on their dials at an extra charge of 10*s.*

THERMOMETERS, &c.

156. **The Casella-Miller Deep-Sea Thermometer,** for registering the maximum, minimum, and present temperatures of the sea to its greatest depths, as supplied only by L. Casella to the English, Indian, French, American, Russian, Italian, German, Austrian, Norwegian, Danish, and other Governments and scientific authorities (*fig.* 156).

If tested to bear a pressure of 2½ miles deep in the sea, with table of errors at various pressures if required £2 10 0

If tested for three miles deep, or three tons per square inch, with tables as above . . . £3 3 0

This interesting thermometer having been fully described and illustrated in my large catalogue, it is hardly necessary to give further particulars here, than to state that after a series of competitive trials it has been adopted for all

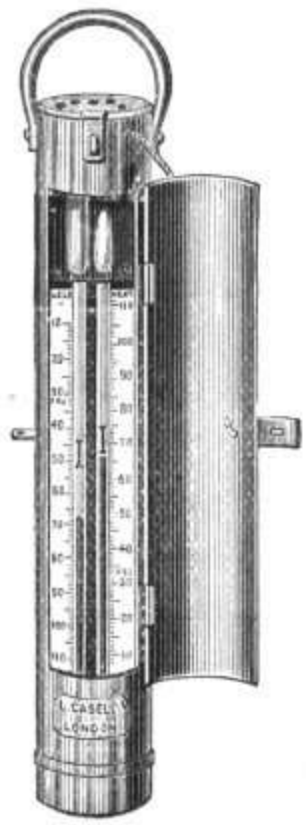


Fig. 156.

trustworthy investigations of deep-sea temperatures. By means of these thermometers exclusively, we have now given us the true temperature of the sea in the varying conditions which exist in so vast a space, viz., almost from the north to the south pole, even to the depth of from four to five miles, in spite of the enormous pressure to which they are then subjected. Off the coast of Japan a depth of six miles has been discovered. The Casella-Miller thermometer can be adapted to record the temperature, even at this depth, if required.

They have been supplied to Her Majesty's ships "Porcupine" and "Challenger," to the "Pandora," under Captain Sir Allen Young, as well as to all other vessels engaged in deep-sea investigations by the leading Governments of the world. They have also been constructed and expressly adapted by L. CASELLA for the English Arctic expedition in command of Captain Nares, and are the only instruments from which reliable results on deep-sea temperature have yet been obtained.

Please observe that each of these thermometers is named in full—Casella-Miller Deep-Sea Thermometer, and has also the consecutive number affixed; Miller Pattern, and other names being applied to mere imitations.

For the satisfaction of purchasers, or their agents, they can see each thermometer tested to the equivalent pressure of any required depth in the hydraulic press employed by L. CASELLA in testing the Government deep-sea thermometers.

157. **Maximum and Minimum Thermometers**; the pair, in a neat pocket mahogany case for travellers, as first arranged by L. CASELLA for Dr. Livingstone and Captains Burton and Speke. They are indelibly divided on the stem, and cannot be injured in travelling, unless by actual breakage £2 2 0

158. **Maximum and Minimum Thermometers,** of smaller size, as specially designed by L. CASELLA for the Alpine Club, and for use at sea; very portable, and admirably adapted for travelling invalids (*fig.* 158) £1 5 0

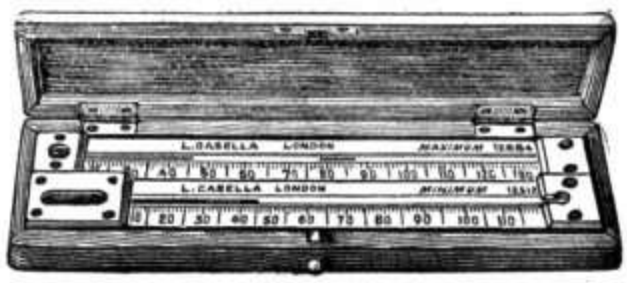


FIG. 158.

Directions.—To set the index of maximum thermometers Nos. 157 and 158, bring it to its place with a moderate swing of the arm, keeping the bulb down at the time. This will bring it within about a degree of the rest of the mercury, at which point also it shows the existing temperature, the reading being taken from the end furthermost from the bulb.

159. **Portable Pocket Hygrometer (Wet and Dry Bulb).** A most convenient form of instrument for travellers (*fig.* 159), especially designed by L. CASELLA as a companion instrument to his Alpine, or pocket, maximum and minimum registering thermometers, No. 158, pocket aneroid barometer, No. 150, and Livingstone's rain gauge, No. 164 . . £2 5 0

160. **Portable Hygrometer,** with divisions and figures etched on the thermometers, mounted on tripod stand, provided with a metal cover for protection when not in use . £3 0 0

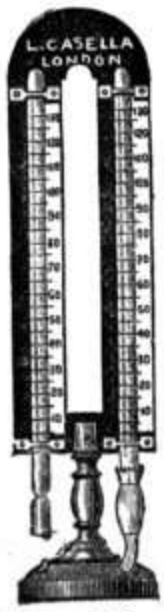


FIG. 159.

161. **Traveller's Hygrometer,** with divisions etched on the thermometers, and mounted on polished boxwood scales, attached to the two folding doors of a neat mahogany case, 6 in. × 2 in. × 1 in. . £1 10 0

162. **Pocket Thermometer,** for shewing temperatures of air or water, divided on ivory, and mounted on an ebonite pillar revolving in metal shield; length 4½ in. . . . . 12*s.* 6*d.*

WIND AND RAIN.

163. **Anemoscope, or Portable Wind Vane,** for travellers, with floating compass card, bar needle, &c., showing the direct course of the wind to half a point of the compass (*fig.* 163) £2 2 0

Pocket Anemometer, see page 36.

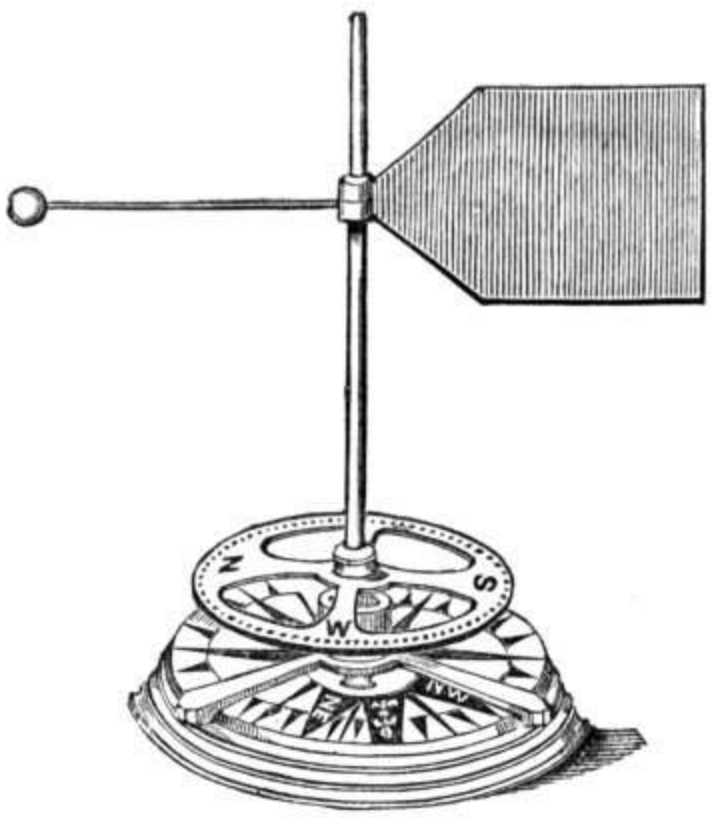


Fig. 163.

164. **Dr. Livingstone's Rain Gauge,** expressly arranged by L. Casella for the Zambesi expedition, with receiving surface of 3-in. diameter, with graduated jar, in maroon case for the pocket 15*s.* 6*d.*

165. **Bathometer** (Bucknill & Casella's Patent), for measuring the depth of the sea, irrespective of the length of the line paid out . . £10 10 0

Particulars on application.

166. **Current Meter,** for showing the rate of flow of tide in any stream or river, and the amount in gallons per hour flowing off (*fig.* 166), in polished mahogany case £5 10 0

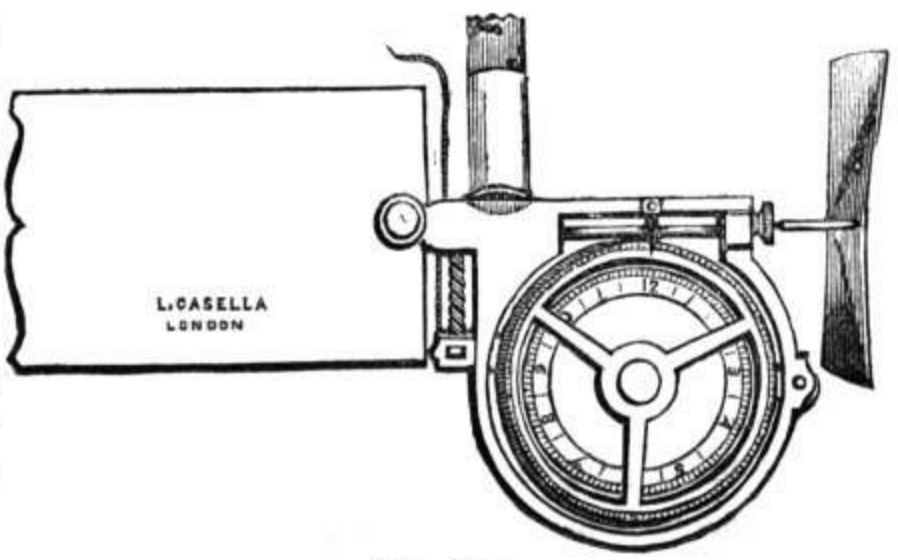


Fig. 166.

