

STANDARD  
METEOROLOGICAL  
INSTRUMENTS

NEGRETTI & ZAMBRA  
LONDON

LIST M2



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# STANDARD METEOROLOGICAL INSTRUMENTS

by

## NEGRETTI & ZAMBRA

SCIENTIFIC INSTRUMENT MAKERS  
to  
The British & Foreign Governments.

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List M.2.



Catalogue of  
**STANDARD  
 METEOROLOGICAL  
 INSTRUMENTS**



<u>SECTIONS</u>	PAGES
ANEMOMETERS .. .. .	4
BAROMETERS .. .. .	23
RAIN GAUGES AND EVAPORIMETERS .. .. .	45
SUNSHINE RECORDERS .. .. .	59
THERMOMETERS .. .. .	65
HYGROMETERS .. .. .	84
THERMOMETERS AND HYGROMETERS (RECORDING) ..	94
AIRCRAFT AND UPPER AIR APPARATUS .. .. .	115
TEST APPARATUS .. .. .	122
PUBLICATIONS .. .. .	137
INDEX .. .. .	138







## Foreword



**I**N endeavouring to make this catalogue of **Meteorological Instruments** as comprehensive as possible, we have considered that it will be of interest and service to our customers abroad to know the patterns and types which are specially recommended by the **Meteorological Authorities of the British Isles**.

With the permission of the **Meteorological Department of the Air Ministry**, we are able to embody extracts of the official specifications of instruments used by the **Meteorological Office**, and also to use in some instances illustrations of the particular pattern.

In addition, we have in many cases quoted the wording in the official publications—"Observer's Handbook," "Marine Observer's Handbook," "British Rainfall," etc.

We therefore acknowledge our indebtedness to the Director of the Meteorological Office for his courtesy in granting us such permission.







## ANEMOMETERS

### EXPOSURE.

The matter of exposure is of great importance to secure accurate results.

The site selected should be such that the instrument is in no way sheltered by trees or buildings : as a rough guide it is recommended that the lowest point above the roof for a Wind Vane is 10 feet, and the minimum height for a Pressure Tube Anemometer Head is 30-40 feet above the roof.

The Mast and Support described on page 22 is designed for the correct exposure of the Heads on pages 10, 12 and 18, which are erected at the top, and the spindle or Compo tubing connects these with the Indicator or Recorder fixed at the base of the mast.

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### TEST.

Anemometers and Pressure Heads are tested in the wind channel of the National Physical Laboratory, as set out on the following pages.

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### CHECK.

The calibration of a Self-recording Anemometer of the Pressure Tube Type can be checked by an accurately-divided " U " Tube Water Manometer, provided that the constants of the head are known : this method does not apply to check readings below 20 miles per hour ; for low velocities, a more elaborate apparatus is necessary, and on page 131 is shown an apparatus which gives pressure readings in head of water to an accuracy of .002".

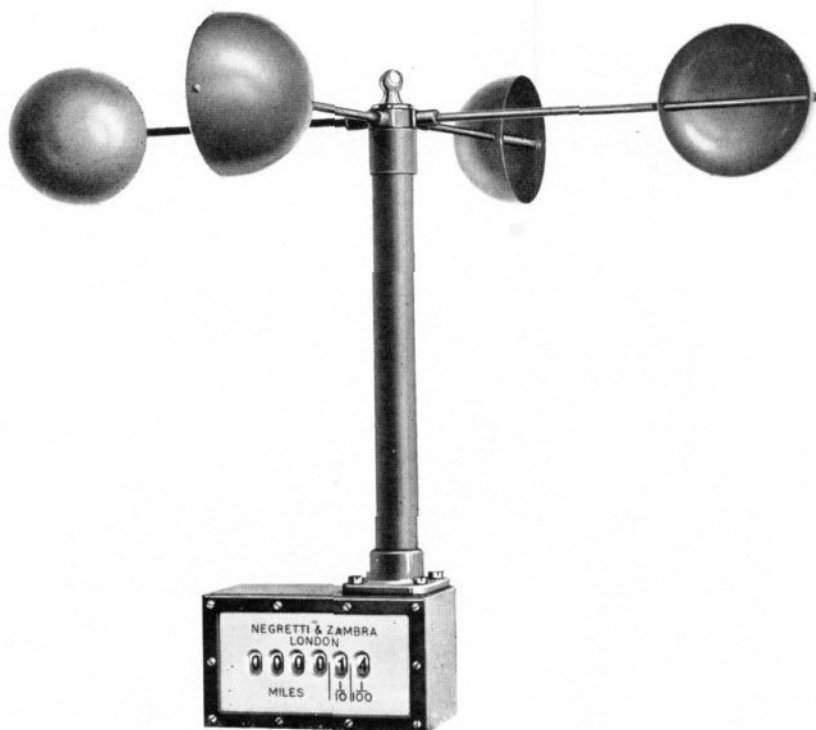
This apparatus may be regarded as a primary standard, but as it requires a certain amount of skill in observation and adjustment, it is not entirely suitable for routine testing. The instrument commonly used for this purpose is that shown on page 130, where the dial of the Water Manometer is graduated in any required units, such as miles per hour, or inches of water pressure. These Gauges are particularly useful in the laboratory for checking instruments where the calibrations are of the order of a few inches water gauge.







ANEMOMETERS



M 2000

**Cup Anemometer.** The Anemometer has four hemispherical copper cups, 3" diameter, attached to two crossed metal arms,  $7\frac{3}{8}$ " long. This is pivoted so as to rotate in a horizontal plane and transmits the movement by a steel spindle to a counter mechanism reading up to 10,000 miles in 1/10 and 1/100. The ratio of the distance travelled by the wind to the distance travelled by the cups is known as "the factor" of the Anemometer, in this type of instrument, 2.73; this is allowed for in the calibration of the instrument.

The run of the wind during the interval between two successive readings, 12 or 24 hours as the case may be, may, therefore, be found by subtracting one from the other. If the instrument is placed in position where access cannot be readily obtained, the dial can be read at a distance by the aid of binoculars.

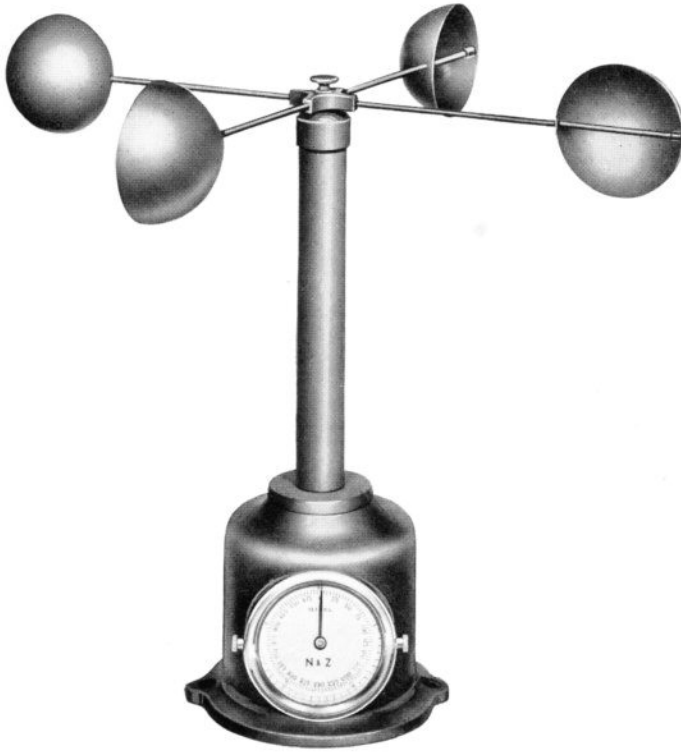
M 2000	Cup Anemometer, Counter Type	.. .. .	£10 10 0
M 2001	Ditto, up to 10,000 metres	.. .. .	£10 10 0
	With Certificate of the National Physical Laboratory, giving the corrections to be applied at various speeds after test in the wind tunnel	.. .. . extra	£1 15 0







### ANEMOMETERS



M 2002

#### Robinson Anemometer.

As described on page 5, with the same dimensions and factor, having a dial and two pointers, one of which registers in one-tenth divisions up to 5 miles, the other up to 500 miles.

M 2002                    £9 0 0

M 2003 Ditto, up to 500 kilometres .. £9 0 0

With National Physical Laboratory Certificate as page 5 .. extra £1 15 0

**Electrical Cup Anemometer.** This Anemometer has four hemispherical cups, 3.05" diameter, attached to arms 4" radius, giving a factor of 2.65. The cups turn a contact maker which completes an electrical circuit and rings a bell once in every 25 turns of the cup. A switch is included in the circuit to cut off the current when not in use.

The outfit consists of the Anemometer, a bell and battery, switch, and a chart giving the run of the wind between the times of any two signals.

M 2004 Electrical Anemometer, £9 10 0



M 2004





ANEMOMETERS



M 2005

The Air Meter or Vane Anemometer is a portable instrument for indicating the number of **linear feet** or **metres** of air passing the instrument, and is particularly suitable for the measurement of low speeds, say 100 to 3,000 feet per minute.

The instrument consists of a number of light vanes mounted on a spindle running on jewelled bearings. By means of a suitable gearing, the rotation of the spindle is communicated to the pointers moving over the dials.

The instrument is held in the air stream, preferably on a rod, and the number of feet of air passing the instrument is timed with the aid of a stop watch. A correction is usually required, which is obtained from calibration factors supplied with the instrument.

The Air Meter is provided with a disconnector for throwing the indicating mechanism out of mesh, and with a setting device for bringing the hands back to zero.

**M 2005 Air Meter**, 2 $\frac{3}{4}$ " dial, 2 $\frac{3}{4}$ " ring, with four dials up to 100,000 feet, complete with disconnector, zero setting device and calibration figures in polished wood case with brass handle. . . **£5 0 0**

With Certificate of the National Physical Laboratory, extra **£1 15 0**





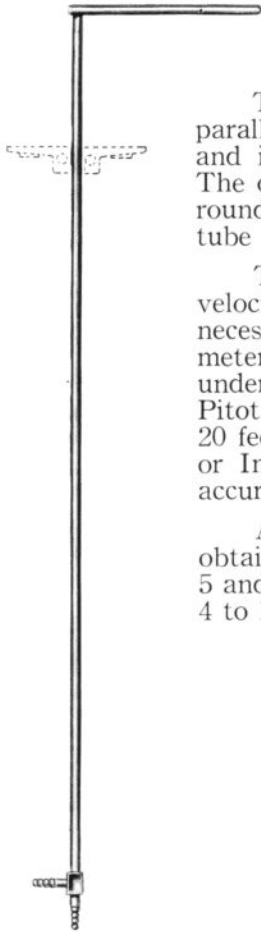
**ANEMOMETERS**

The **Pitot Tube** method of measuring air velocities is not only one of the most convenient but probably the most accurate.

The Pitot Tube consists essentially of two tubes placed parallel with the air stream. One (pressure) tube is open-ended, and is connected to the pressure side of a differential gauge. The other (static) tube has a closed end, but with holes drilled round the tube at right angles to the air stream. This static tube is connected to the suction side of the differential gauge.

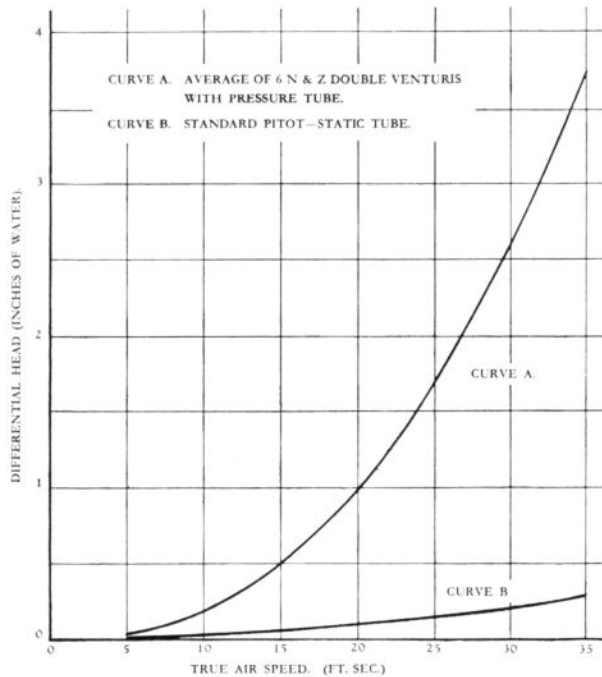
The limitations to the use of a Pitot Tube are that for low velocities the pressure differences obtained are extremely small, necessitating the use of delicate and extremely sensitive manometers which are not suitable for general use. Except under laboratory conditions, therefore, it is not advised that a Pitot Tube should be used to measure air velocities below, say, 20 feet per second, as the scale of the usual type of Manometer or Indicator becomes very condensed towards this point, and accuracy of reading is not readily obtainable.

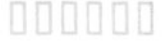
A considerably larger differential pressure can, however, be obtained from a double Venturi head, which, in air flows between 5 and 20 feet per second, will produce a differential pressure from 4 to 10 times that given by a Pitot Tube at the same velocities.



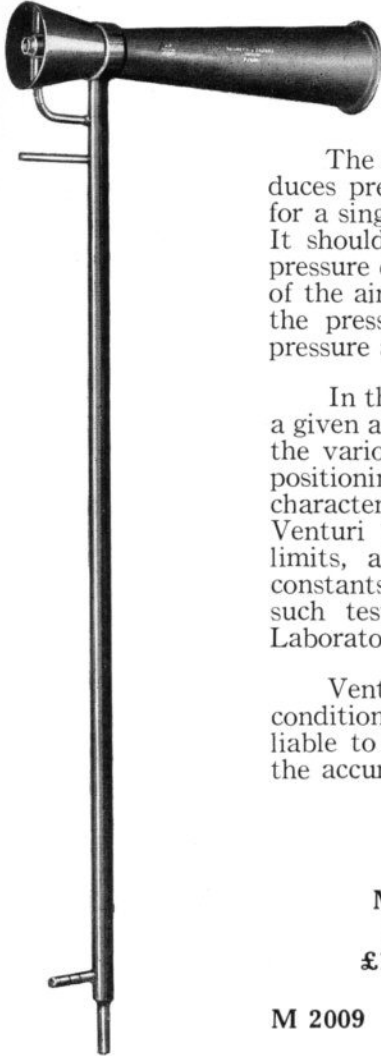
**M 2006**

The diagram shows the performances of a typical Double Throat Venturi Type compared with the ordinary Pitot Tube.





## ANEMOMETERS



M 2009

In a double Venturi the down-stream open end of a small inner Venturi is situated concentrically at the throat of a considerably larger outer Venturi as shown.

The resulting air flow through the inner Venturi produces pressure differences which considerably exceed those for a single Venturi Tube, at the same external air velocity. It should be noted that with a Pitot Tube the available pressure difference is the pressure due to the actual velocity of the air, whereas with a Venturi Tube the greater part of the pressure difference is due to the suction or reduced pressure at the throat of the inner Venturi.