167. **Current Meter,** as above, much improved £6 10 0

Rods and appliances for the above, for sounding at various depths, extra.

168. **Current Meter,** large size, as constructed for the Severn Commission, complete in case £17 12

GEODESY.

THEODOLITES.

169. **Traveller's Transit Theodolite** (arranged and constructed by L. CASELLA for Alpine and military surveying, and occasional astronomical observation). In designing this instrument the object has been to condense into the least possible bulk the instrument with which the most useful results can be obtained. Its telescope gives it the advantage of optical power, and it has complete 3-in. circles, both vertical and horizontal, with verniers reading to one minute; it can therefore be used not only as a theodolite for terrestrial surveying, but also as an altazimuth for determining time, latitude, and azimuth. Astronomically it will be found most convenient, its diagonal eye-piece admitting of zenith stars being observed with perfect facility. It is supplied with a reflector for illuminating the wires at night, and a dark glass for solar observations, with a finely-divided level, a compass, and with the means of performing all necessary adjustments. It packs in a mahogany case, 6¾ inches by 5½ inches, and 4 inches deep (outside measurement), the whole weighing only 3½ lbs. A light tripod staff is also added. Important and extensive public surveys are constantly being done with this instrument, especially in rough or difficult positions, or where rapidity is required (*fig.* 169) . . £16 10 0

A paper, descriptive of the instrument, was read at the meeting of the British Association at Exeter, 1869, in Section E, by Lieut.-Colonel A. STRANGE, F.R.S., Inspector of Scientific Instruments, India Department.

170. **Traveller's Transit Theodolite,** as above (*fig.* 170), with the telescope in the centre, the supports being raised to allow it to revolve vertically. In this arrangement, whilst the height is increased, the width is reduced in

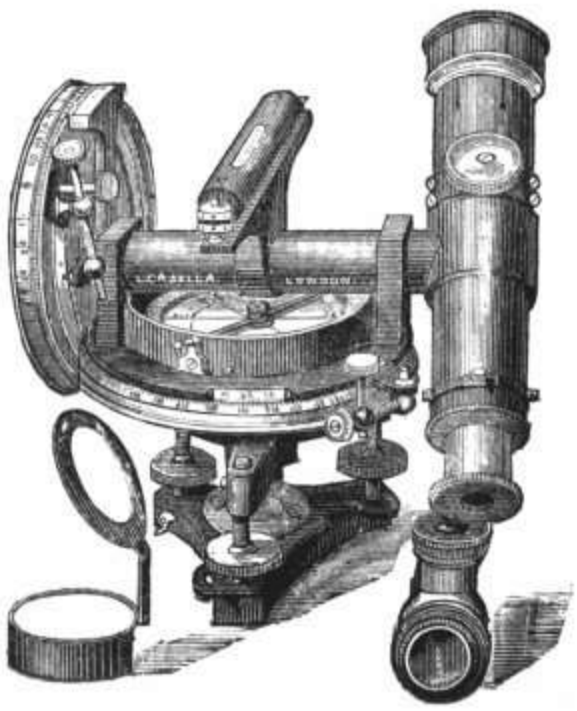


FIG. 169.

FIG. 170.

proportion, and the centre position of the telescope is found preferable in measuring short distances. A tangent screw adjustment with clamp is added to the horizontal limb as well as to the horizontal circle, so that the instrument may be set to zero at each observation without disturbing the adjustment. Besides inverting and diagonal eye-pieces as above, an erecting eye-piece is also added £19 10 0

For other surveying instruments see large catalogue.

ALTAZIMUTHS.

171. **Casella's Pocket Altazimuth,** for travellers and military surveyors, improved and modified by the kind assistance of Francis Galton, Esq. F.R.S. Altitudes, azimuths, compass bearings, clinometric degrees and levels are all obtainable by this handy and accurate little instrument, whose diameter is 2¼ inches, thickness 1⅛ inches, and weight 8 oz. Its usefulness has been so much increased by the recent addition of an excellent telescope for distant objects, as well as in the arrangement of stops, as to make it perfect for the various purposes to which it is applicable (*fig.* 171) £6 6 0

The stops A or B to be turned on or off to stop or liberate the clinometer or compass ring respectively; C, the eye lense, to be pushed in or out to focus the wires, as well as the divisions and figures on the inner edge of the rings. The steady pin D to be pushed in to fix the compass before reading off. Angles of wet ground or grass may also be taken by laying down a walking-stick or umbrella, resting the base of the instrument on it and fixing the circle by turning the stop when the instrument may be raised and the angle read off from the outside rim.

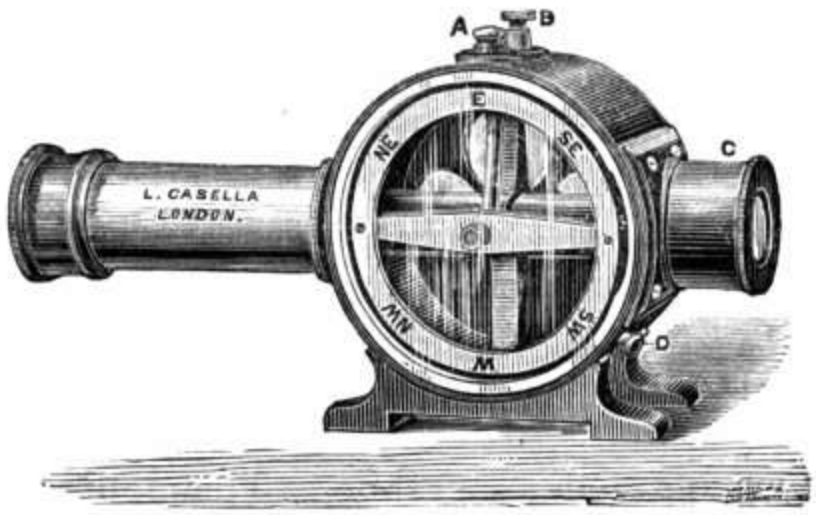


Fig. 171.

172. **Pocket Altazimuth,** as above, without the telescope, for shorter distances, with the object end the same size as the eye-piece . . £5 10 0

173. **Tacheometer,** or transit theodolite, for rapid surveying and shewing distance without the use of tape or chain, 4-in. 5-in. 6-in.
£28 0 0 £32 0 0 £40 0 0

ACCESSORIES FOR USE WITH TACHEOMETER.

Station staff £2 15*s.*, metal logarithmic scale £5, horn protractor 10*s.*, book of instructions 7*s.* 6*d.*

SEXTANTS.

174. **Pillar Sextant** (highly finished), 7-inch radius, divided on silver, with verniers reading to 10 seconds, four telescopes, spring tangent screw, seven neutral shades, star finder, and swing reflector, in best polished mahogany case £15 10 0

175. **Metal Sextant,** plain, flat limb, with three telescopes, seven neutral shades, divided on silver to 10 seconds, in polished mahogany case . £7 10 0

176. **Ebony Sextant,** with best centre, three telescopes, seven neutral shades, and ground glass reflector, divided on ivory to 15 seconds, in polished mahogany case £4 15 0

177. **Pocket Sextant,** with telescope, levels, supplementary arc, and divided circle for difference of hypotenuse and base . . . £6 0 0

178. **Pocket Sextant,** with telescope and supplementary arc, in case £5 15 0

179. **Pocket Sextant,** with telescope, in case, as supplied to the Royal Engineers (*fig.* 179.) £3 10 0 & £4 0 0

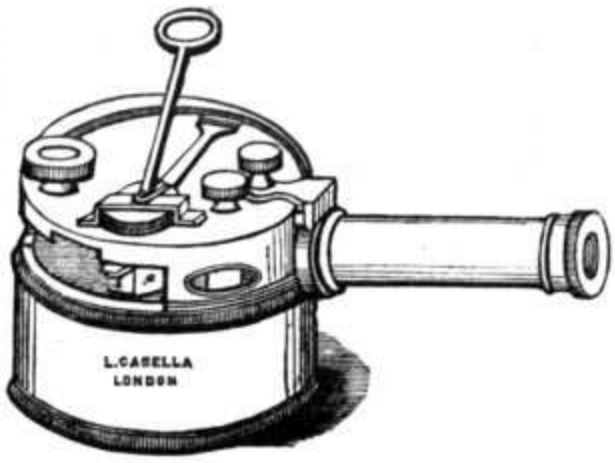


FIG. 179.

180. **Leather Sling Case for Box or Pocket Sextant,** with strap for portability . . . . . 7*s.* 6*d.*

ARTIFICIAL HORIZONS.

181. Casella's Mercurial Artificial Horizon. A metal box containing mercury is covered by a glass with parallel surfaces. When not in use, a slide valve admits the mercury into a lower compartment, so that it cannot be spilled. In leather sling case (*fig.* 181) £3 15 0

FIGS. 181.

Smaller size £3 5 0

If the glass cover has its surfaces carefully worked to parallelism, extra £1 0 0

182. **Artificial Horizon,** of perfectly parallel black glass, with level and three adjusting screws, in mahogany case, for the pocket; 2½-in. reflector, £1 17 6

3-in. do. £2 10 0

STATION POINTERS.

Station Pointer, or double arm protractor, with which two angles relative to a base may be taken together; a convenient instrument for plotting or sketching in new countries, where magnetic bearings may lead to error, from local and other causes.

183. **Station Pointer,** 4-in. brass divided circle, with 10-in. arms and tangent screw adjustment, best construction . . . £7 10 0

184. Do. do. with arms lengthening to 18 inches £8 8 0

185. **Station Pointer,** 4-in. circle, divided on silver, with arms lengthening to 18-in. and tangent screw adjustment, best construction . £9 0 0

186. Do. do. 4½-in. with arms lengthening to 20-in. £9 10 0

187. Do. do. 6-in. ,, ,, 27-in. £10 10 0

188. Do. do. 8-in. ,, ,, 34-in. £12 15 0

The same sizes, if divided on brass instead of on silver, 12*s.* to 20*s.* each less.

LEVELS AND CLINOMETERS.

189. **Gravatt's or Dumpy Level,** 10-in. with parallel plates, divided silver ring to compass, tripod stand, &c. complete in mahogany case (*fig.* 189) £13 10 0

190. **Troughton's Level,** 14-in. with compass and tripod stand, complete £11 10 0

191. **Abney's Level,** improved, with magnifier attached, and extra divisions for measuring depressions as well as elevations £2 10 0

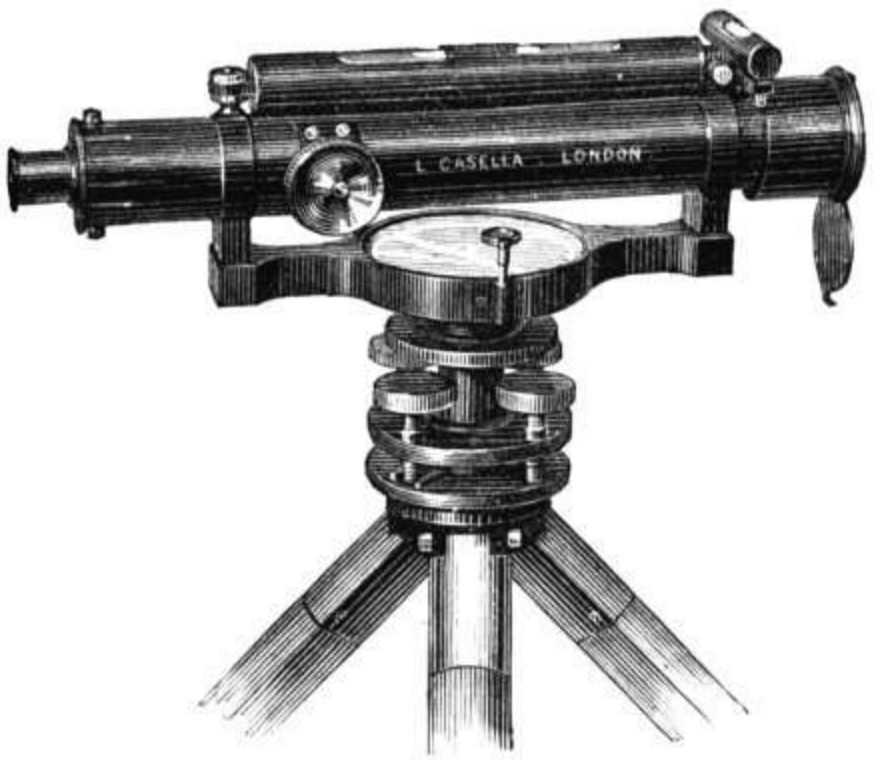


Fig. 189.

192. **Burrell's Reflecting Level,** in maroon case . . £1 5 0

193. **Clinometer Level,** brass, 6-in. or 9-in. with level, sights, and graduated arc, for determining inclination of strata, also for draining and levelling, in neat case with socket for staff (*fig.* 193) 6-in. £1 15*s.*; 9-in. . £2 15 0

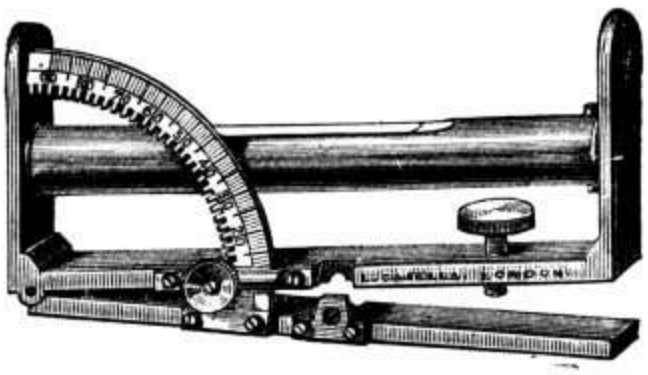


Fig. 193.

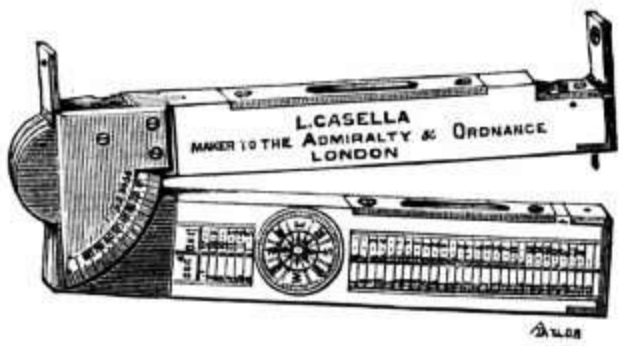


Fig. 197.

194. **Vivian's Clinometer** (Casella's improved), for miner's use, very complete, with best bar needle, two sets of levels and sights, graduated arc, graduated quadrant with pendant, &c. in leather case . £3 0 0

195. **Vivian's Clinometer,** in mahogany, with sights, graduated brass mounting, four small levels, best bar needle compass, graduated arc, and quadrant with pendant to detach, 3-in. . . . £2 15 0

196. **Vivian's Clinometer,** simple form, with sets of sights and levels £1 7 0

197. **Clinometer,** with two levels and sights, compass, inclination scale and scale of fathoms, in 6-in case ; best quality (*fig.* 197, p. 52) . £1 17 6

198. **Clinometer,** superior, as above, with bar needle to compass and independent motion to joint, adapted to plummet, &c. . £2 10 0

199. **Clinometer** (Geographical), having 12-in. boxwood rule, folding to six inches, divided arc and pendant, with scale of angles and the comparative scale of thermometers £1 1 0

SUN DIALS.

200. **Magnetic Sun Dials,** for the pocket, suitable for any latitude, in hardwood or metal boxes, with cover and best agate cap 5*s.* to 12*s.* 6*d.*

201. **Universal Sun Dial,** for any position either north or south of the line, with folding arc and gnomon, by which it is set at pleasure to any latitude, in morocco case, divided circle

2½-in.	3-in.	3½-in.
£1 4 0	£1 8 0	£1 14 0

202. **Universal Sun Dial,** with two levels, adjusting screws, bar needle, agate cap and stop, divided circle

2½-in.	3-in.	3½-in.
£2 10 0	£2 18 0	£3 8 0

203. **Universal Sun Dial,** with improved gnomon, bar needle, two levels, and adjusting screws, in morocco or mahogany case, divided circle

2½-in.	3-in.	3½-in.	4½-in.
£3 0 0	£3 15 0	£4 4 0	£5 5 0

In ordering either of the above, it should be stated whether it is for north or south latitude.

204. **Universal Sun Dial,** as above, but divided to serve for northern or southern latitudes, divided circle

2½-in.	3-in.	3½-in.	4½-in.
£4 4 0	£4 12 0	£5 0 0	£6 6 0

205. **Horizontal Sun Dial,** slate, highly finished, adapted to any locality to order

9-in.	12-in.	15-in.	18-in.
£1 4 0	£1 7 0	£1 16 0	£2 10 0

206. **Horizontal Sun Dial,** brass, ditto

4-in.	6-in.	8-in.	10-in.	12-in.	15-in.	18-in.
12*s.*	£1 1 0	£2 0 0	£3 0 0	£4 4 0	£6 6 0	£9 10 0

207. **Horizontal Sun Dial,** brass, with equation tables

10-in.	12-in.	15-in.	18-in.
£4 4 0	£5 10 0	£8 10 0	£12 0 0

*** **Pedestal and vertical Sun Dials made to order.**

COMPASSES.

208. **Prismatic Compass,** with sight, plain, in maroon or sling case.

2-in.	2½-in.	3-in.	3½-in.	4-in.
£1 13 0	£2 0 0	£2 7 0	£2 10 0	£3 0 0

209. **Prismatic Compass,** with sights, shades, and mirror, in maroon or sling case (*fig.* 209)

1½-in.	2-in.	2½-in.	3-in.	3½-in.	4-in.
£1 15 0	£2 5 0	£2 13 0	£3 2 0	£3 5 0	£3 12 0

Any of the above with extra light aluminium ring 15*s*. additional.

Fig. 209.