In the case of a Venturi Tube, the suction produced by a given air flow depends upon the exact shape and location of the various portions of the tube, and a slight variation in positioning or size results in a considerable variation in its characteristics. For this reason it is not possible to construct Venturi Tubes to be interchangeable except within wide limits, and it is necessary, therefore, to determine the constants for each tube by actual tests in a wind channel, such tests being carried out by the National Physical Laboratory.

Venturi Tubes cannot be used satisfactorily if the conditions of the air are such that dust or other matter is liable to be deposited in the inner Venturi, as this affects the accuracy.

### Portable Pitot Tubes.

<b>M 2006</b>	<b>M 2007</b>	<b>M 2008</b>
2' 0"	3' 6"	5' 0"
£1 18 0	£2 2 0	£2 15 0

<b>M 2009 Double Throat Venturi Tube</b>	..	<b>£3 15 0</b>
With National Physical Laboratory Certificate	.. .. .	extra <b>£1 15 0</b>

References to Treatises dealing with this subject are:—

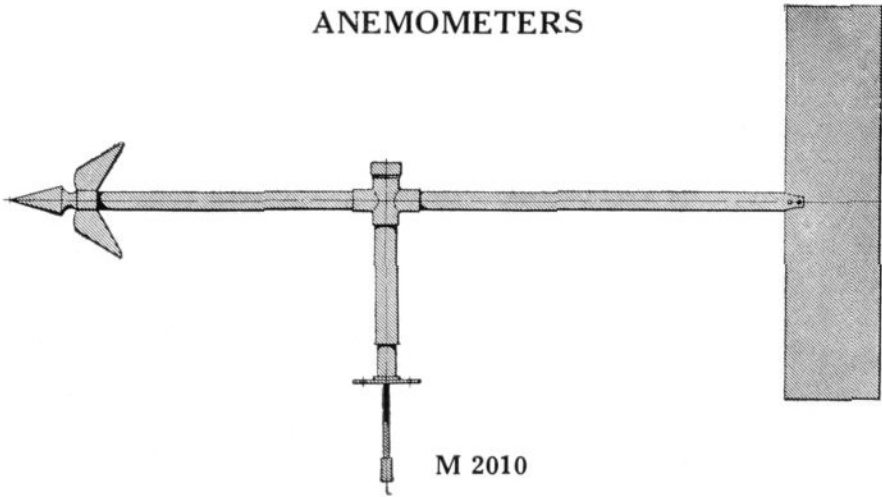
- “ Fluid Velocity and Pressure ” . . . . . J. R. Parnell, A.M.I.Mech.E.
- “ Engineering Instruments and Meters ” . . Edgar A. Griffiths.
- “ Measurement of Air Flow ” . . . . . E. Ower, B.Sc.
- “ Chemical Engineering applied to the Flow of Gases, Steam, Water, etc.” . . . . Geoffrey Martin, D.Sc.







### ANEMOMETERS



**Wind Direction Head.** This Head is for use with the Indicators and Recorders which follow : it consists of a brass tubular standard and flange, at the top of which a vane rotates on ball bearings.

The Vane is constructed of brass tubing, overall length 48", weight 11½-lbs. It is furnished with a cast-iron arrow point at one end and a streamlined shaped tail of light copper sheet 24" long × 6" wide at the other end.

- |        |   |                  |         |
|--------|---|------------------|---------|
| M 2010 | Wind Direction Head   | .. . . . .       | £9 15 0 |
| M 2011 | Spindle in lengths of 5 feet of 5/8" steel tubing with brass joints screwed and pinned. | Length of 5 feet | £0 15 0 |

**Wind Direction Indicator.**  
The mechanism consists of a set of accurately-machined bevel wheels transferring the motion of the spindle and vane to the Index Hand ; the dial is painted with the Compass Points.

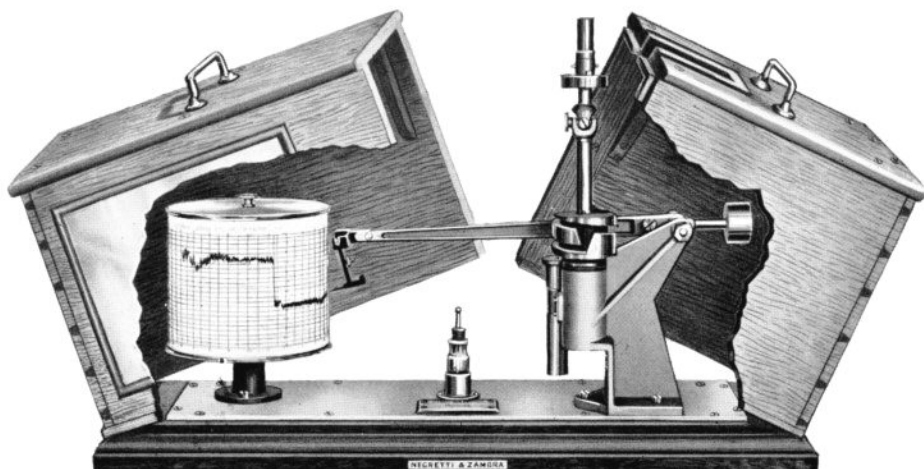
The Case is of cast iron with 8" or 16" aperture bezel and flange mounting at back.

- |        |                           |          |          |
|--------|---------------------------|----------|----------|
| M 2012 | Wind Direction Indicator. |          |          |
|        | 8" size                   | .. . . . | £10 10 0 |
| M 2013 | Ditto, 16" size           |          | £18 0 0  |





ANEMOMETERS



M 2014

**Wind Direction Recorder.** This instrument is used with the Head described on the preceding page. The pen is carried on a pivoted lever having a roller engaging with a spiral groove, which is rotated by the spindle of the vane : the spiral groove, by the continued rotation of the vane in one direction causes the pen to rise to the highest point of the chart, when a gap on the cam allows it to fall to zero ; a plunger working in a dashpot of oil damps the fall. When the pen reaches the lowest point of the chart, a mechanism raises it to a more central position.

At the point where the instrument is coupled up to the direction shafting there is provided a Hook's joint to compensate for any error in alignment, also a key-way for taking up expansion of the shaft due to changes of temperature ; and a clamping device for setting the recorder in correct orientation.

Daily Drum (8-day clock).	.. . . . .	5" dia. × 4.5" high.
Pen Travel	.. . . . . 1 revolution of vane	.. . . . . 2.3"
Chart	.. . . . .	.. . . . . 4.2" high × 16.2"
Time Scale	.. . . . .	.. . . . . 0.6" per hour

The Case is of polished mahogany, with glass front and two folding covers.

M 2014	<b>Wind Direction Recorder</b> , with pen, ink and 100 charts..	£32 0 0
	<b>Charts</b> .. . . . . extra per 100	£0 12 0

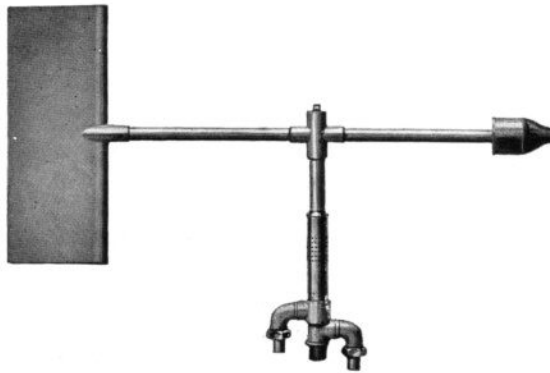
*Head and Spindle, see page 10.*







**ANEMOMETERS**



**M 2015**

**Wind Velocity Head**, used in conjunction with recording instruments on the principle developed by the late Mr. W. H. Dines.

It consists of an open-ended tube set into the wind by means of the vane, and a suction tube exposed on all sides to the wind. The effect of the wind is to produce a pressure in the former and a suction in the latter, both dependent on the wind velocity.

The Head consists of two vertical concentric brass tubes with a clearance between them. The outer tube is drilled with a number of small holes of standardised size and position

The horizontal tube, made of brass tubing 24" long with an open end facing the wind, and at the other end a stream-lined shaped tail of light metal sheet measuring 15" x 5 3/4". This horizontal tube is balanced on a hardened steel point working in the centre of a small reservoir filled with oil. At the base of the spindle are two fittings, to which is attached composition tubing 3/8" bore; the pressure and suction of the wind are transmitted through these composition tubes to the Indicator or Recorder.

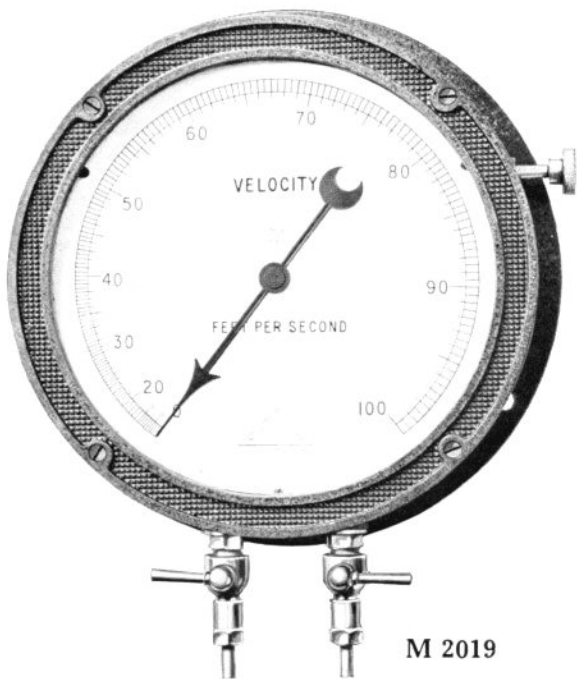
<b>M 2015</b>	<b>Wind Velocity Head</b>	.. .. .	<b>£7 10 0</b>
<b>M 2016</b>	Composition Tubing, 3/8" bore	.. .. . per foot	<b>£0 0 4</b>
<b>M 2017</b>	Two Water Traps, Brass Tubular Type, fitted with brass cocks	.. .. . per pair	<b>£2 2 0</b>
	Determination of the Constants of Head in the Wind Tunnel of the National Physical Laboratory	.. .. .	<b>£2 0 0</b>

*(For Head with 1" bore, see page 15).*





ANEMOMETERS



M 2019

**Dial Anemometer.** This Indicator is a Precision Differential Pressure Gauge, calibrated in velocity, and is suitable for use with the Head and Vane illustrated on the preceding page. The construction is similar to a Low-reading Pressure Gauge with specially balanced movement. Pressure is led to the inside of the diaphragms, which are enclosed in an air-tight case, with static connection. The Square Law of the velocity scale is partially evened out by the introduction of a spring.

The movement is mounted in an air-tight cast-iron case, with an 8" or 16" aperture bezel; flange mounting at back. An external zero adjustment is provided by means of a milled-headed screw on the right-hand side of the case. Two cocks are provided to open to vent.

- M 2018 **Dial Anemometer**, with 8" aperture dial . . . . . £10 10 0
- M 2019 Ditto, with 16" aperture dial . . . . . £18 0 0

RANGES

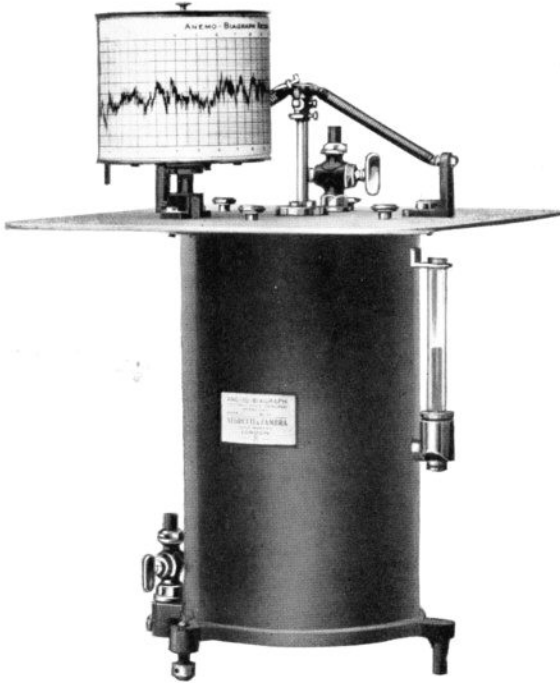
Miles per Hour.	Feet per Second.
0 to 70	0 to 100
0 „ 140	0 „ 200
Kilos per Hour.	Metres per Second.
0 to 100	0 to 30
0 „ 220	0 „ 60

*For Connecting Pipes, Water Traps, etc., see page 12.*





### ANEMOMETERS



M 2020

**Anemo-Biograph.** This Recording Anemometer, which is used with the head described on page 12, consists of a concentric brass chamber half filled with liquid. A floating dome is inserted in the chamber, and pressure from the head is led to the inside of the dome. The dome is fitted with a brass spindle moving closely through an ebonite guide, and on which is mounted the recording pen. The suction effect on the top of the dome increases the motion of the float, but its main object is to eliminate the effects of changes of pressure of the surrounding air.

The dome is controlled by two springs of hardened, tempered steel, treated against corrosion and calibrated so as to convert the effects of pressure and suction into a practically uniform scale of velocity.

The liquid used is a mixture of pure glycerine and water, having a specific gravity of 1.16.

Daily Drum (8-day clock) .. .. .	5" dia. × 4.5" high
Pen Travel, 100 m.p.h. (160 k.p.h.) .. .. .	3"
Chart .. .. .	4.2" × 16.2"
Time Scale .. .. .	0.6" per hour

The mechanism is protected by a glass-domed cover.

<b>M 2020 Recording Anemometer</b> , with glass cover, liquid, pen, ink and 100 charts .. .. .	<b>£42 10 0</b>
Charts .. .. . extra per 100	<b>£0 12 0</b>
Can of Liquid .. .. . extra	<b>£1 7 6</b>

*(For Head, Connecting Pipes, Water Traps, etc., see page 12.)*







### ANEMOMETERS

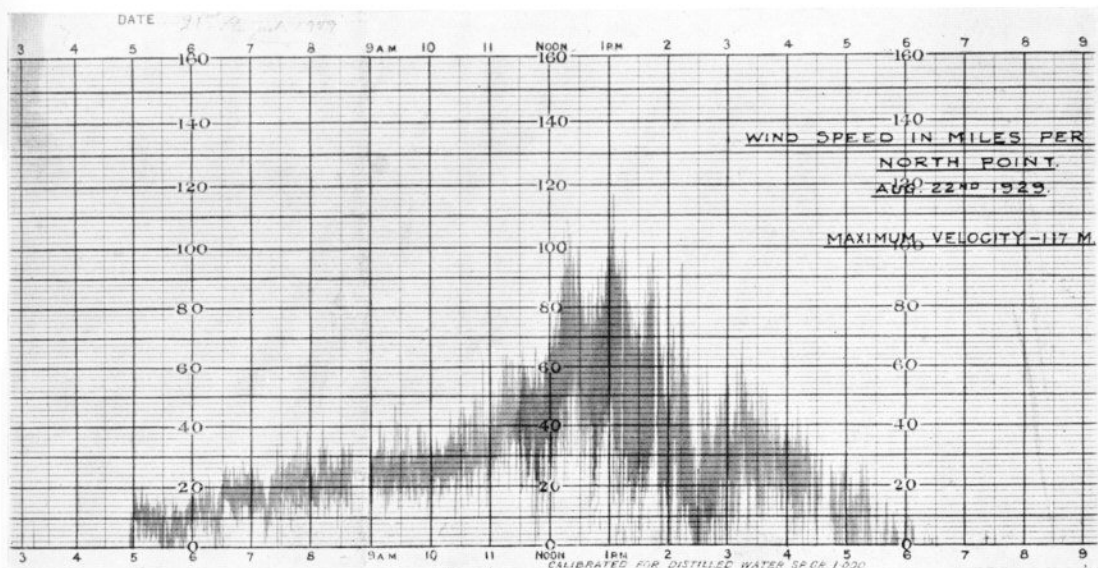
**Anemo-Biograph** for high velocities. Recording Anemometer on the principle and design of the foregoing, but with 1" passages. The head and vane are of the type on page 12 but are of larger dimensions. All fittings are of 1" bore ; the clock drum is taller ; the composition tubing is also 1" bore, but it is recommended that 1" gas barrel should be used on the mast, and short lengths of composition tubing from the mast to the Recorder.

Daily Drum (8-day clock).	5" dia. x 6" high
Pen Travel, 0/70 metres per second, or 0/160 miles per hour	5"
Chart	5.8" x 16.2"
Time Scale	0.6" per hour

**M 2021 Anemo-Biograph**, with 1" connections, with head, vane and recorder, metal cover with glass front, two water traps, liquid, pen, ink and 100 charts .. .. . **£93 0 0**

Charts .. .. . extra per 100 **£0 15 0**

**M 2022** Composition Tubing, 1" bore .. .. . per foot **£0 0 10**



Record from a high-velocity pattern Anemo-Biograph at North Point, China, August 22nd, 1929, showing a gust of 116 m.p.h.

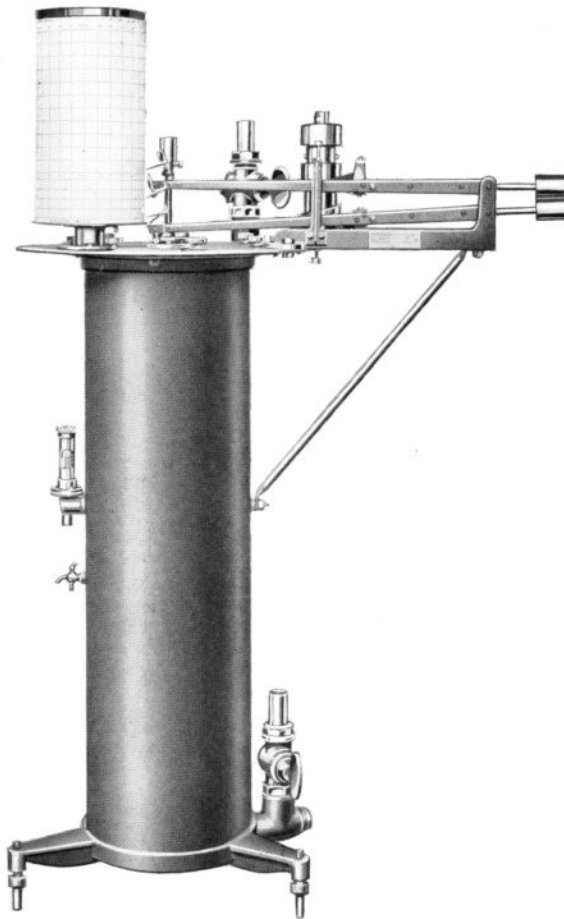
*Reduced scale).*

*By courtesy of Mr. W. H. Wickham, A.M.Inst. C.E.*





## ANEMOMETERS



M 2023

**Dines' Recording Anemometer, with Direction Recorder.** This instrument consists of two independent parts—the Head, which is exposed to the wind, and the Recording Apparatus; these two parts are connected with each other by composition tubing and steel shafting. The principle is that described on the preceding pages.

The latest type of Head is furnished with a stream-lined shaped vane, has passages of 1" bore, and a cylindro-conical shroud over the elbows; this has been found to give results to a nearer approximation of the Dines' factor.

The Head is given a free exposure to the wind by erection at the top of a mast as shown on page 22. This type of Head is connected to the Recorder by gas barrel, 1" size: this can be supplied at extra cost.

The Velocity Recorder consists of a float, which is a specially-shaped cylindrical copper vessel closed at one end, placed with its open end downwards in a vessel partially filled with water and sealed from the air in the room in which it is placed.

To the top of the float is fixed a rod which passes through what is practically an airtight collar in the cover of the water vessel; this rod carries a pen of the swinging gate type. The curve of the float is calculated mathematically according to the law governing the relation of pressure to wind velocity.





## ANEMOMETERS

The Direction Recorder is of the Meteorological Office Twin Pen, Mark II. Type. The arms carrying the pen are actuated by a cam mechanism attached to a spindle, which is coupled up to the head by light steel shafting.

At the lower end of the direction shaft is a sliding sleeve for disconnection of the recorder, if necessary, without altering the orientation. A sliding key-way guards against stress from expansion of the direction shaft.

Standard Charts employ the following ranges :—

Velocities to 120 m.p.h., and equivalent pressure to lbs. per sq. ft.
.. 180 km.p.h. .. .. kgs. per sq. metre.
.. 100 m.p.h. .. .. lbs. per sq. ft.
.. 110 m.p.h. and direction record.
.. 50 Metres per Second and direction record.

Daily Drum (8-day clock) .. .. .	9.15" high
Chart .. .. .	9" × 16½"
Time Scale .. .. .	0.6" per hour
Pen Travel, 0 to 120 m.p.h. .. .. .	6"
.. .. North to North .. .. .	1.8"

**M 2023 Dines' Anemometer with Direction Recorder, Mark II.**, with head and vane, 40 feet of direction shaft, 15 feet of 1" bore composition tubing, 12 pens, 2-oz. bottle of ink, 400 charts, and full set of accessories .. .. . **£107 0 0**

**M 2024 Dines' Anemometer Velocity Recorder**, with head and vane, glass shade, two coils of 50 feet composition tubing, 12 pens, ink, 400 charts, and full set of accessories .. .. **£62 0 0**

**M 2025** Composition Tubing, 1" bore .. .. . extra per foot **£0 0 10**  
 Charts .. .. . extra per 100 **£1 0 0**

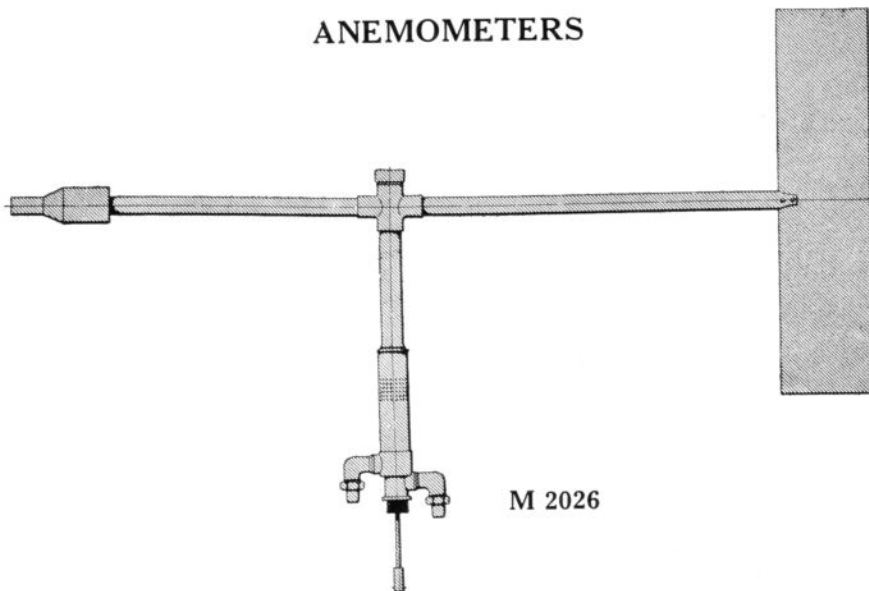
Certificate of the National Physical Laboratory for the head, see page 12 .. .. . **£2 0 0**







### ANEMOMETERS



M 2026

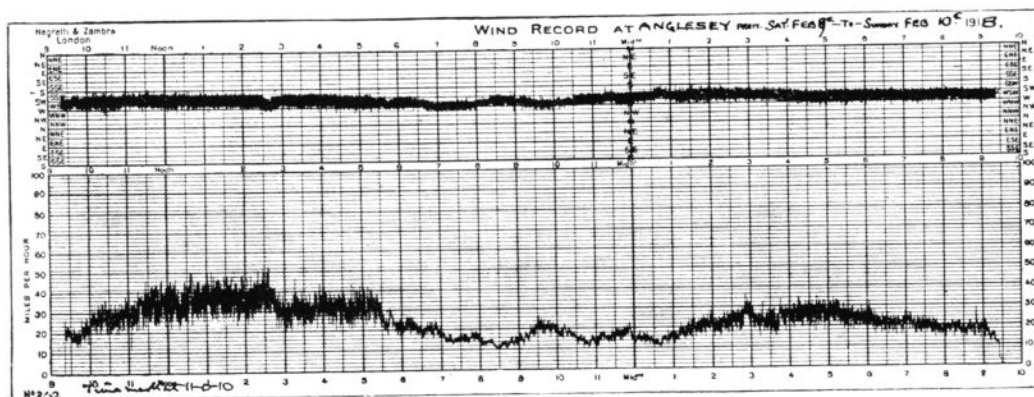
**Wind Velocity and Direction Head.** This Head is used in connection with the combined Anemo-Biograph and Wind Direction Recorder described on the following page. It consists of a Wind Direction Head which actuates the transmitting spindle to the Recorder combined with a Velocity Head, as described on page 12, which gives the required differential air pressure for operating the Recorder.

The horizontal tube is 3' 6" long and the stream-lined tail 2' 0" x 6". The head rotates on ball bearings.

M 2026 Wind Velocity and Direction Head . . . . . £11 5 0

With Certificate of the National Physical Laboratory, extra £2 0 0

*For Connecting Tubes, Water Traps, etc., see pages 10 and 12.*

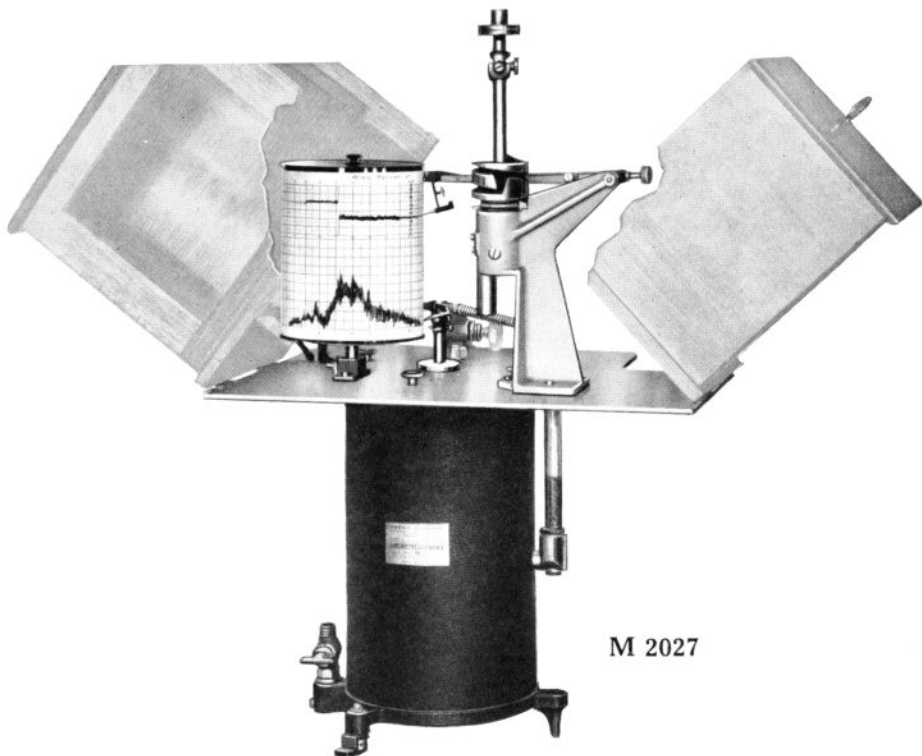


Record from a Combined Anemo-Biograph and Wind Direction Recorder.  
(Reduced scale.)





### ANEMOMETERS



M 2027

**Combined Anemo-Biograph and Wind Direction Recorder.**—The Direction Recorder is mounted on the baseplate of the instrument (see page 14) so that the record of the direction is directly above that of the velocity, the two records of the chart, therefore, being synchronised.

Daily Drum (8-day Clock) . . . . .	5" dia. × 6" high.
Chart . . . . .	5.8" × 16.2"
Time Scale . . . . .	0.6" per hour.
Pen Travel, 0 to 100 m.p.h. (160 k.p.h.) . . . . .	3.1"
"    "    North to South . . . . .	1.1"

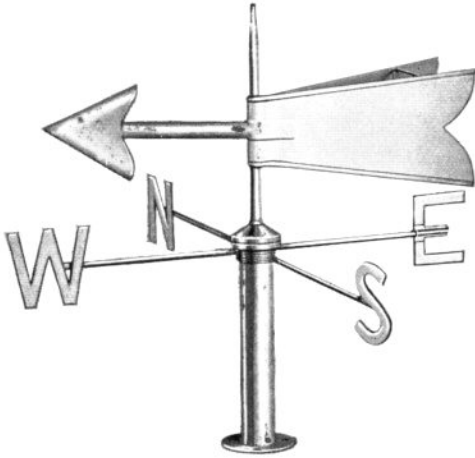
<b>M 2027 Combined Anemo-Biograph and Wind Direction Recorder</b> , with 20-ft. of steel spindle, 2 lengths of 25 feet composition tubing, two water traps, liquid, two pens, ink and 100 charts . . . . .	<b>£76 5 0</b>
Charts . . . . . extra per 100	<b>£0 15 0</b>

*For Head and Vane, see page 18; extra Composition tube, Spindle, etc., see pages 10 and 12.*

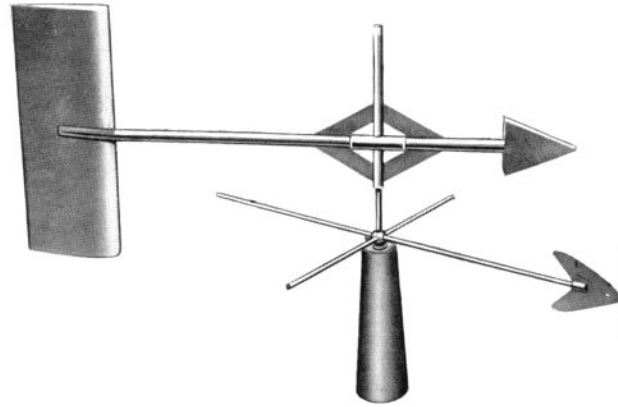




### ANEMOMETERS



M 2028



M 2029

**Wind Vane.** Small size, measuring 16" overall, for attaching to a pole or standard, with brass flange fitting. All parts enamelled and stoved white. The fittings unscrew and take to pieces for convenience in packing.