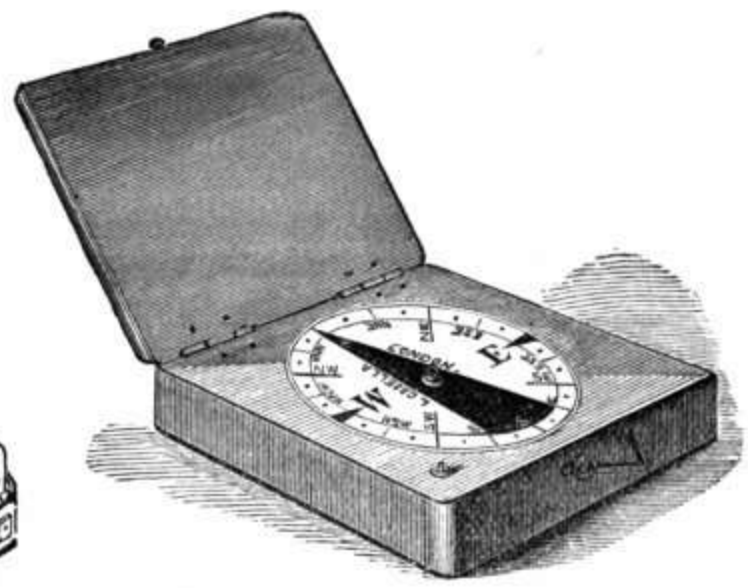


Fig. 215A.

Fig. 215B.

210. **Prismatic Compass,** 2¾-in. with sights, graduated aluminium ring, in maroon case, Ordnance and War Office pattern . . £2 10 0

211. **Kater's Azimuth Pocket Compass,** with magnetic floating card and folding sight, for estimating angular distances on land or at sea £2 10 0

212. **Tripod Stand for Prismatic Compass,** plain, with horizontal motion £1 10 0

213. **Tripod Stand for Prismatic Compass,** with ball and socket joint for horizontal and vertical motions £1 17 6

214. **Yacht or Boat Compass,** with chrysolite cap, floating dial and gimbal movement, in round polished metal cases with lid

1¼-in.	1½-in.	2-in.	2½-in.	3-in.
14*s*. 6*d*.	15*s*. 6*d*.	17*s*. 6*d*.	£1 0 0	£1 3 0

If nickel plated 5*s*. extra.

215. **True North Compass** (Symons's Patent).

The magnetic north and the geographical or true north differ considerably, the declination of the magnetic needle in England being now more than 18°, a circumstance often leading to error. This compass carries a corrected dial, which indicates unmistakably the true or geographical north (*figs.* 215A and 215B p. 54).

TRINKET PATTERN.

(With agate cap, stop, and crystal face.)

No.	Diameter.	Material.	Price.
1	0·7-in	Gold	£2 6 0
2	0·9-in	,,	£2 16 0
3	0·7-in	Silver	£0 18 0
4	0·9-in	,,	£1 2 0

WATCH PATTERN.

(With agate cap and stop.)

7	1·3-in.	Nickel plated or Gold plated	16*s.* 0*d.*
8	1·7-in.	,, ,,	19*s.* 0*d.*

BOX PATTERN.

(With agate cap and stop.)

9	2-in. square	Ebonite	10*s.* 0*d.*
10	2½-in. ,,	,,	11*s.* 0*d.*
11	2-in. ,,	Mahogany	8*s.* 0*d.*
12	2½-in. ,,	,,	9*s.* 0*d.*

216. **Charm Dipping Compass** (CASELLA'S improved pattern), very sensitive, a most useful combination of compass, dipping needle, and magnifier. The crystal case forms a magnifying lens not easily scratched or injured, the rim carrying on one side the points of the compass and on the other the divisions of the circle; the needle is carefully poised and pivotted in jewelled centres, so that it can be used either horizontally in the ordinary manner, or vertically as a dipping needle, 1-in. diameter, gold rim £

Charm Compasses in great variety from . 15*s.* to £3 3 0

217. **Fox's Circle, or Inclinometer,** for use on board ship. In this instrument the needles are held between agate centres, but an arrangement is provided for causing them to take up the true inclination Other magnets, termed deflectors, are used in conjunction with the dip needles when at sea, to obtain the values of the total force, the angles of deflection being compared at the base station with similar deflections produced by the action of weights upon the needles. This instrument is used on board H.M.S. Challenger and on the Arctic ships. Almost all our knowledge of terrestrial magnetic force in the southern hemisphere has been obtained by means of observations made with this instrument . . £35 0 0

Kew Constants computed,

218. **Casella's Dipping Needle Instrument,** from a design by W. T. Goolden, M.A., Oxon, Science Master at Tonbridge School, specially adapted for schools and colleges. A 3½-in. needle, carefully poised, is carried in hard chrysolite bearings; the circle is divided in degrees, and can be read by estimation to 10 minutes of arc, with spring arm capable of being clamped to the vertical axis of the circle, and stops (to facilitate adjustments), three levelling screws to base, in box complete, with instructions for use (*fig.* 218) £5 10 0

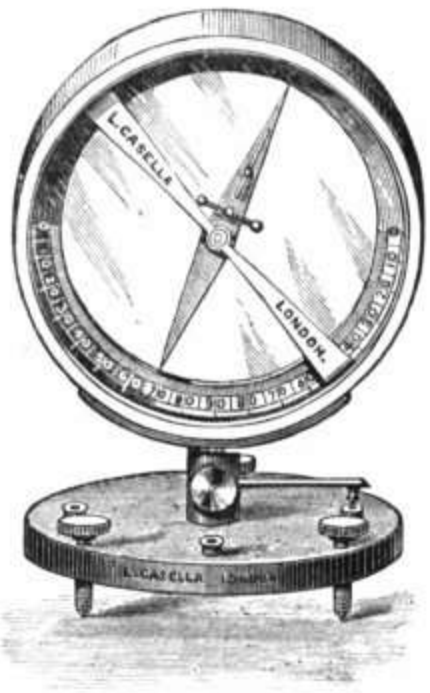


FIG. 218.

219. **Dipping Needle Compass** (CASELLA's), with 3-in. needle and hard chrysolite bearings, for showing the dip of the needle in any locality, as well as its declination, with adjusting level, in neat pocket case £2 12 0

Kew Pattern Dip Circle. See page 38.

Kew Pattern Unifilar Magnetometer. See page 39.

INSTRUMENTS FOR MEASURING DISTANCES.

220. **Best Tape Measures,** warranted strong, in round cases, divided to feet and links, or feet and metres, 33 ft. 7*s.*; 50 ft. 8*s.*; 66 ft. 8*s.* 6*d.*; 100 ft. 13*s.* 6*d.*

221. **Best Tape Measures,** in small round brass cases, for the waistcoat pocket, divided to metre and yards, 2*s.*; or with steel tape . 5*s.* 0*d.*

222. **Best Tape Measures,** in electro, 4*s.* 6*d.*; or with steel tape (*fig.* 222) 6*s.* 4*d.*

223. **The Passometer, or Step Indicator.**—This admirable little instrument is used to show the number of steps traversed by the wearer, and is found invaluable by surveyors, civil and military engineers, and others desirous of making approximate measurements of ground by walking or pacing the distance.

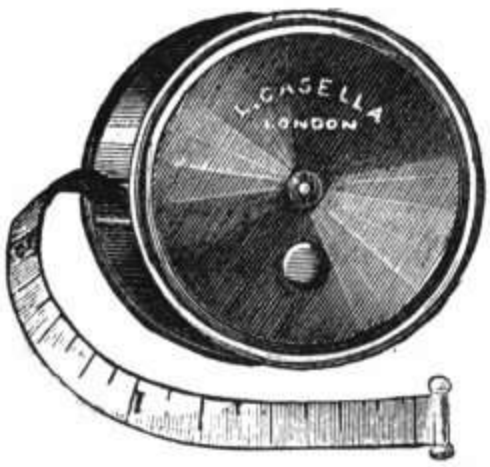


FIG. 222.

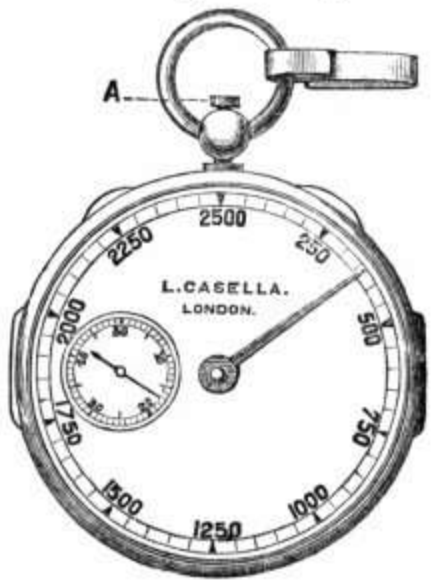


FIG. 223.

By using the passometer, the absorbing attention required by the old method of counting is entirely dispensed with, and any number of steps, of whatever length they may be, is accurately shown on the dials.