M 2028 Wind Vane . . . . . £2 12 6

**Wind Vane.** British Meteorological Office Pattern. Copper streamlined vane, 2' 8" long overall, with lead arrow accurately balanced and fitted with hardened steel bearing. The bearing spindle is hardened steel carried in a brass base, which is arranged with screwed fitting for attachment either to a steel mast or to a flange for fitting on a wooden post. All parts heavily enamelled and stoved grey.

M 2029 Wind Vane, M.O. Pattern . . . . . £12 0 0

**Direction Indicator.** The compass point letters are made of sheet steel, 4" high, riveted to the ends of the direction arms, which are of steel rod and screw into the brass boss which fits on the brass base fitting. The arms of the brass boss are all detachable for transport purposes, and are supplied with steel setscrews for rigidly fixing in position.

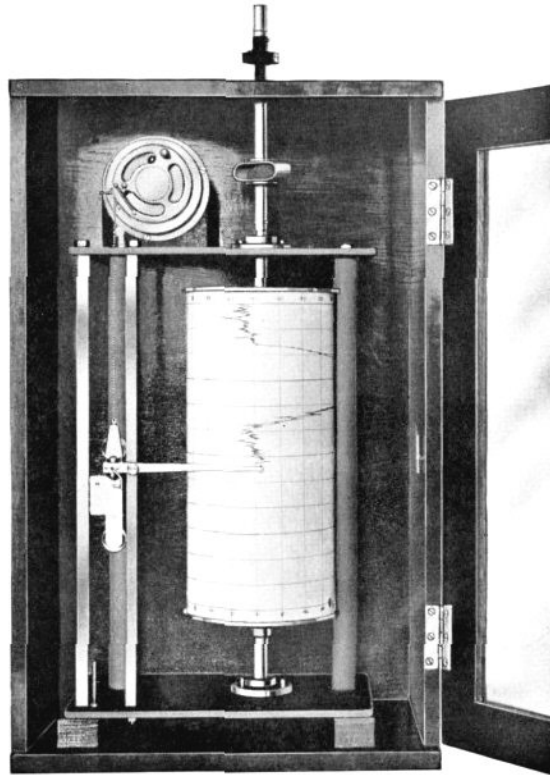
M 2030 Direction Indicator . . . . . £3 10 0







ANEMOMETERS



M 2031

**Wind Direction Recorder (Anemoscope).** This Recorder is used in conjunction with the Vane described on page 10. The pen is suspended from a clockwork mechanism mounted on a bracket situated above the chart drum. The drum on which the chart is mounted is driven direct from the spindle of the vane, one complete rotation of the drum representing one complete turn of the vane. The pen travels down the chart along two vertical guides, and its movement is operated by the clockwork mechanism. The drum is provided with an arrangement for orienting the recorder with the vane.

Daily Drum (8-day Clock)	.. . . . .	6" dia.
Scale 24 hours	.. . . . .	12"
Wind Scale 90 degs.	.. . . . .	4.725"

The Recorder is mounted in a polished mahogany case with glazed front, sides and hinged door.

M 2031 Anemoscope, with pen, ink, and 100 charts	.. . . . .	£47 5 0
Charts	.. . . . . extra per 100	£1 0 0

*For Head and Spindle, see page 10.*





## ANEMOMETERS

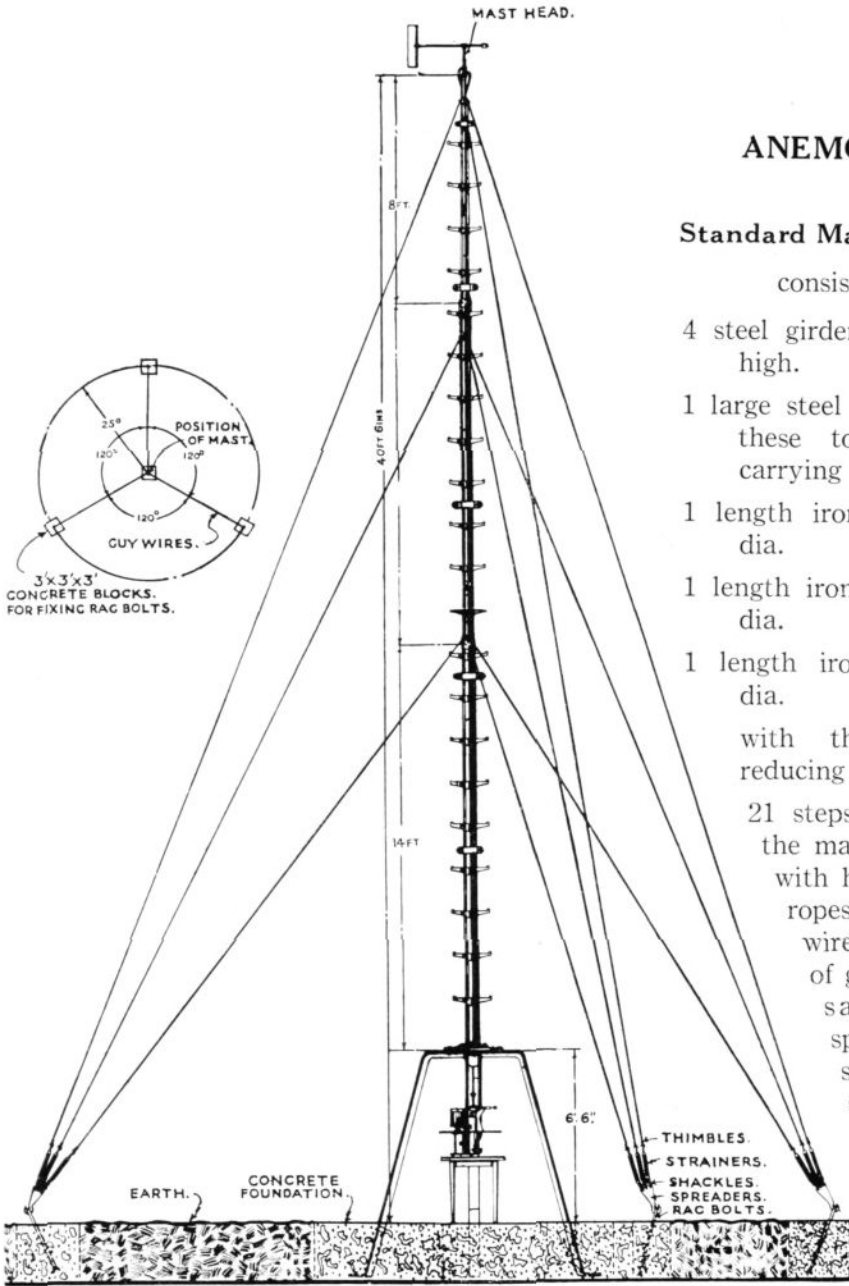
### Standard Mast and Support

consisting of :—

- 4 steel girder supports, 7' 6" high.
- 1 large steel plate for bolting these together and for carrying the mast, with
- 1 length iron tube, 14' × 3" dia.
- 1 length iron tube, 12' × 2½" dia.
- 1 length iron tube, 8' × 2" dia.

with the corresponding reducing sockets.

21 steps for clamping to the mast ; 2 or 3 collars with hooks for the guy ropes ; galvanised steel wire for 8 or 9 sets of guy ropes ; necessary rag bolts, spreaders, thimbles, shackles and straining bolts.



M 2032 Mast and Support, 40-ft. high, as described above .. £33 0 0

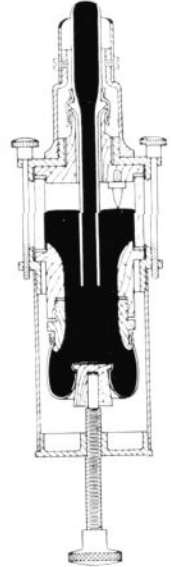
M 2033 Mast, as above, but without supports .. .. . £26 10 0



## STANDARD BAROMETERS

There are two main types of Standard Mercurial Barometers, viz., the Fortin and Kew patterns.

The **Fortin Barometer** measures the actual head of mercury from a fixed datum point in the cistern. Before readings are taken, it is necessary to adjust the level of mercury in the cistern to the fixed datum, consisting of an ivory point. This adjustment serves the double purpose of raising the mercury until it is in contact with the ivory point, and of rendering the instrument portable by entirely filling the tube and cistern with mercury.



Fortin Cistern.

The illustration shows the construction of a Fortin cistern, where the mercury is contained in a boxwood cylinder with a leather bag at its lower end and a glass cylinder at its upper end. The adjustment screw raises or lowers the level of mercury in the cistern, and the level of mercury can be adjusted with precision to the ivory point.

The **Kew Barometer** measures the head of mercury direct, without any adjustment of the cistern level. The cistern is of cast iron, and in the calibration of this Barometer, allowance is made for the rise and fall of mercury in the cistern.

Both types of Barometers require correction for Index or Scale errors, Temperature, Latitude and Reduction to Sea Level.

National Physical Laboratory Certificates provide the corrections for Index or Scale errors, and the corrections for Temperature, Latitude and Reductions to Sea Level can be found in various meteorological text books (see page 137).

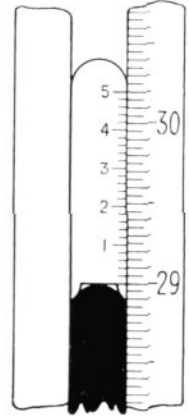


## BAROMETERS

The **Vernier** consists of a short scale, the distance between the divisions of which is slightly less than that between those of the barometer scale.

In the case of English scales divided in inches, 25 vernier divisions are equal to 24 divisions on the barometer scale. As each of the latter is equivalent to 0.050", each vernier division is thus shorter by 0.002".

To bring successive vernier divisions in coincidence with scale divisions, a movement of the vernier of 0.002" per division is therefore required. Thus, for instance, the coincidence of the fifth vernier division above the bottom datum line or reading edge of the vernier, indicates that the latter is  $5 \times 0.002"$ , *i.e.*, 0.010" above the next lower barometer scale division, and 0.010" must be added to the reading represented by this scale division to obtain the exact barometric height (to the nearest 0.002").



For metric scales, each vernier division usually represents 0.05 mm. to be added to the barometer scale reading immediately below the datum.

### MANIPULATION.

A Standard Barometer requires great care in handling, erection, etc. If it has to be moved it should be sloped very carefully so that the mercury slowly fills the upper part of the tube. When the tube is full, the barometer may be carried in a **horizontal** position, or preferably, with the **cistern uppermost**, when it is safe for transport.

However carefully a barometer may be packed, it will not arrive safely unless the case is specially handled during a journey. For export, the tube and cistern are supported in a case with cork packings, and the front of the case is left open so that the fragile nature of the contents may be recognised. This case is taken to the docks by one of our staff and stowed specially at a safe spot on board a ship sailing direct to the port nearest its destination. The consignee, having previously been warned of the date of sailing, should arrange to meet the ship on its arrival, and personally remove the case from where it has been placed.

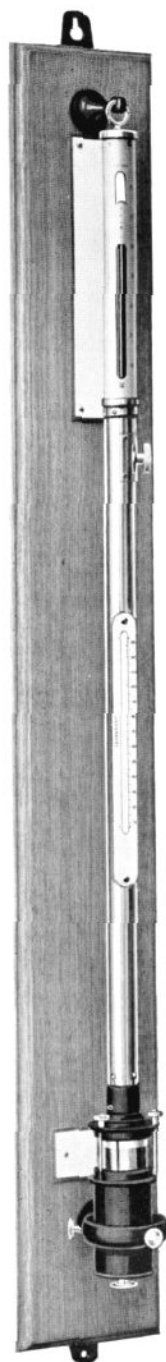
For inland carriage, a similar plan is adopted with the guard of a through train.







## BAROMETERS



Type A

**Standard Fortin Barometer, Type A**, with tube 0.4" internal diameter, filled with pure distilled mercury boiled in the tube. The cistern is built up of brass, glass and boxwood with adjustment screw. The scale is engine engraved and silvered, and fitted with glass protecting sheath, and the Vernier is operated by a milled-head screw with a rack and pinion movement. The thermometer is mounted in a brass frame, and the tube is graduated and figured on the scale. The Barometer is mounted on an oak panel (or mahogany if specially required) with opal glass reflectors; strong metal support at top, and ring at the bottom fitted with three clamping screws. Standard Ranges as follows:—

	Scale Range.	Divided to	Vernier Range.	Thermometer.
Inches .. ..	26 to 32	0.002	26 to 31	5° to 120° F.
Millimetres ..	660 .. 810	0.05	660 .. 790	-15° .. 50° C.
Millibars .. ..	880 .. 1080	0.1	880 .. 1050	250° .. 320° A.

### STANDARD FORTIN BAROMETERS, Type A

#### Single Scale

M 2034	Inches .. .. .	£16 10 0
M 2035	Millimetres .. .. .	£16 10 0
M 2036	Millibars .. .. .	£16 10 0

With National Physical Laboratory Certificate .. .. . extra £1 10 0

#### Double Scale

M 2037	Inches and Millimetres .. .. .	£18 5 0
M 2038	Inches and Millibars .. .. .	£18 5 0

With National Physical Laboratory Certificate .. .. . extra £1 15 0





## BAROMETERS

### STANDARD FORTIN BAROMETERS

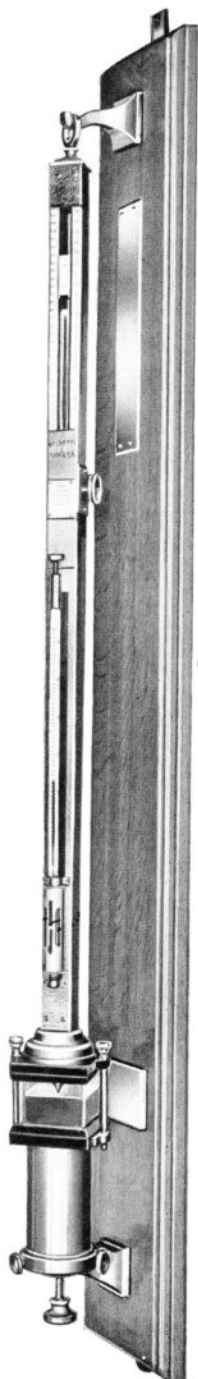
Type B, with tube 0.5" diameter.

„ C „ 0.6" „

These instruments are similar to Type A but of heavier construction and larger cisterns. The large bore tubes give greater accuracy and precision of reading.

**Standard Fortin Barometer, Type D**, with tube 0.6" diameter; square frame and cistern suitable for an Observatory, Public Institution, etc., where an imposing Barometer of high precision is required.

The cistern is built up of cast iron, and enclosed in a highly-finished brass case; the scale is engine engraved and silvered on a square brass tube. The Vernier is operated by a milled-head screw with a rack and pinion movement. The attached thermometer is exceptionally bold, and mounted in a highly-finished brass frame. The Barometer can be supplied mounted on a polished mahogany panel with bevelled opal glass reflectors, but usually it is enclosed in a glass-panelled case (see page 27).



Type D

### STANDARD RANGES

	Scale Range.	Divided to	Vernier Range.	Thermometer.
Inches .. ..	26 to 32	0.002	26 to 31	5° to 120° F.
Millimetres ..	660 „ 810	0.05	660 „ 790	-15° „ 50° C.
Millibars .. ..	880 „ 1080	0.01	880 „ 1050	250° „ 320° A.

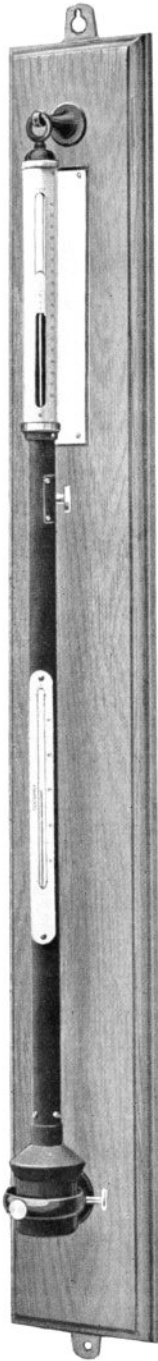
**Standard Fortin Barometer**, complete as described above, mounted on a panel with any two of the above scales.

- M 2039 Type B .. .. . £22 10 0
- M 2040 Type C .. .. . £28 10 0
- M 2041 Type D .. .. . £52 10 0

With National Physical Laboratory Certificate .. .. . extra £1 15 0



**BAROMETERS**



M 2043

**Standard Kew Type Barometer.** This Barometer requires only one setting, and is universally used for general observations of barometric pressure ; it is constructed on similar lines to the Fortin previously described (except for the cistern), and is supplied on a polished wood panel with reflectors and brackets.

M 2043	<b>Standard Kew Barometer, 0.3" tube, range 26 to 32" reading to .002".</b> Thermometer °F. . . . .	£14 0 0
M 2044	Ditto, 660 to 810 mm. to 0.05 mm. . . . .	£14 0 0
M 2045	Ditto, 880 to 1080 mb. to 0.1 mb. . . . .	£14 0 0
	With National Physical Laboratory Certificate . . . . .	£1 10 0

**Double Scales**

M 2046	Ditto, range 26 to 32" and 660 to 810 mm. . . . .	£15 10 0
M 2047	Ditto, range 26 to 32" and 880 to 1080 mb. . . . .	£15 10 0
	With National Physical Laboratory Certificate . . . . .	£1 15 0

**Glass-panelled Cases for Standard Barometers**

The foregoing Fortin and Kew Barometers can be supplied mounted in glass-panelled, dust-proof fumed oak cases (or polished mahogany, if specially required) fitted with two locks and keys at the following additional prices.

With plate-glass door and sheet-glass sides.

M 2048	For Fortin Barometer, Type A . . . . .	£6 10 6
M 2049	.. .. " .. " .. B . . . . .	£6 18 0
M 2050	.. .. " .. " .. C . . . . .	£6 18 0
M 2051	.. .. " .. " .. D . . . . .	£7 5 0
M 2052	.. .. " .. " .. E . . . . .	£5 10 0
M 2053	.. Kew Barometers . . . . .	£5 10 0
	With bevelled-glass fronts and sides . . . extra	£1 5 6



**BAROMETERS**

**Kew Pattern Station Barometer, British Meteorological Office Specification.** Tube, bore of the visible part 8 mm. filled with pure distilled mercury ; fitted with air trap in the form of an inverted pipette 2" to 2½" long. Cistern made of Firth's "Staybrite" steel, 3 to 4 mm. thick, left bright. Scale silvered, protected by a glass tube, graduated 870 to 1100 millibars or 25.7" to 32.6". Vernier operated by milled-head screw working with a rack and pinion, and reading to 0.1 mb. or 0.002". Thermometer mounted in a brass frame, tube graduated 260/320° A. or 5/120° F. Gymbal ring with suspension arm 60 mm. long, and bracket for wall attachment. Box of varnished deal ½-in. thick, with lock and key and rope handles ; box fitted with india-rubber packings.



M 2055

**M 2054 Kew Station Barometer to M.O. Specification,** graduated millibars and inches, and with National Physical Laboratory Certificate .. **£21 15 0**

**M 2054A "Gold" Slide.** For attachment to a Kew pattern Barometer in place of the ordinary attached Thermometer for the purpose of computing the corrections to be applied to the Barometer readings. . . . . **£6 0 0**

**Kew Pattern Marine Barometer,** similar in all respects to the N. & Z. Station Barometer except that the bore of the tube is contracted above the air trap so that the movement of the mercury is damped.

The falling time for 1.5" to 0.5" (50 mb. to 18 mb.) above actual reading being between 4 and 5 minutes. The suspension arm is 12" long.

**M 2055 Kew Type Marine Barometer,** scale 26.5" to 32", reading to .002" .. **£14 0 0**

**M 2056** Ditto, 670 to 810 mm. to .05 mm. .. **£14 0 0**

**M 2057** Ditto, 890 to 1080 mb. to .1 mb. .. **£14 0 0**

With National Physical Laboratory Certificate .. . . . . **£1 10 0**





**BAROMETERS**

**Mountain Barometer.** A standard barometer of the Fortin Type for determining altitudes.

The tube is of 0.2" bore filled with pure distilled mercury ; the cistern is constructed on the Fortin principle as described on page 23. The scales are graduated from 15 to 32", or 380 to 810 mm., and reading by vernier to 0.002" or 0.05 mm.

Thermometer mounted in brass case, graduated on the stem 1° F., or 0.5° C. Tripod of brass tubes, folding into three parts.

The case is of solid leather built up on a light metal frame shaped to take the barometer and its tripod ; it has a leather cap and long strap.

- M 2058 **Mountain Barometer**, scale 15 to 32", reading to .002" . . . . . **£22 10 0**
- M 2059 Ditto, scale 380 to 810 mm., reading to 0.05 mm. . . . . **£22 10 0**
- With National Physical Laboratory Certificate **£2 5 0**



M 2058

**Student Barometer** (Type E). This is a simpler form of the Fortin Barometer described on page 25. The tube is of 0.25" bore, the frame and cistern bronzed ; the board is of stained oak, fitted with reflectors and brackets.

- M 2060 **Student Barometer**, range 26.5" to 32", reading to 0.002" . . . . . **£8 10 0**
- M 2061 Ditto, range 670 to 810 mm., reading to .05 mm. . . . . **£8 10 0**
- With National Physical Laboratory Certificate **£1 10 0**





## BAROMETERS

### DIAPHRAGMS FOR ANEROID BAROMETERS

The quality and performance of diaphragms used in aneroid barometers has a very important bearing on the accuracy of the instrument.

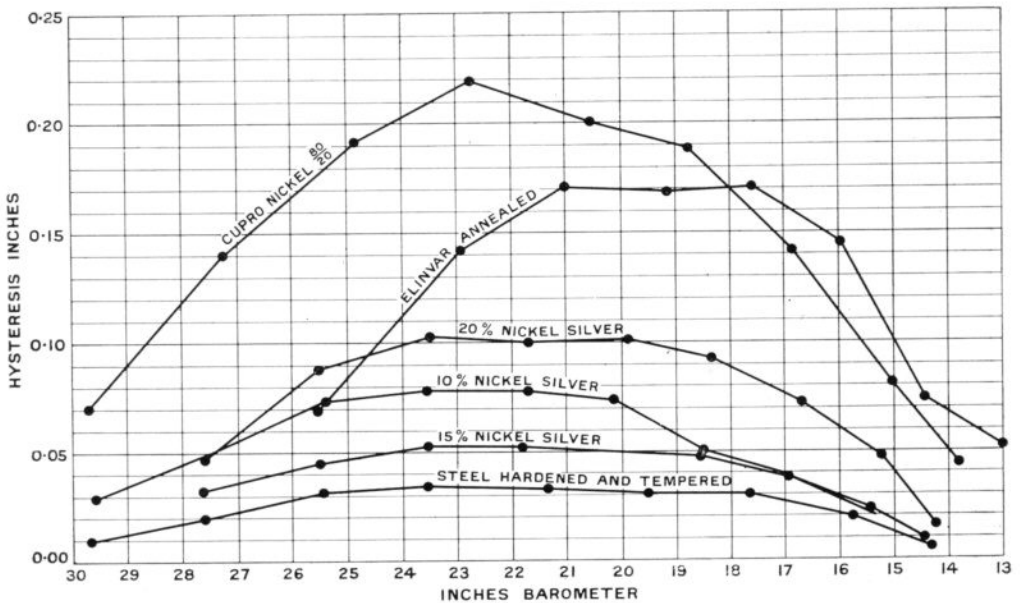
The problem was investigated by us some years ago, when, at the request of the Survey Department of Canada, we undertook the construction of a Recording Barometer of extreme precision. This instrument was to be used as a standard in connection with field work, and the limits of error allowed were very small. In due course the barometer was completed and despatched to Canada to be tested by the Survey Laboratory at Ottawa.

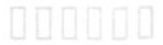
In their Report No. 8468, dated June, 1925, they state the following :—

“The Negretti & Zambra Surveying Barograph submitted has met all the requirements of the specifications, and its maximum errors amount to only a small percentage of the tolerances allowed.”

Actually, the errors found by the Laboratory in the readings of the instrument were in all cases less than one-tenth of the errors allowed in the Specification.

We first of all carried out research into the performance of the diaphragms of various materials. The materials tested included carbon steels, nickel-carbon steels, Elinvar, nickel silver of the following percentages of nickel—10%, 15%, 18%, 20%, 25%, 30%; Cupro nickel 80/20, copper silver alloys, phosphor



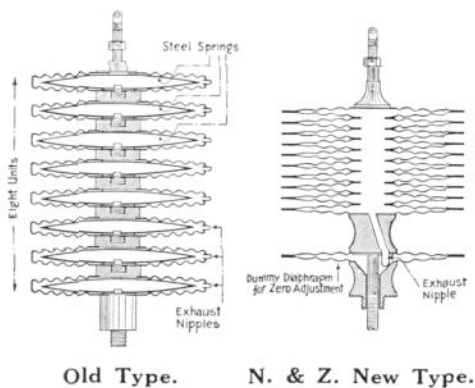


## BAROMETERS

bronze, "Staybrite," etc., and the diagram on previous page shows the result of a hysteresis test carried out on some of the diaphragms under varying conditions of atmospheric pressure.

The tests carried out immediately eliminated a large number of diaphragms with inferior performances and gave direct indication that the hardened and tempered steel diaphragm gave the best results.

It was also discovered that having selected a material of good and reliable elasticity, and by correctly proportioning the shapes and sizes of the corrugations it was possible to eliminate the internal or external springs usually employed, and so prevent the friction caused by their use.



We also developed a new method of stamping diaphragms instead of spinning them in the usual manner. Though it is possible by the spinning method to produce single diaphragms of a very high quality, in quantity production the results vary considerably. With the stamping method, however, it is possible to produce diaphragms in quantity production of a high consistency as regards performance, and we have installed a special 50-ton press for the purpose.

Another detail of construction which is of importance is the proportion and shape of the corrugations, and this problem has been carefully investigated by us with a view to determining the shape which gives the best results.

The result of these improvements in construction is that we are able to produce diaphragms of a considerably higher quality and consistency as regards performance than was previously possible.

In the case of instruments of very high precision—the Precision Aneroid and the Micro-Barograph—hardened and tempered-steel diaphragms are employed, and in the case of other instruments, a nickel-silver alloy is used.



## BAROMETERS

### ANEROID BAROMETER

The Aneroid Barometer is an instrument which has been the subject for a very great amount of criticism, and the problem of producing a more accurate instrument has been a recurring one since it was invented about the year 1847, by Vidi. Many experimenters have dealt with this subject, and the theory has been examined by many notable physicists.

#### Established Type.

The high-class Aneroid to-day usually follows an established design, although there are many details of construction which are unsound.

The movement consists of two corrugated discs soldered together and made completely air-tight and exhausted of air. The pressure of the surrounding air tends to collapse the discs or diaphragms, but they are restrained from complete collapse by a U-shaped leaf spring supported on knife edges. One end of the spring is anchored to the base of the instrument, and the other end is free to operate an arm, which, in turn, operates a magnifying lever mechanism linked to a chain and pulley device.

#### Magnification.

The movement of the discs or diaphragms with varying atmospheric pressure is extremely small, and may be 0.013" or less for a barometric change from 28" to 31" of mercury. The pointer tip may travel 10" or more for this change of pressure, in which case the mechanism magnifies the movement of the diaphragm 800 times.

If it is required that the pointer shall repeat its readings on the dial, and be consistent to one-hundredths of an inch linear movement (as close as the naked eye can conveniently read), it is obvious that microscopic errors of 0.000012" must be eliminated in the diaphragm mechanism, and if it is required to obtain accurate readings to 0.002" barometer, an accuracy of one part in 15,000 is required. This gives some indication of the magnitude of the problem, and suggests that great attention must be given to details both in design and materials.

#### Sources of Error.

An Aneroid Barometer is subject to four main sources of error as follows :--

- (1) **Hysteresis**, *i.e.*, the observed difference between the instrument readings with pressure increasing and decreasing at a known rate of exchange.
- (2) **Creep or Drift**, *i.e.*, the change of reading at a constant pressure after a change of pressure.
- (3) **Temperature**, *i.e.*, the change in the elasticity modulus of the dilating members.
- (4) **Friction, Backlash** and mechanical inconsistency.

## BAROMETERS

### Sources of Error.

An examination of the established type of Aneroid with reference to these errors reveals the following :—

- (a) The design of the carriage piece, anchoring of the U-shaped spring, and methods of assembly, introduce errors of Hysteresis and Creep.  
As we are dealing only with the question of design, no reference is made to the quality of the diaphragms, but this has an important bearing on the subject. See table, page 30.
- (b) The method of compensation by means of a bimetallic arm effects a zero compensation only. This may be a fair approximation for an aneroid reading 28" to 31" of mercury, but does not apply to a greater range.
- (c) The mechanical magnification of the diaphragm movement is usually too high for consistent readings free from friction.

### N. & Z. PRECISION ANEROID.

As the result of prolonged investigations and research, Negretti & Zambra have established an entirely new design of Aneroid Barometer, which is probably the most notable advance made in Aneroid design. The inherent errors have been reduced to such small proportions that this Aneroid Barometer might well replace the Mercurial Barometer for scientific observations, since it requires no corrections for temperature or latitude.

#### Hysteresis and Creep (a).

It has been seen how the use of the improved diaphragms eliminates the use of the U-shaped spring and its anchorage.

#### Temperature (b).

Errors due to temperature changes occur only in a minor degree from the thermal expansion of the various members, and are mainly due to the physical property that materials have of a change of elasticity modulus with temperature. A curve of load extension of a spring shows the effect of temperature and also the effect of a zero compensation, and indicates that temperature alters the slope of the load deflection curve. Assuming two dotted lines represent a load equivalent to that in an Aneroid ranged 28" to 31", it will be seen that a bimetallic compensation (which merely sets the pointer back for a rise in temperature) does not alter the slope or scale value. What, therefore, is required is some form of compensation which varies with the load or deflection of the diaphragms.