In size and form the passometer resembles a watch, and has two dials divided and figured, as shown in the sketch. The hand on the small dial shows, by a dead beat, the number of paces or steps taken up to 50; that on the large dial continues the enumeration up to 2500, each division being equal to 50 steps, or one revolution of the small hand. There is no limit to the number of revolutions. In silver, with crystal glass (*fig.* 223 p. 56) . £3 15 0

224. **Passometer,** with crystal glass, with small extra dial, showing the revolutions made by the hand on the large dial up to 25,000 steps,
In silver, £4 15 0
In nickel, £1 15 0

225. **Pedometer.** This consists of a simple arrangement of weight and pendulum acting on plain toothed wheels, by which the distance walked by the wearer is measured. In size and form it resembles a small watch. The figures and divisions on the large dial represent one to ten miles, divided into halves, quarters, and eighths, and the numbers on the small dial indicate from 10 to 100 miles. To the invalid lady or gentleman requiring limited walking exercise, and to the hearty active pedestrian, it is equally valuable. It may be worn suspended from the neck, or placed in front of a waistcoat pocket, being kept upright by means of a small hook attached to the pendant. The pedometer is adjusted with perfect ease to the step of the wearer, however long or short, and altered at pleasure to any step required. In silver case, with strong crystal glass . . . £2 5 0

226. **Pedometer,** nickel-plated £1 15 0

227. **Perambulator.** An instrument of great utility for measuring the distance of places from each other, the length of roads, &c. It consists of a large wheel of known circumference, having its axis attached to a frame and handle; a system of wheels connected with the axis of the large wheel registers the number of its revolutions upon a dial in English measure, or it may be divided to any foreign measure if required. Specially adapted for tropical climates. (*fig.* 227) . . . £10 10 0

Fig. 227.

228. **Perambulator.** Do. small size £6 0 0

229. **Telemeter** (Redier's), for measuring distances by the time occupied by the travelling of sound. It is in the form of a watch with stop-hand marking seconds, and an inner graduated circle marking the distance
£2 2 0

MEASUREMENT OF TIME.

230. **Chronometer** (Ship's), of the best construction and highest finish, as made for various Governments . . 8 days £42 0 0
2 days £32 0 0

231. **Improved Chronograph,** for the correct registration of any number of rapidly passing objects, as at regattas and races, as well as eclipses and occultations of stars, the exact speed of machinery, &c. by merely touching a spring, *without removing the eye from the objects.* In size and form the chronograph precisely resembles a watch ; it is made of silver, and consists of an ordinary quick train lever movement, with the addition of a centre seconds-hand, which traverses the dial as in a stop-seconds watch. By this means time is taken to the tenth of a second, in either scientific or sporting pursuits, without the confusion and anxiety of taking the eye from the object £7 10 0

232. **Improved Chronograph,** smaller size . . . £4 15 0

232A. Do. do. Woolwich pattern . . £4 0 0

TELESCOPES AND TRANSIT INSTRUMENTS.

The following short list is intended to meet the wants of travellers who require compact and portable instruments available both for celestial and terrestrial observations. The powers are such as are best suited to each instrument, especially in the hands of inexperienced observers, though higher powers can be added with advantage if required. Quartz is occasionally substituted by L. CASELLA for glass in the lenses of some of these instruments at a moderate extra cost with great advantage.

233. **Portable Transit Circle,** 2-in. object glass, $4\frac{1}{2}$-in. circle reading to minutes by two microscopes and verniers, reversible level to ride on the axis of the telescope, micrometric and diagonal eye-pieces, adjusting screws, &c. in red pine case £40 0 0

234. **Portable Transit Instrument,** $1\frac{1}{2}$-in. object glass, with divided circle, double microscopes and verniers, cross-axial level, micrometric and diagonal eye-pieces, illuminating lantern, cast iron stand, &c. complete in red pine case £20 0 0

235. **Portable Astronomical Telescope,** 3-ft., 4-draw, closing to 12 inches, powers 30, 35, 40, and 45, with astronomical powers of 80 and 120, $2\frac{1}{4}$-in. object glass, with clip and table stand, in case, complete £9 15 0

236. **Portable Astronomical Telescope,** 30-in. 4-draw, closing up to $10\frac{1}{2}$ inches, with 2-in. object glass, pancratic draw, giving powers of 30 to 40. Astronomical powers 30 and 80, and sun-shade, clip and table stand, in mahogany case £7 10 0

237. **Portable Astronomical Telescope,** 2-ft., 4-draw closing up to 8 inches, $1\frac{7}{10}$ object glass, with day power of 25, astronomical power of 60, sun-shade, stand and clip, in mahogany case, complete . £6 10 0

238. **Pocket Astronomical Telescope,** 1-ft. 6-draw, closing to 3¾ inches, with small clip and screw support, and extra astronomical power, in morocco case, showing Jupiter's satellites very beautifully, powers 12 to 20 times £2 12 6

TELESCOPES ON CLAW TABLE STANDS.

239. **Economic Telescope,** for astronomical or terrestrial purposes, with brass body, mounted on brass pillar with iron claw table stand, one terrestrial and one astronomical eye-piece, in polished case—

Length 30-in.	Length 42-in.	Length 50-in.
Object glass 2¼-in.	Object glass 3-in.	Object glass 3½-in.
£5 0 0	£6 15 0	£11 15 0

240. **Economic Telescope,** for astronomical or terrestrial purposes, with brass body, highly finished (and mounted on brass claw table stand, in mahogany case)

2¼-in. object glass.	3-in. object glass.	3½-in. object glass.
£7 10 0	£10 10 0	£16 16 0

Cheap pine garden stands for the above, from £1 1 0 to £1 10 0

241. **Astronomical Telescope,** with 30-inch brass body, object glass 2¼-in. clear aperture, two terrestrial and two astronomical eye-pieces of 30, 50, 80, and 110 powers respectively, rackwork adjustment, sunshades or dark glasses to eye-pieces, vertical rack and horizontal motion, with handsome brass tripod stand, in mahogany case complete . . £13 0 0

242. **Strong Garden Stand,** to suit the above . . £1 15 0

243. **Astronomical Telescope,** 3-feet focal length, 2½-in. object glass, pancratic eye-draw, giving powers 30, 40, and 50, and astronomical powers of 80 and 150 respectively, rack-work, sunshades, or dark glasses to eye-pieces, with brass table stand, &c. &c. complete, as above . £18 10 0

244. **Astronomical Telescope,** 3½-feet focal length, 3-in. aperture, with star-finder, day eye-draw, giving powers of 30, 40, 50, and 60; three astronomical powers of 100, 150, and 200 respectively, vertical rack, and rack adjustment, dew cap and dark glasses or sunshades to eye-pieces, with pillar and claw stand, in mahogany case, with lock . £28 10 0
Without finder £26 10 0

245. **Stout Solid Mahogany Garden Stand,** with metal fittings, to suit the above £3 15 0

246. **Sea Coast or Station Telescope,** with 4-feet brass body, vertical rack, and horizontal motions, two terrestrial and one astronomical eye-pieces, with powers varying from 35 to 120, 3-in. object glass and sunshade, in strong case with lock, and strong mahogany stand, admirably suited for observation over an extensive range of country, for telegraphic or sea coast stations, or for occasional astronomical observation . . £22 10 0

ASTRONOMICAL TELESCOPES WITHOUT STANDS.

247. **Astronomical Telescope,** object glass 3¼-in. clear aperture, 4-feet focal length, mounted in polished brass, with sliding draw and rack adjustment, star-finder, dew cap, pancratic day-draw, giving powers of 30 to 50, three astronomical eye-pieces, magnifying to 100, 150, and 200 respectively, low moon power, with different shades of glass to sun caps, in stained pine case £25 15 0

248. **Astronomical Telescope,** 3½-in. object glass, 4½-feet focal length, complete, as above. £28 10 0

249. **Astronomical Telescope,** as above, with 3¾-in. object glass, 4-feet 9-in. focal length, four separate powers of 45, 55, 65, and 75, four astronomical powers of 100, 150, 200, and 250 respectively; with low moon power of 20, and diagonal eye-piece, in case . . £35 0 0

250. **Astronomical Telescope,** with 4-in. object glass, with day powers, &c. precisely as No. 249, but 5-feet focal length, and 5 astronomical powers, viz. 100, 150, 200, 250, and 300, and low moon power of 20, in case, complete £45 0 0

251. **Astronomical Telescope,** as above, but with 4½-in. object glass, £66 0 0

EQUATORIAL MOUNTINGS, STANDS, AND APPARATUS.

252. **Universal Equatorial Axis,** mounted on strong lath oak stand, adapted to telescopes Nos. 247, 248, with 6-in. hour and declination circles, divided on silver, with the latest improved motions, in strong pine case £37 0 0

253. **Universal Equatorial Axis,** of larger size, adapted to carry Nos. 249, 250, 251, in strong pine case £45 0 0

254. **Driving Clock,** suitable for either of the above . . £15 10 0

255. **Strong Out-door Lath Oak Stand,** No. 253, . £8 10 0

256. **Altazimuth Oak Lath Garden Stand,** with centre rod and vertical rack, suitable for Nos. 247, 248, 249, 250, 251, from . £18 to £22

257. **Iron Pillar,** jointed in the centre for azimuth adjustment, with bracket to carry a driving clock, for either No. 253, £7 10 0
Or . . No. 254, £9 0 0

258. **Higher or Lower Powers,** added to any of the above telescopes 15*s.* 0*d.* to £1 10 0

259. **Diagonal Eye-pieces** fitted to any of the above telescopes £1 3 0 to 1 0 0

260. **Transit Eye-piece,** (five lines), with one power, suitable for any of these telescopes, by means of which transit observations may be taken £2 2 0

261. **First Surface Reflection Prism,** for the sun . 18*s.* 0

262. **Total Reflection Prism,** for stars . . . £1 10 0

263. **Illuminating Apparatus** for Nos. 249, 250, 251 . £7 10 0

For Micrometers and object glasses see large catalogue.

Observatories, large or small, with or without revolving roofs, constructed and arranged with all their appliances and instruments down to the smallest detail, from the most elaborate to the most simple, on application.

TELESCOPES AND BINOCULARS FOR THE ARMY AND NAVY, TRAVELLERS AND TOURISTS.

264. **Traveller's Telescope,** bronzed, with leather caps and straps, 1-foot, 3-draw, 1¼-in. object glass £1 5 0

265. **Traveller's Telescope,** bronzed, with leather caps and straps, 18-in., 3-draw, 1⅜-in. object glass £2 0 0

266. **Traveller's Telescope,** bronzed, with leather caps and straps, 30-in., 4-draw, 2-in. object glass £3 15 0

267. **Rifle Practice or Target Telescope,** as used at Wimbledon, 30-in., 3-draw, 1⅝-in. object glass, with sun shade, leather caps and strap £3 12 6

268. **Reconnoitring Military Telescope,** 21-in., 4-draw, closing to 6½ inches, 1½-in. object glass with shade, power 20, in leather sling case £3 10 0

269. **Military or Target Telescope,** 30-in., 2-draw (taper form), closing up to 12 inches, 2⅛-in. object glass, with pancratic eye-draw to increase or diminish the power from 20 to 25, or 30, for dark or clear weather, as used by the leading members of the rifle corps. In clear weather the rifle-hits at 1100 yards are perfectly visible with this telescope, whilst in ordinary weather they are seen with it at 1000 yards off. It will show the time by a clock at six miles distance, and the form of the rocks of Calais from Dover, a distance of twenty-one miles . . . £4 0 0

CASELLA's improved leather sling case for ditto, 10*s.*

270. **Portable Target Telescope,** as above, 3-feet, 4-draw, straight form, closing up to 11 inches, 2⅛-in. object glass, pancratic eye-draw, power 25, 30 35 . . . . . £5 0 0

Leather sling case for ditto, 12*s.*

271. **Target Telescope,** with pancratic eye-draw, rack adjustment, 2¼-in. object glass, power 20, 30, 40, and firm light tripod stand, with universal motion, with attached board for scoring the marks; length when in use 44 inches, in strong 3-foot case, with lock . . . £9 10 0

271A. **Target Telescope,** as above, with 2½-in. object glass . £12 0 0

With this target telescope signal marking is dispensed with, as it shows the hits or bullet marks clearly at 1200 yards range, and is used by the leading volunteer corps, and at all the great international matches at Wimbledon. It is also an excellent telescope for private use on raised situations, or any position commanding an extensive view of the sea.

272. **Army Signalling Telescope,** as supplied to the Army, 2-feet, 3-draw, with shade, 1¾-in. object glass, bronzed and brown calf £2 10 0

If fitted with scale for measuring distance of Infantry and Cavalry, 10*s.* 6*d.* extra.

273. **Government Contract Coast Guard Telescope,** but with 2¼ object glass £4 10 0

274. **Naval Telescope,** 30-in., 1-draw, taper form, closing to 24 inches, 1⅞-in. object glass, with shade, magnifying power 24 . £2 10 0

275. **Naval Telescope,** 36-inch, 1-draw, taper form, closing up to 30 inches, 2¼-in. object glass, with shade, pancratic draw to increase or diminish the power and adapt it at pleasure for dark or clear weather. The light and power of this glass showing clearly an amount of distant detail often of the utmost importance on board ship £4 4 0

Signal cards protected by horn cover, 10*s.*

Caps and sling straps for ditto, 10*s.*

276. **Naval Telescope,** as above, but with 2½-in. object glass £5 0 0

277. **Deer-Stalking Telescope,** with extra large field and increased light, 30-in., 3-draw, closing up to 10 inches, 2¼-in. object glass, pancratic eye draw, power 20, 25, 30, in leather sling case . . £6 10 0

This telescope is used by the most distinguished deer stalkers and sportsmen, and is considered the *ne plus ultra* of a deer stalking telescope. The encomiums constantly received of these telescopes enable L. CASELLA to recommend them with the utmost confidence.

278. **Target Binocular Telescope,** 2-draw, with extra power, to show bullet marks distinctly on a target at 800 yards distance, with bending adjustment for the eyes, in black sling case . . . £8 0 0
In aluminium £18 10 0

279. **Binocular Telescope,** do. do., to show bullet marks distinctly at 1000 yards to 1100 yards distance . . . £9 0 0
In aluminium £19 0 0

280. **Binocular, Field, or Marine Glasses;** Emperor pattern and size, with sun or spray shades, twelve glasses, finest quality, in best sling case (*fig.* 280)

Size of object glass.	Metal.	Aluminium.
1¾-in.	£3 10 0	£6 6 0
2-in.	£4 5 0	£7 7 0
2¼-in.	£4 15 0	£8 8 0

FIG. 280.

281. **Field and Opera Glass combined,** with 3-change revolving eye-piece, for opera, field, or marine use, in collapsing leather case, £3 0 0 £3 10 0 £3 15 0

282. **Captain's and Pilot's Binoculars.** Finest quality, with twelve glasses, object glass 2¼-in. diameter, bronzed and covered with black leather £6 15 0

283. **Captain's and Pilot's Binoculars.** Bronzed and covered with black leather, good quality, highly recommended . . . £4 10 0

Opera glasses specially adapted for picture galleries or the theatre, at various prices.

SPECTROSCOPES.

284. **Automatic Spectroscope,** in which the prism is maintained by a simple contrivance in the proper position for minimum deviation for every part of the spectrum successively, complete in case—

One prism	£12 10 0
Two prisms	£20 0 0
Three prisms	£25 0 0
Six prisms	£35 0 0

285. **Automatic Spectroscope (Direct Vision),** with micrometer showing a dark line in the bright and a bright line in the dark parts of the spectrum respectively, on universal stand, complete, in case . . £35 0 0

286. **Spectroscope (Direct Vision),** 18-in., very high power, three prisms, with hinge joint motion to telescope and stand, in case . £10 10 0

287. **Spectroscope (Direct Vision),** 18-in., will divide the D lines easily, in case £8 10 0

288. **Spectroscope (Direct Vision),** 8-in., will divide the D lines £4 10 0

289. **Pocket Spectroscope,** closing to 3½ inches, with achromatic object glass and adjustable slit, suitable for rain-band observations, in brass case £2 5 0

290. **Pocket Spectroscope,** closing to 3½ inches, with fixed slit, suitable for rain-band observations, in brass case . . . £1 0 0

CALCULATING AND DRAWING INSTRUMENTS.

291. **Arithmometer or Calculating Machine,** giving the product or quotient of 12 figures, with quotient effacer . . £18 0 0

292. **Pantagraph or Engraving Machine,** for enlarging or reducing maps and drawings, or multiplying small writing on valuable documents, as cheques, &c. £105 0 0

293. **Planimeter,** for calculating the areas of figures on paper . £3 10 0

294. **Drawing Sets.**

Admiralty pattern . . .	£3 10 0
Ordnance pattern . . .	£2 15 0
Woolwich pattern . . .	£1 12 6
East India Company's pattern . .	£1 4 0
(Sappers and Miners) . . .	12*s.* 6*d.*

ELECTRICAL TEST INSTRUMENTS.

For Electrometers see page 37.

295. **Detector Galvanometer,** with vertical needle, from £1 10 0 to £3 3 0

296. **Portable Horizontal Astatic Galvanometer,** 1500 ohms resistance, with jewelled centres, and small bar magnet, fitted in leather travelling case, best make £4 15 0

297. **Portable Horizontal Astatic Galvanometer,** same as above, but not so highly finished and adjusted £3 10 0

298. **Sir W. Thomson's Reflecting Galvanometer,** tripod pattern, short thick wire, in case, fitted with lamp and scale . . £10 0 0

299. **Sir W. Thomson's Reflecting Galvanometer,** long coil, resistance from 2000 to 3000 ohms £12 0 0

300. **Sir W. Thomson's Reflecting Differential Galvanometer,** four coils, resistance from 5000 to 7000 ohms, glass cylinder pattern (*fig.* 300, p. 65) £18 0 0

301. **Sir W. Thomson's Reflecting Differential Galvanometer,** four coils, resistance from 5000 ohms to 7000 ohms, square pattern . £19 0 0

302. **Copy of B. A. Unit,** as issued by the Committee of the British Association . . £3 0 0

303. **Set of Resistance Coils,** from 10 ohms to ·01 ohm . £8 10 0

304. **Set of Resistance Coils,** from 2000 ohms to 1 ohm . £12 10 0

305. **Set of Resistance Coils,** from 10,000 ohms to 1 ohm £14 0 0

306. **Set of Resistance Coils,** Post Office Pattern, with bridge, battery, and contact keys attached, the wire of standard gauges, platinum-silver alloy, from 1 ohm to 10,000 ohms in the coil, and 10 ohms, 100 ohms, and 1000 ohms on each side of bridge, best make and accurately adjusted £20 0 0