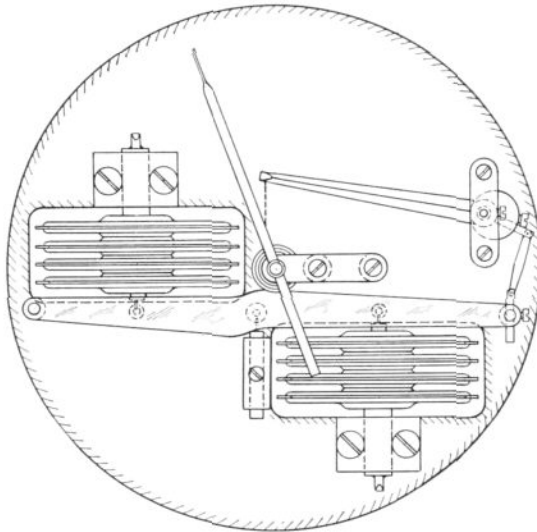
## BAROMETERS

### *Precision Aneroid (continued).*

#### **Temperature.**

By suitably proportioning the volume of the space inside the boxes when closed to that when open, and by leaving a certain definite amount of dry air in the boxes, a compensation, that varies with the deflection, can be effected. As the boxes open, the pressure of imprisoned air falls, due to the increased volume, and consequently the correcting effect of temperature on the air diminishes as the load or deflection decreases.

This method of compensation, together with the improved method of construction of the diaphragms and their connections, secures practically perfect compensation for temperature over the whole range of the instrument.



#### **Movement (c).**

The movement employs two sets of four exhausted diaphragm boxes; each box consists of eight nickel-plated hardened and tempered steel diaphragms. The two sets of boxes are fixed to the frame of the instrument, and the free ends are connected to a magnifying lever in such a manner that the two boxes are balanced. The magnifying lever is of girder construction, and the fulcrum is formed by a flexing strip of stainless steel. The diaphragm

boxes are also connected to the balancing lever by flexing strips. At the end of the magnifying lever the movement of the boxes is magnified, and at this point the movement is unaffected by position and balance, and is free from friction or backlash. The control at this point is considerable, due to the number of diaphragms used. The end of the magnifying lever is then linked to a second lever mounted on a practically frictionless spindle with point bearings. Attached to this spindle is a third lever which operates a chain and pulley mechanism. The pulley is of large diameter and operates on a spindle with a thrust bearing. A hair spring is used to give the required tension on the chain.





## BAROMETERS

### Precision Aneroid (continued).

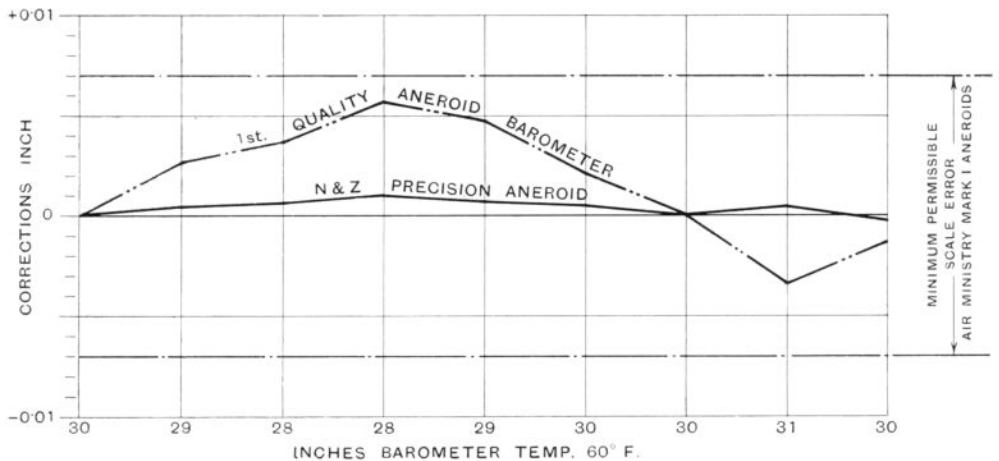
#### Standard Ranges.

The Standard Ranges are as follows. In the case of the Range 28 to 31", divided to 0.01", estimation of pressure may be obtained to 0.002", and possibly 0.001", by subdividing with the eye.

INCH.	Divided to	MILLIMETRES.	Divided to	MILLIBARS.	Divided to
28 to 34	0.02	710 to 860	0.50	950 to 1150	0.50
28 " 32	0.01	710 " 810	0.20	950 " 1080	0.50
28 " 31	0.01	710 " 790	0.20	950 " 1050	0.20
25 " 31.5	0.02	640 " 800	0.50	850 " 1060	1.00
21 " 31	0.02	540 " 790	0.50	710 " 1050	1.00

#### Height Scales.

The Precision Aneroid is usually calibrated in pressure units only. A height scale in Feet or Metres can be added, however, and derived from the I.C.A.N. Law, Isothermal Law, or from Airy's Tables, with zero height at a pressure of 31, 30, or 29.90". Unless otherwise required, the height scale will be derived from the I.C.A.N. Law, which assumes that the air temperature falls uniformly at the rate of 1.98° C. per 1,000 feet from 15° C. on the ground.

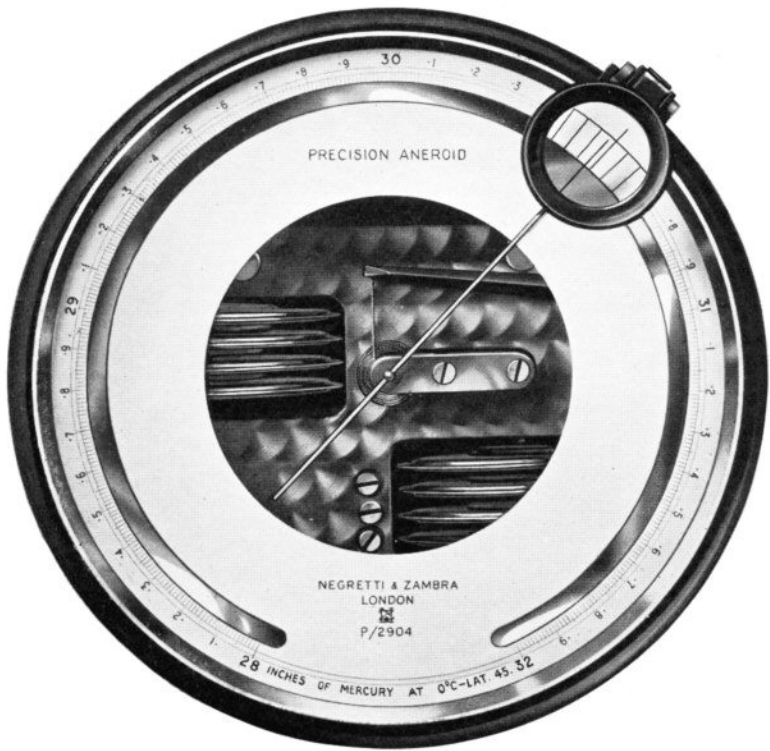


The above graph of the performance of an N. & Z. Precision Aneroid under various tests for Hysteresis, Temperature, etc., shows the marked superiority when compared with the usual type of first class Aneroid, and with the limits of the Air Ministry specification.





### BAROMETERS



M 2062

**Precision Aneroid (continued).**

The pointer is of tubular form, extremely light and rigid in construction, and is formed into a knife edge for reading purposes.

The frame carrying the diaphragms and movement is of special construction to avoid effects of strain or distortion.

The setting adjustment consists of a quadrant and pinion which, in effect, rotates the whole movement and eliminates any possibility of characteristic errors being introduced when a setting is made. This is operated from the back of the case.

The dial is of brass, 4 1/2" diameter, engine divided and silvered. An anti-parallax mirror is fitted behind the knife edge of the pointer.

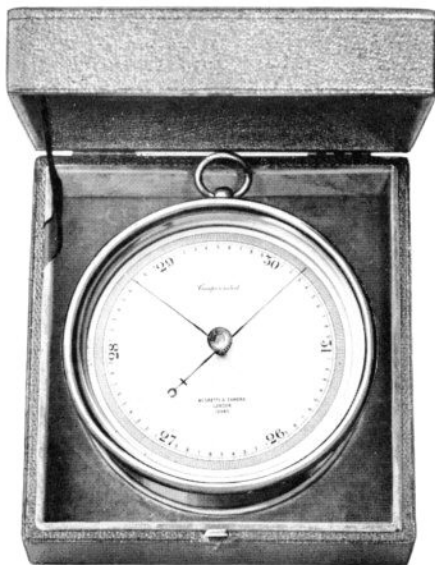
A magnifying lens is also provided, which is attached to the rotating bezel.

**M 2062 Precision Aneroid Barometer . . . . . Prices on application.**





### BAROMETERS



**M 2064**

**Aneroid Barometer**, British Meteorological Office Specification, Mark II.

Movement compensated for temperature, mounted in a brass case with suspension bow and bevelled-glass front. An index hand is provided on the cover glass and is set by a knurled button. The dial measures 4" diameter, scale 855 to 1055 mbs., engine divided and figured.

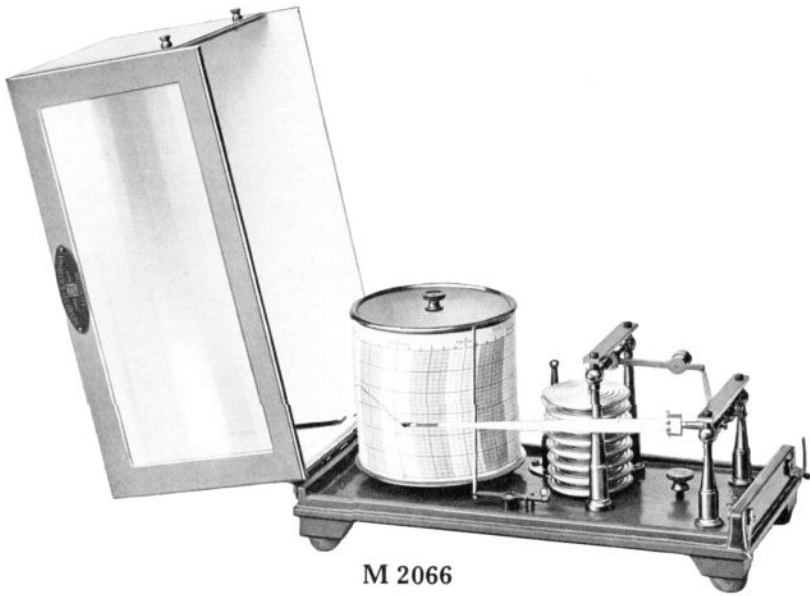
Leatherette case with hinged lid 6" × 6½" × 3".

<b>M 2063</b>	<b>Aneroid Barometer</b> , M.O. Pattern, Mark II., as specified above, graduated in millibars.. .. .	<b>£5 10 0</b>
<b>M 2064</b>	Ditto, 26" to 31" .. .. .	<b>£5 10 0</b>
<b>M 2065</b>	Ditto, 600 to 800 mm. .. .. .	<b>£5 10 0</b>
	With National Physical Laboratory Certificate .. extra	<b>£1 0 0</b>





### BAROMETERS

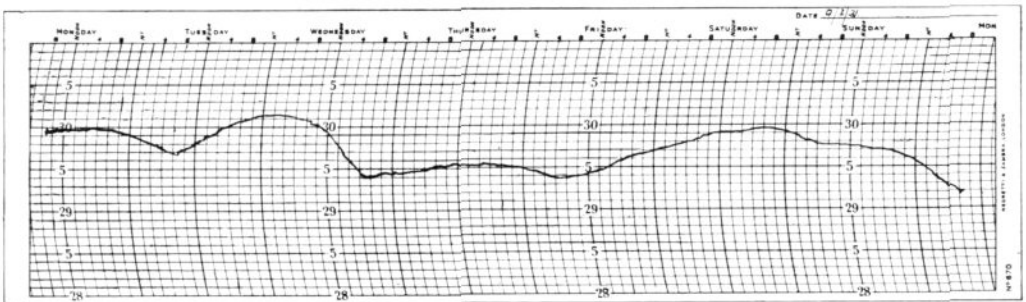


M 2066

**Recording Barometer** (Barograph). Movement consisting of a set of 8 boxes with spun diaphragms mounted on a cast aluminium base with hinged, polished copper cover, glass panelled. The Range is from 28/31" or 720/800 mm. Weekly or Daily (8-day clock) Drum.

Clock Drum .. .. .	3.6" high x 3.6" dia.
Pen Travel .. .. .	3"
Chart .. .. .	3.6" x 11.8"
Time Scale (daily) .. .. .	0.45" per hour.
" " (weekly) .. .. .	1.54" per day.
Pressure Scale .. .. .	1" per 1" barometric pressure.

M 2066 **Recording Barometer**, English or Metric scale, with pen, ink, and 100 charts .. .. . **£10 10 0**  
 Charts .. .. . extra per 100 **£0 12 0**

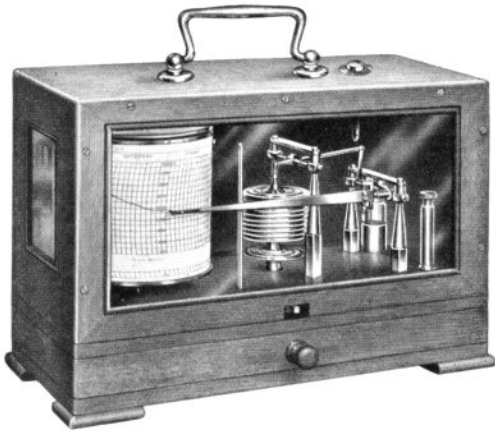


Barograph Trace. (Reduced Scale).





### BAROMETERS



M 2067

**Barograph (Recording Barometer), British Meteorological Office Specification.** Movement 7 to 8 chambers of spun diaphragms with inside springs.

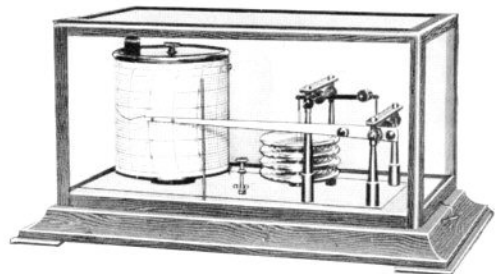
Case of mahogany, french polished dovetailed corners, front and left-hand side of case glazed; a stout handle is secured to lid. A spring push is fitted into the cover for depressing the recorder arm at the right-hand end, the push-knob being flush with the mahogany.

A drawer is fitted to the bottom of the case to hold a spare pen arm. A stoppered bottle for ink is sunk into a socket in the baseplate, with a brass dipper. The Range is from 970/1050 mb. Weekly Drum.

Clock Drum . . . . .	93 mm. high.
Time Scale (12 hours) . . . . .	2.0 cm.
Pressure Scale (10 centibars) . . . . .	7.5 cm.

M 2067 <b>Barograph</b> , M.O. Pattern, with pen, ink, and 100 charts . .	£10 10 0
Charts . . . . . extra per 100	£0 12 0

**Recording Barometer**, of the simplest type. Movement consisting of four sets of spun diaphragms mounted on brass baseplate, and fitted in plain oak case with removable cover, glass all sides and top. Scale, English or Metric as previous page; Clocks, Daily or Weekly as M 2066.