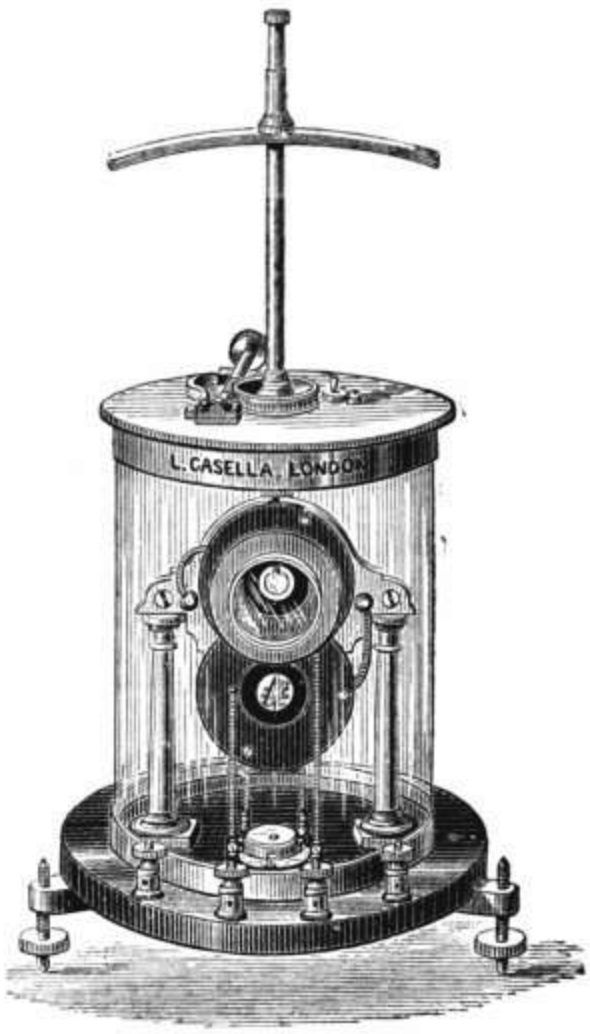


FIG. 300.

307. **Set of Resistance Coils,** same as above, but wire made of German silver, and not so highly finished and adjusted . . £14 10 0

308. **Set of Resistance Coils,** large size, wire of German silver, Bridge pattern, best make and accurately adjusted . . . £30 10 0

SPECIAL MILITARY AND NAVAL INSTRUMENTS.

309. **Torpedo Instruments,** with sight bars, in case, complete £15 15 0

310. **Gun Directors, or Concentrating Ship's Directors,** as used in Her Majesty's Navy, for giving the gradient or angles for directing guns, with verniers reading to 30 seconds, and correcting verniers attached, in case . . . . . each £18 18 0

311. **Gunner's Quadrant,** with graduated arc 0° to 80°, level and clamp; for giving the gradient in directing guns, in case . . £5 10 0

312. **Stadiometer,** as used throughout the army for the rapid measurement of distances, for rifle practice £4 10 0

313. **Measuring and Weighing Machines,** for measuring and weighing recruits £7 10 0

314. **Standard,** for measuring the heights of recruits, as used by the Army £4 10 0

315. **Ballooning, Military;** the following instruments are used for this purpose:—

Portable Mercurial and Aneroid Barometers and Hypsometers, for measuring ascents; Thermometers and Hygrometers, for observing the temperature and dew point at different elevations; the Anemoscope, or Portable Wind Vane, with Card Compass, for ascertaining the direction followed by the balloon; Air Meter for measuring the speed; Reconnoitring Telescopes, with high and low powers; Reconnoitring Binocular Glasses; Graduated Cloud Mirror and Cone, for ascertaining the direction of clouds; Pocket Altazimuth, for taking azimuthal and zenithal bearings, slopes, levels, &c. Prices of these on application.

316. **Ship's Pendulum,** as used in Her Majesty's Navy, for ascertaining the inclination or rolling of ships £5 10 0

317. **Ship's Clinometers,** to register the greatest angle described by a rolling ship, in circular bronzed cases, with portable screws, Large . £3 15 0
Small . £2 15 0

318. **Batten Instrument, or Level,** for ascertaining the inclination or rolling of ships £12 10 0

319. **Station Heliograph** (MacGregor's pattern), with 10-inch mirrors, Morse key, in case, complete . . . per pair £20 0 0

Extra Mirror, for signalling against the sun . . £3 3 0

Lamp, for night signalling £4 0 0

320. **Portable Heliograph,** (MacGregor's pattern), complete, in leather case, with instructions for use, per pair, with 8-inch mirrors £16 10 0
,, 6-inch ,, £15 0 0
,, 5-inch ,, £12 0 0
,, 3-inch ,, £8 8 0
With shovels, extra £1 12 0

321. **Spherometer,** with verniers to read to $\frac{1}{1000}$th of an inch and $\frac{1}{10}$th of a millimètre, respectively, for measuring bullets and spherical bodies £5 5 0

322. **Wire Gauge,** to measure the diameter of wires to $\frac{1}{1000}$th of an inch £2 0 0

323. **Naylor's Gauge,** for iron, to read to $\frac{1}{100}$th of an inch . £3 10 0

324. **Naylor's Gauge,** for iron, with double compass . . £3 15 0

325. **Calliper Gauge,** as constructed for the Royal Gun Factories, to measure from 0 to 36 inches outside with vernier to read to $\frac{1}{1000}$th of an inch

	£28	0 0
0 to 20 inches	£18	10 0
0 to 16 ,,	£14	0 0
0 to 12 ,,	£12	0 0
0 to 9 ,,	£10	10 0
0 to 6 ,,	£8	0 0
0 to 4 ,,	£6	0 0

PHOTOGRAPHY.

326. **Traveller's Photographic Sets,** (CASELLA's Improved), practically arranged and carefully adapted to the special purposes for which they may be required; extra light and very portable; lenses of the finest description by the best makers, and the cameras with one or more double backs for dry plates; in leather sling cases, from £10 10 0 upwards.

All chemicals pure and carefully selected.

Special photographic sets made to order.

MISCELLANEOUS.

327. **Hydraulic Press.** Three tons pressure per square inch, or twelve tons total pressure on the table £28 0 0

328. **Heliostat,** Spencer's local, one mirror, by means of which the direction of the reflected beam can be re-adjusted with great ease during the course of observation (*fig.* 328) £8 10 0

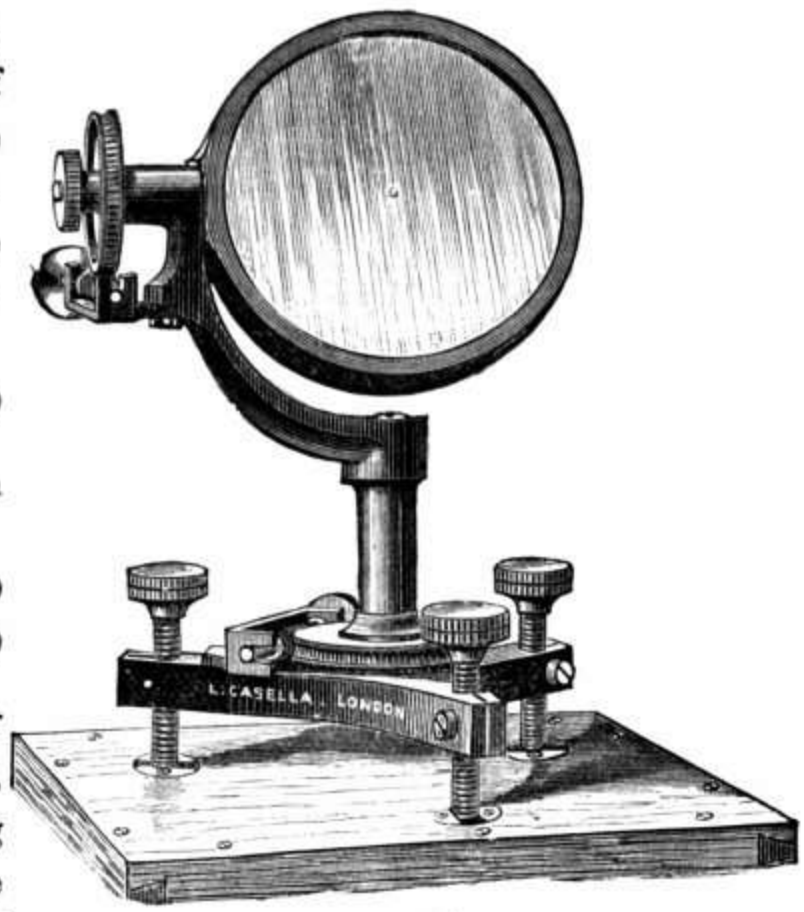


FIG. 328.

329. **Heliotrope,** for use in trigonometrical surveys,
10 inches £10 10 0
6 inches £6 10 0

330. **Dynamometer or Weighing Machine,** for weighing when loading or unloading, and while suspended, all kinds of machinery, girders, armour plates, &c., &c., and also for testing chains, rope, &c., to weigh 100 tons £165 0 0
,, 50 tons £88 0 0
,, 30 tons £52 0 0
,, 20 tons £40 0 0
,, 10 tons £30 16 0
,, 5 tons £27 0 0
,, 3 tons £19 10 0
,, 50 cwt. £17 10 0
,, 30 cwt. £12 10 0
,, 20 cwt. £9 10 0
,, 10 cwt. £8 0 0

331. **Comparing Micrometers,** pair, for comparing rules or measures and other standard bars, reading to $\frac{1}{1,000,000}$th of a metre, in cases £29 0 0

332. **Steam Engine Indicator,** Richard's, with one spring, stopcock, screw-tap, parallel rulers, and steel square, in mahogany case . £8 10 0

EXTRAS. Metallic paper, packet of 360 sheets, for ditto, 4*s.*; oscillating arrangement for ditto, 13*s.*; stopcock for ditto, 8*s.*; extra pressure springs for ditto, each 10*s.*; steel parallel ruler, 6*s.*; steel square, 1*s.*; screw-tap, $\frac{3}{4}$-in. Whitworth, 10 to the inch, 5*s.*; reducing gear, to adapt the indicator to oscillating engines 10 to 12 stroke, £7.