M 2068

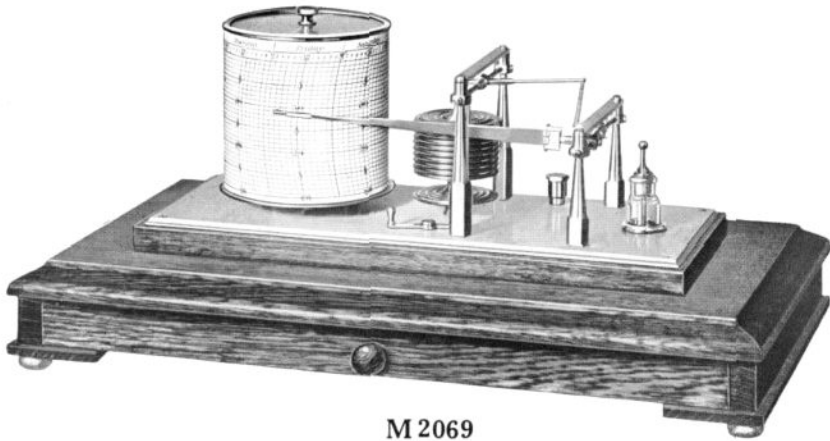
M 2068 <b>Recording Barometer</b> , English or Metric scale, with pen, ink, and 100 charts . . . . .	£7 10 0
Charts . . . . . extra per 100	£0 12 0







**BAROMETERS**



**M 2069**

With Bevelled Glass Cover Removed.

**Recording Barometer** of the highest quality workmanship and finish. Movement consisting of a specially-formed set of diaphragms (see page 31), fully compensated, operating lever mechanism to the pen-arm spindle. Jewelled pivots are provided to reduce friction to a minimum. A special form of zero adjustment is fitted, by which the diaphragms are raised or lowered in a truly vertical plane. The pen arm is hinged in order to ensure an even pressure of the pen on the chart. The whole movement is mounted on a polished brass plate, and all brass parts are highly polished and stove-lacquered with the best possible finish. The instrument is mounted in an oak or polished mahogany case, with bevelled glass panels and drawer for charts.

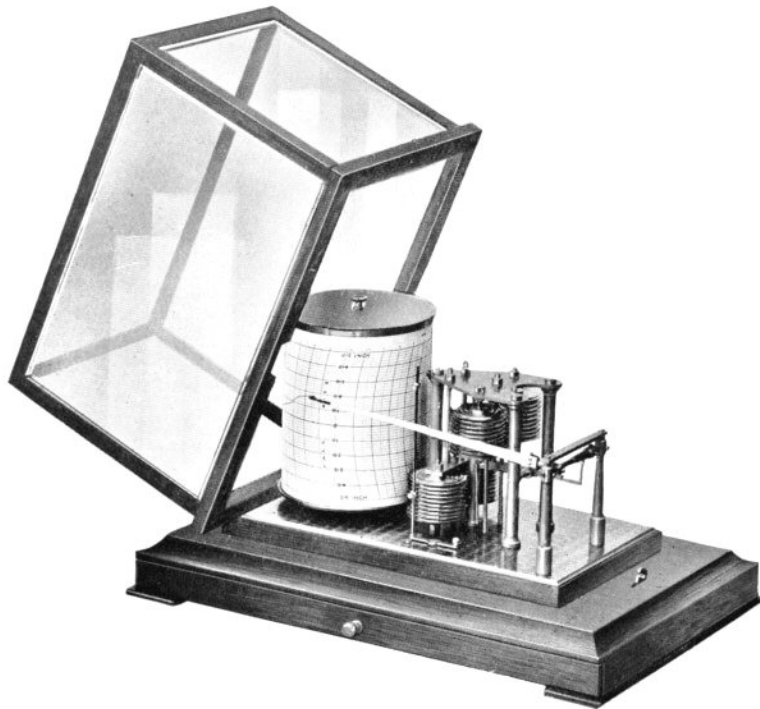
Daily (8-day Clock) or Weekly Drum . . . . .	3.6" high × 3.6" dia.
Pen Travel . . . . .	3"
Chart . . . . .	3.6" × 11.8"
Time Scale (daily) . . . . .	0.45" per hour.
"    " (weekly) . . . . .	1.54" per day.
Pressure Scale . . . . .	1" per 1" barometric pressure.

<b>M 2069</b>	<b>Recording Barometer</b> , with pen, ink, and 100 charts . . . . .	<b>£12 10 0</b>
<b>M 2070</b>	Ditto, with sector dial, graduated 28/31" in 1/10ths of an inch, with pen, ink, and 100 charts . . . . .	<b>£15 0 0</b>
	Charts . . . . . extra per 100	<b>£0 12 0</b>





## BAROMETERS



M 2071

**Precision Recording Barometer**, or Micro-Barograph. A Recording Barometer with a greatly amplified scale, showing that fluctuations of pressure of the order of 0.02" may be faithfully recorded, is required in the investigations of various meteorological phenomena, and in the Tropics where the movements of the barometer are practically only those of diurnal variation of the order of a few tenths of an inch. Further, such an instrument is indispensable in air surveys for recording the barometric changes at the base.

An amplification of five times normal scale cannot be effected by the ordinary type of barograph, for the reason that there is not sufficient control to overcome the friction of the moving parts of the pen on the chart, etc., nor can temperature corrections be arranged to the necessary fine degree. Therefore, in the Precision Barometer, four sets of the special diaphragms described on page 31 are used in two pairs, which achieves the desired end in giving adequate control on the pen arm. Their movement is transmitted to the main lever through flexing strips, thus avoiding the use of pivots, then by a crank slotted link to the pen arm.





## BAROMETERS

### Micro-Barograph (continued)

The pen arm is adjustable to the middle position of the chart by a spring-controlled thumbscrew on the main lever; when the pen reaches the top of the chart, further movement of the diaphragm and main lever is unrestrained, but the pen movement is restricted by stops on the pen lift rod.

A spring lever device in the mechanism prevents any strain on the mechanism.

The charts may be overprinted for actual Barometric Pressures, such as 25/26", 30/31", 700/725 mm., or  $\pm 0.5$ ,  $\pm 12.5$  mm.

Daily (8-day Clock) or Weekly Drum	..	5" dia. $\times$ 6" high.
Pen Travel	.. .. .	5"
Chart	.. .. .	5.8" $\times$ 16.2"
Time Scale (daily)	.. .. .	0.6" per hour.
" " (weekly)	.. .. .	2.06" per day.
Scale	.. .. .	1" per 0.2" pressure.

Case polished oak or mahogany, with drawer for charts, hinged cover, glass top and four sides.

<b>M 2071 Precision Recording Barometer</b> , with pen, ink, and		
100 charts	.. .. .	£40 0 0
Charts	.. .. . extra per 100	£0 15 0

**Recording Barometer, Large Size.** This instrument is designed to give a more open scale than that described on page 40. The scale value is nearly twice that of the usual pattern, and to obtain this open scale the instrument is provided with a fully balanced movement described in the foregoing, where the movement of the four sets of diaphragms is transmitted through link and flexing strips.

Daily (8-day Clock) or Weekly Drum	..	5" dia. $\times$ 6" high.
Pen Travel	.. .. .	5"
Chart	.. .. .	5.8" $\times$ 16.2"
Time Scale (daily)	.. .. .	0.6" per hour.
" " (weekly)	.. .. .	2.06" per day.
Scale	.. .. .	1" per 0.6" pressure.

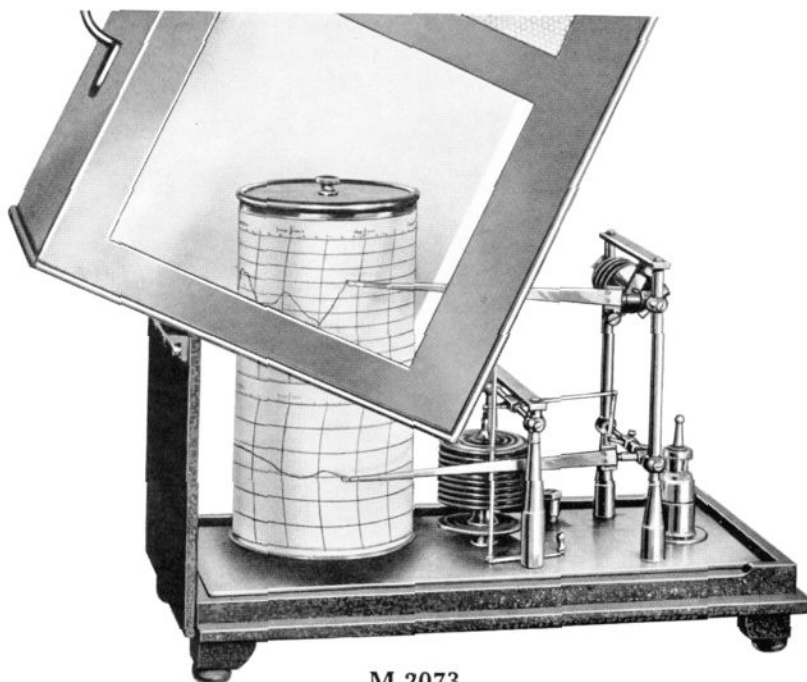
Case, polished oak or mahogany, with drawer for charts, hinged cover, glass top and four sides.

<b>M 2072 Recording Barometer</b> , with pen, ink, and 100 charts	..	£34 10 0
Charts	.. .. . extra per 100	£0 15 0





BAROMETERS



M 2073

**Baro-Thermograph.** An instrument for recording on one chart the traces of Barometric Pressure and Temperature.

The barometer mechanism consists of a set of aneroid diaphragms operating the pen arm on the usual link and lever principle.

The thermometer mechanism consists of a bimetallic spiral coil mounted on brackets in such a way that the centre is above that of the barometer. The two records are, therefore, one above the other, and the traces are synchronised on the chart. Ranges are as follows :—

Barometer Scale .. .. .	28/31"
Thermometer .. .. .	0/100° F., or 30/130° F.
Daily (8-day Clock) or Weekly Drum ..	3.6" dia.
Chart .. .. .	7" × 11.8"
Time Scale (daily) .. .. .	0.45" per hour.
" (weekly) .. .. .	1.54" per day.
Scales .. .. .	0.1" pressure per inch and 33.3° F. (18.3° C.) per inch.

The movements are mounted on a cast-iron base, with well-ventilated glass-pannelled metal cover.

M 2073 <b>Baro-Thermograph</b> , with 2 pens, 2 bottles of different coloured ink, and 100 charts .. .. .	£21 0 0
Charts .. .. . extra per 100	£0 15 0









## RAIN GAUGES

Rainfall is measured in terms of the depth of water which would be collected upon a level area of any size, supposing the rain to fall uniformly over the area at the rate at which it falls into the gauge.

The Rain Gauge is used to measure the precipitation of rain, snow, hail and sleet, and in its simplest form consists of a funnel to collect the rain, and a glass or metal receiver to collect the rain which falls into the funnel. The important considerations of a satisfactory gauge are the proportion of the funnel to prevent splashing out of heavy rain ; the collection of snow, etc., the height of the rim of the funnel above the ground level ; the minimising of evaporation errors, and the prevention of damage by frost or corrosion.

It has been proved that the amount of rain measured in a gauge with a rim of 5" diameter is practically identical with that of a gauge with an 8" rim. Rain Gauges are almost invariably of 5" or 8" diameter (metric equivalent 12.5 mm. and 20 mm.).

The measurement of rain may be in terms of decimals of an inch, usually .01" (with an exceptional .005") or decimals of a millimetre usually .1 mm., the former being employed by the average observer in the British Isles—the latter by the British Meteorological Office and countries using the metric system.

The Recording Rain Gauge is not a labour-saving device but is an adjunct to an eye-read instrument, and provides information which is not apparent in a 12 or 24 hours' reading, viz., INTENSITY, RATE and DURATION.





RAIN GAUGES



M 2080

**Rain Gauge, British Meteorological Office Specification.** Constructed of stout copper, funnel surmounted with turned brass rim 8" diameter ; outer case fitted with splayed base ; inner can with wire rim and lip and brass drop handle. Taper Measure as shown under Fig. M 2094, page 49.

- |        |   |       |    |    |   |
|--------|---|-------|----|----|---|
| M 2080 | Rain Gauge, 8" size, with measure graduated in inches | ..    | £3 | 12 | 6 |
| M 2081 | Ditto, with measure graduated in millimetres          | .. .. | £3 | 12 | 6 |

**Rain Gauge, 8" "Snowdon" Pattern.** Specification as above but the outer case is parallel without a splayed base.

- |        |  |    |    |   |   |
|--------|--|----|----|---|---|
| M 2082 | Rain Gauge, with measure as Fig. M 2102 on page 49 | .. | £3 | 5 | 0 |
|--------|--|----|----|---|---|

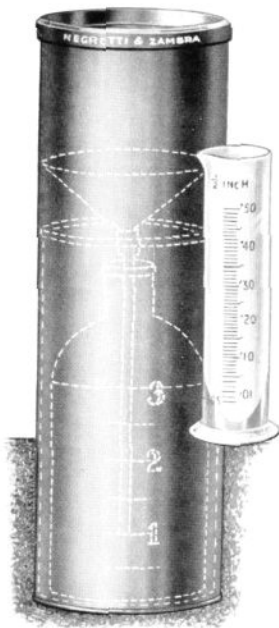
**Rain Gauge, British Meteorological Office Specification.** Constructed of stout copper, funnel surmounted with a turned brass rim 5" diameter. Outer case with splayed base ; inner can with wire rim, lip, and brass drop handle. Graduated measure, taper form, as shown on page 49.

- |        |   |       |    |   |   |
|--------|---|-------|----|---|---|
| M 2083 | Rain Gauge, 5" size, with measure graduated in inches | ..    | £2 | 2 | 0 |
| M 2084 | Ditto, with measure graduated in millimetres          | .. .. | £2 | 2 | 0 |
|        | Certificate of Test of the Meteorological Office      | .. .. | £0 | 3 | 0 |





### RAIN GAUGES



M 2085

**Rain Gauge, 5" "Snowdon" Pattern.**  
The specification of the "Snowdon" Rain Gauge is similar to the foregoing, except that the outer case is parallel without a splayed base. There is provided a glass bottle graduated in  $\frac{1}{2}$ " of rainfall. The graduated measure is of the "Camden" type shown under Fig. M 2097 on page 49, with lip and foot.

M 2085 Rain Gauge, 5"  
"Snowdon" Pattern,  
in copper, with measure, £1 17 6

M 2086 Ditto, in galvanized  
iron, with measure .. £1 7 6

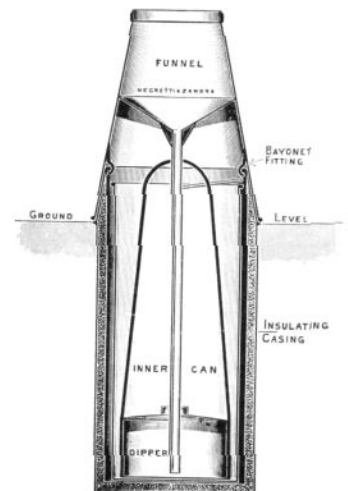
Certificate of the  
Meteorological Office, £0 3 0

**Rain Gauge, "Seathwaite" Pattern.**  
A Gauge of large capacity for outlying districts. The funnel is of the "Snowdon" type made of galvanized iron, brass rim 5" diameter; outer case of galvanized iron with secret catch for securing the funnel; annular space filled with pitch to guard against frost. Inner can of galvanized iron with wire rim, dished cover, and brass drop handle. Dipper of copper to hold exactly 5" of rainfall with brass wire handle.