333. **Camera Lucida,** with ball and socket joint, on brass stand, in deal case £1 15 0

334. **Camera Lucida,** best, to clamp on drawing board or table, in mahogany case £2 5 0

335. **Camera Lucida,** with shades, &c., &c., in mahogany case, with pencil and india-rubber complete £3 10 0

336. **Camera Obscura** for sketching from nature, for pictures, 7-in. by 5-in. £1 0 0

SETS OF INSTRUMENTS.

L. Casella is so frequently consulted as to the selection of instruments, that he believes the following lists will be of general utility. The numbers refer to those in the body of the catalogue, where a full description of each instrument will be found.

No. I.

MINIMUM EQUIPMENT REQUIRED BY THE METEOROLOGICAL SOCIETY.

(See Quarterly Journal of Met. Soc. Vol. II. p. 316.)

		£.	s.	d.
Standard barometer, ...	No. 9	4	15	0
,, Maximum thermometer, . . .	No. 46	1	0	0
,, Minimum ,, . . .	No. 48	1	0	0
,, Dry and wet bulb thermometers, . .	No. 78	1	15	0
Stevenson's thermometer stand, . . .	No. 84	1	15	0
Rain gauge, ...	No. 94	0	15	6
Verification of instruments		1	7	6
		£12	8	0

Adding to this the cost of packing cases, &c., the total may be taken at £13.

No. II.

COMPLETE EQUIPMENT OF A METEOROLOGICAL OBSERVATORY OF THE SECOND ORDER.

		£.	s.	d.		£.	s.	d.
Standard barometer . .	No. 3	10	0	0	No. 5	22	0	0
Maximum standard thermometer	No. 46	1	0	0	Two are desirable	2	0	0
,, ,, ,, black bulb,	No. 64	1	5	0	,,	2	10	0
,, ,, ,, bright ,,	No. 66	1	5	0	,,	2	10	0
Stand for these two instruments .	No. 67	0	7	6	,,	0	7	6
Minimum thermometer for air .	No. 48	1	0	0	,,	2	0	0
,, ,, radiation .	No. 62 or 63	1	5	0	,,	2	10	0
Dry and wet bulb thermometers .	No. 78	1	15	0	No. 77	2	5	0
Stevenson's thermometer stand .	No. 84	1	15	0	. . .	1	15	0
Rain gauges . . .	No. 93	0	17	0	No. 88	2	15	0
Anemometer . . .	No. 104	10	10	0	No. 103 B	5	10	0
Earth thermometers (at discretion)	No. 56	1	1	0	Nos. 56 to 60	7	2	0
Sunshine recorder . .	No. 74	17	0	0	. . .	17	0	0
Total cost .		£49	0	6	to	£69	19	6

No. III.

COMPLETE EQUIPMENT OF A METEOROLOGICAL OBSERVATORY OF THE FIRST ORDER.

		£.	s.	d.		£.	s.	
Observatory standard barometer .	No. 2	33	0	0	No. 1	35	0	0
Cathetometer, for reading No. 2 .	No. 20	53	0	0	(or No. 21	28	0	0)
Recording barometer (King's) .	No. 16	260	0	0	Beckley's, No. 19	92	10	0
Natural standard thermometer .	No. 39	5	5	0	No. 40	2	5	0
Maximum ,, ,, (two are desirable in case of breakage).	No. 46	2	0	0	One only	1	0	0
Ditto, for solar radiation, black bulb	No. 64	2	10	0	,,	1	5	0
,, ,, ,, bright ,,	No. 66	2	10	0	,,	1	5	0
Stand for these two instruments .	No. 67	0	7	6		0	7	6
Minimum thermometer, mercurial .	No. 47	2	10	0				
,, ,, spirit (two)	No. 49	2	10	0	One only	1	5	0
,, ,, for radiation ,,	No. 62 or 63	2	10	0	,,	1	5	0

		£.	s.	d.		£.	s.	d.
Self-recording thermograph .	. No. 73	120	0	0	. . . .	120	0	0
Wet and dry bulb thermometer	. No. 76	3	10	0	No. 77	2	5	0
Stevenson's thermometer stand	. No. 84	1	15	0	. . . .	1	15	0
Sunshine recorder .	. No. 74	17	0	0	. . . .	17	0	0
Symon's earth thermometers, a set of	Nos. 56 to 60	7	2	0	. . . .	7	2	0
Rain gauge . .	. No. 88	2	15	0	No. 91	3	5	0
Recording rain gauge .	. No. 99	50	0	0	No. 100	6	6	0
Recording anemograph .	. No. 109	78	0	0	No. 108	65	0	0
Electrometer . .	. No. 119	35	0	0	No. 120	8	0	0
Water-dropping collector	. No. 123				. . . .			
Magnetograph .	. No. 125	330	0	0	No. 126 & 127	101	10	0
Verification of instruments	. about	15	0	0	. . about	7	10	0
Total cost between		£1025	0	0	and	£470	0	0

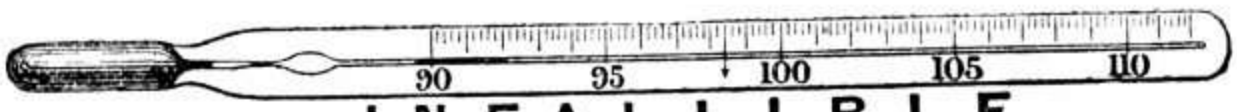


FIG. A

INFALLIBLE

No. IV.

TOURIST'S SET.

		£.	s.	d.
Maximum and minimum thermometers in case,	. No. 158	1	5	0
Pocket thermometer on ebonite scale .	. No. 162	0	12	6
Clinical thermometer (invaluable in case of illness)	(*fig.* A) .	0	9	6
Aneroid Barometer, watch or pocket size .	No. 139 or 151	4	10	0
Pocket compass . . .	. No. 215	0	16	0
Field binocular, in sling case . .	. No. 283	4	10	0
Total cost	.	£12	3	0

The above may be fitted into a portable case at an extra charge of about £1. Total weight about 3 lbs. 12 oz.

No. V.

TRAVELLER'S SET.

		£.	s.	d.
Maximum and minimum thermometers in case	. No. 158	1	5	0
Portable hygrometer . . .	. No. 161	1	10	0
Livingstone's rain gauge . .	. No. 164	0	15	6
Aneroid barometer, in case . .	. No. 150	4	15	0
Hypsometer . . .	. No. 136	2	10	0
Prismatic compass . . .	. No. 208	2	10	0
Box sextant, with telescope, in sling case .	. No. 179	4	15	0
Artificial horizon, with mercury, but without sling case	. No. 181	2	15	0
Total cost	.	£20	15	6

Fitted into a case at an extra cost of about £1 10 0. Total weight about 9 lbs.

No. VI.

EXPLORER'S SET.

		£.	s.	d.
Maximum and minimum thermometers in case	No. 157	2	2	0
Pocket thermometer	No. 162	0	12	6
Portable hygrometer	No. 159	2	5	0
Livingstone's rain gauge	No. 164	0	15	6
Aneroid barometer in case	No. 149	5	10	0
Hypsometer	No. 136	2	10	0
Prismatic compass, with graduated aluminium ring	No. 209	4	0	0
Box sextant, with supplementary arc	No. 178	5	15	0
Artificial horizon, with mercury, but without sling case	No. 181	3	5	0
Field glass, of great power (aluminium)	No. 281	7	15	0
Total cost		£34	0	0

Fitted in a case at an extra cost of about £2 10 0 Total weight about 12 lbs.

Any of the following instruments may be added to the above sets, or substituted for some of the instruments in them :—

		£.	s.	d.
Camera lucida, for sketching from nature	No. 334	2	5	0
Clinical thermometer, for detecting symptoms of fever		0	9	6
Portable telescope, of great power, in leather sling case, with caps	No. 270	5	12	0
Casella's altazimuth	No. 171	6	6	0
Portable anemometer	No. 111	4	4	0
Rain band spectroscope	No 289	2	5	0
Coddington lens, and three magnifying lenses in shell frame, for the pocket		0	12	6

No. VII.

FOR MILITARY PURPOSES.

		£.	s.	d.
Pocket sextant	No. 179	4	15	0
Prismatic compass, 2½ inch	No. 209	2	13	0
Field glass	No. 280	4	5	0
Telescope, pancratic	No. 269	4	0	0
Military protractor		0	7	0
Tape measure, 50 feet	No. 220	0	8	0

No. VIII.

FOR STUDENTS FOR THE NAVY.

		£.	s.	d.
Small sextant		8	0	0
Case of instruments		1	10	0
or		2	12	6
Telescope, with sling	No. 274	2	10	0
Parallel rule		0	5	6

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