Dip rod of cedar, graduated 30" in subdivisions of .1". A stout wooden case, with hinged lid and strap handle, carries the dip rod, dipper and graduated measure.

M 2087 Rain Gauge "Seathwaite"  
Pattern, with accessories  
as above .. .. . £6 13 6

Certificate of the  
Meteorological Office, £0 9 0

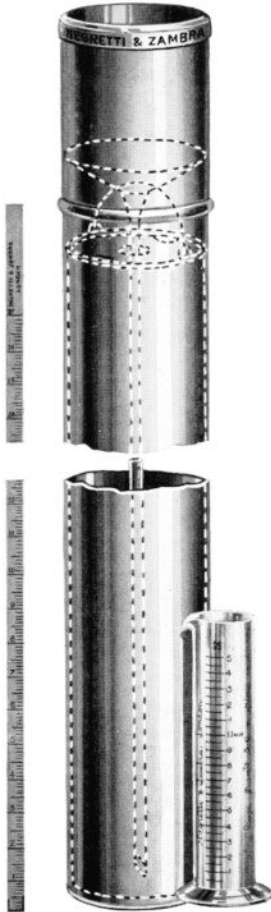


M 2087





**RAIN GAUGES**



**M 2088**

**Rain Gauge, "Bradford" Pattern.**  
Capacity 18"; funnel of the "Snowdon" type, made of galvanized iron with turned brass rim 5" diameter; outer case of galvanized iron, inner can of zinc with wire rim, dished cover and brass drop handle. Dip rod of cedar, graduated 18" in .1".

Measure graduated 1" in sub-divisions of .01".

- M 2088 Bradford Gauge . . . . £2 15 0
- M 2089 Ditto, in stout copper . . . . £3 12 6

**Rain Gauge, "Mountain" Pattern.**  
Capacity 27". Specification as above. Graduated measure to 1½" in sub-divisions of .05".

- M 2090 Mountain Rain Gauge as above . . . . £3 12 6
- M 2091 Ditto, in copper . . . . . £4 10 0

Certificate of the Meteorological Office . . . . . £0 9 0

**Rain Gauge, Dial Pattern.** This Gauge indicates on the dial the number of hundredths of an inch of rainfall passing the gauge since the last observation.

The funnel is of copper with brass rim 8"

square; the outer case is of copper with glass front and setting hand; the mechanism is a bucket with open ends divided into two parts and pivoted about its central point—this bucket tilts when .01" of rain has been collected; an escapement advances a toothed wheel, and the index hand moves over the dial at each step. The dial is graduated in divisions of .01" up to 1", with a smaller dial to 12".



**M 2092**

- M 2092 Dial Rain Gauge . . . . £6 6 0

**Note.**—As the funnel is not of the "Snowdon" type, and as mechanically-operated gauges may cause an interruption in the record, readings from the Dial Gauge are not accepted by the Rainfall Authorities in Great Britain.





### RAIN GAUGE MEASURES



M 2097

M 2098

M 2094

M 2102

M 2095

Made of good, stout flint glass thoroughly annealed, conforming to the specification of the Meteorological Office. Accuracy as follows:—

<b>Millimetre Measures.</b>	Maximum error below 1 mm.	±0.01 mm. of rainfall.
	“ “ above 1 mm.	±0.05 mm. “
<b>Inch Measures.</b>	Maximum error below 0.05"	±0.001" of rainfall.
	“ “ above 0.05"	±0.005" “

The “Taper” and “Camden” patterns show the sub-division .005" or .05 mm.

**Rain Gauge Measure**, Meteorological Office pattern, with long taper at the lower end and stout rim for pouring and holding.

M 2093	For 5" Gauge, graduated in millimetres..	£0 8 6
M 2094	For 5" " " " inches ..	£0 8 0
M 2095	For 8" " " " millimetres ..	£0 11 6
M 2096	For 8" " " " inches ..	£0 10 0

**Rain Gauge Measures, with foot and lip.**

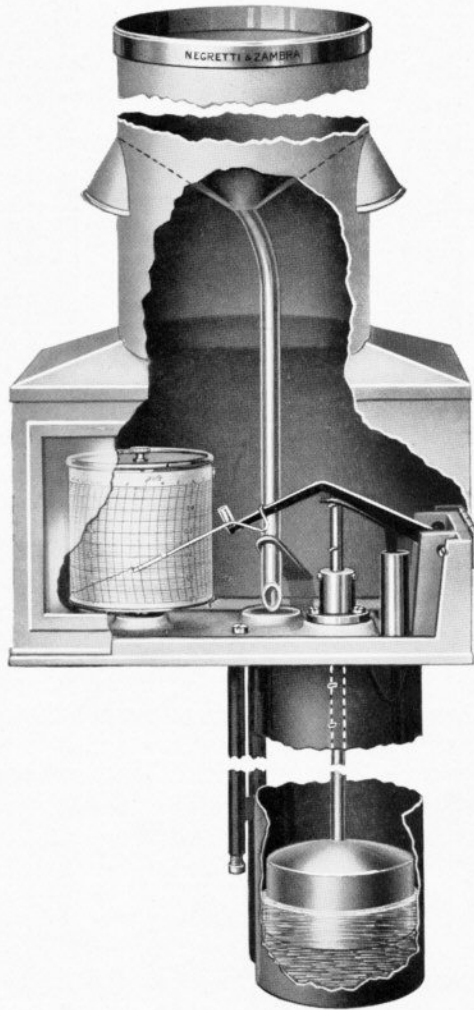
M 2097	For 5" Gauge, graduated in inches, “Camden” pattern, taper showing the first .005"	£0 7 0
M 2098	For 5" Gauge, graduated in millimetres ..	£0 7 0
M 2099	For 5" " to hold 1" ..	£0 8 0
M 2100	For 5" " " 1½" ..	£0 9 0
M 2101	For 12.5 cm. Gauge, graduated in millimetres ..	£0 8 0
M 2102	For 8" " " inches ..	£0 8 0
M 2103	For 8" " " millimetres ..	£0 8 0
M 2104	For 20 cm. " " " " ..	£0 8 6

Certificate of the Meteorological Office, ..	£0 1 3
excepting Nos. 2099, 2100 ..	£0 1 9





RAIN GAUGES



M 2105

The "Hyetograph" is a Rain Gauge for giving a record of duration and intensity of rainfall.

The rain is collected in a 6" diameter funnel and is led through a pipe to a float chamber where it is recorded by a float mechanism.







## RAIN GAUGES

As the float rises, the rod attached to the float lifts the pen arm through a stud and pallet device. At the moment when the pen arm reaches the top of the chart, viz., 0.5" rainfall, the pallet disengages with the stud and the pen arm falls to the bottom of the chart ; an oil-filled dashpot damps the fall. The pallet then engages with the next stud, and this operation is continuous until the container is full, viz., 4" of rainfall. To empty the float chamber, the float rod is depressed by hand ; this primes a syphon tube which rapidly empties the gauge.

The Gauge is constructed with a cast-iron baseplate aluminium painted to prevent corrosion ; cover of galvanized iron with glass-panelled front surmounted by a funnel of the " Snowdon " type with 6" diameter turned brass ring ; the float chamber and float are of copper.

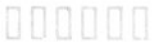
The " Hyetograph " is an accurate and reliable form of Rain Gauge as it has few moving parts, and will give good service without attention beyond the usual changing of charts and occasional syphoning.

The charts are printed on waterproof paper to avoid buckling and stretching.

<b>M 2105</b>	<b>" Hyetograph,"</b> English scale, with pen, ink, and 100 special charts .. .. .	<b>£17 10 0</b>
<b>M 2106</b>	Ditto, metric scale, with pen, ink and 100 charts .. .. .	<b>£17 10 0</b>
	Charts, on waterproof paper .. .. . extra per 100	<b>£0 11 0</b>

Maximum Capacity .. .. .	4" of rainfall.
Funnel .. .. .	6" in diameter.
Float .. .. .	4" ..
Pen Travel .. .. .	3" = $\frac{1}{2}$ " of rainfall.
Daily Drum (8-day Clock) : Time Scale ..	0.45" per hour.
Depth in the ground .. .. .	12"
Height above ground .. .. .	18"



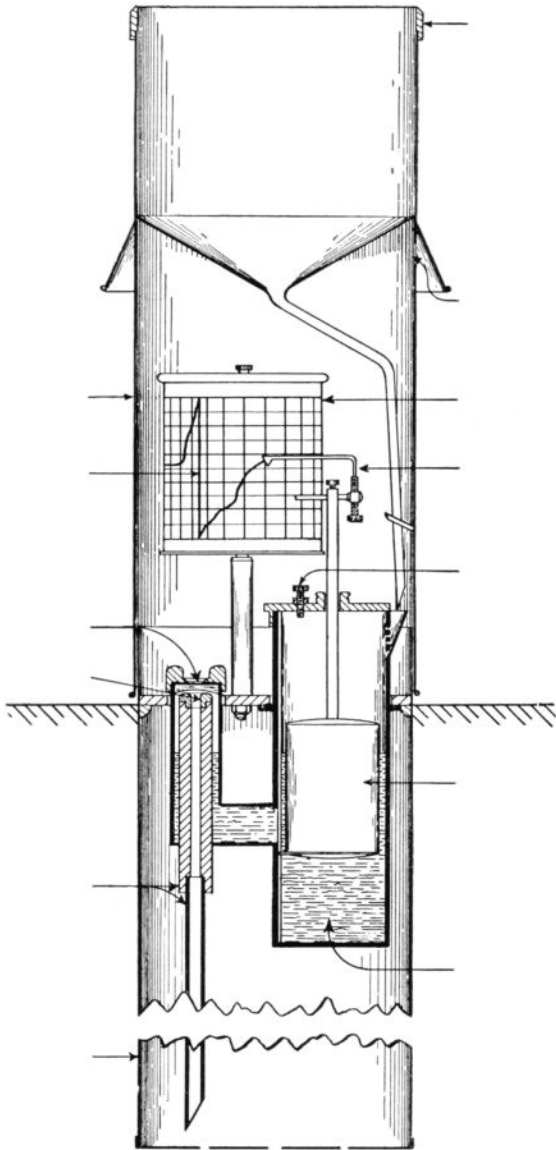


## RAIN GAUGES

**“ Natural Syphon ” Gauge.** This is a type of gauge which automatically syphons after each 0.5” of rainfall, and does not require hand operation of the syphon. The rain is collected in a 6” diameter funnel and is led through a pipe to a float chamber, where it is recorded by a float mechanism. As the float rises, the pen attached to the float rod traces the record on a clock-driven chart. When the pen reaches the top of the chart for 0.5” of rainfall, the syphon automatically comes into action and discharges the gauge rapidly. The pen falls to the bottom of the chart and the cycle is repeated.

The Gauge is constructed of galvanized metal, aluminium painted to prevent corrosion. The cover is surmounted by a funnel of the “ Snowdon ” type, with 6” diameter turned brass ring.

The charts are printed on waterproof paper to prevent buckling and stretching.



M 2107

**M 2107 “ Natural Syphon ” Rain Gauge,**  
with pen, ink, and 100 charts on  
special waterproof paper, £17 10 0

**M 2108** Ditto, metric scale . . . £17 10 0  
Charts, waterproof, per 100,  
£0 11 0

Capacity . . . . . Unlimited.  
Funnel . . . . . 6” diameter.  
Float . . . . . 2” diameter.  
Pen Travel . . . . . 3” = ½” of rainfall.  
Daily Drum (8 - day  
Clock) : Time Scale 0.45” per hour.  
Depth in the ground . . 15”  
Height above ground . . 15”





## RAIN GAUGES

- M 2109** “**Natural Syphon**” **Rain Gauge** to British Meteorological Office Specification, with pen, ink, and 100 charts on special waterproof paper . . . . . **£20 0 0**
- Cover and cylinder of sheet copper. Syphon discharges at 10 mm. rainfall. Time of discharge not more than 10 seconds.
- Pen Trace . . . . . 6 mm. = 1 mm. rainfall.
- Daily Drum (8-day Clock) : Time Scale . . . . . 11.4 mm. per hour.
- Overall Height . . . . . 30"
- With Certificate of Test of the Meteorological Office . . . . . **£0 12 6**

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### THE “TILTING BUCKET” RAIN GAUGE.

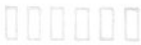
This gauge records on the chart the amount of rainfall in increments of 1/100".

The rain is collected in an 8" diameter funnel and is led through a pipe to a bucket with open ends divided into two compartments and pivoted about its central point ; it tilts over when .01" of rainfall has been collected.

An escapement advances a toothed wheel, to which is attached a profile cam ; resting on this cam is a brass roller attached to the pen arm, which is thus raised step by step for each .01" of rainfall up to 1" ; the roller then trips off the cam and the pen returns to zero of the chart ; an oil-filled dashpot damps the fall. Attached to the escapement wheel is a dial graduated to 1" in subdivisions of .01".

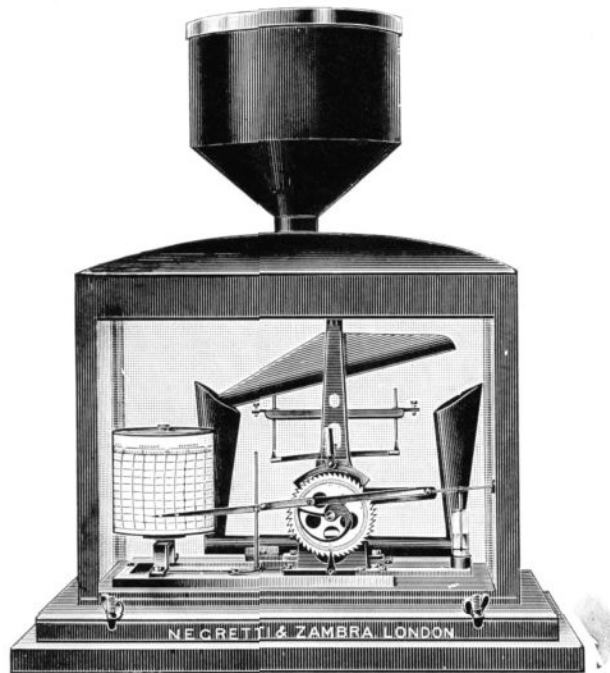
The Gauge is constructed with a metal base and a sheet-metal cover with glass-panelled front clamped to the baseplate by four wing nuts. The cover is surmounted by a funnel of the “Snowdon” type, with 8" diameter brass ring detachable for convenience in packing.

Base, cover and funnel stoved and enamelled green or white.





RAIN GAUGES



M 2110

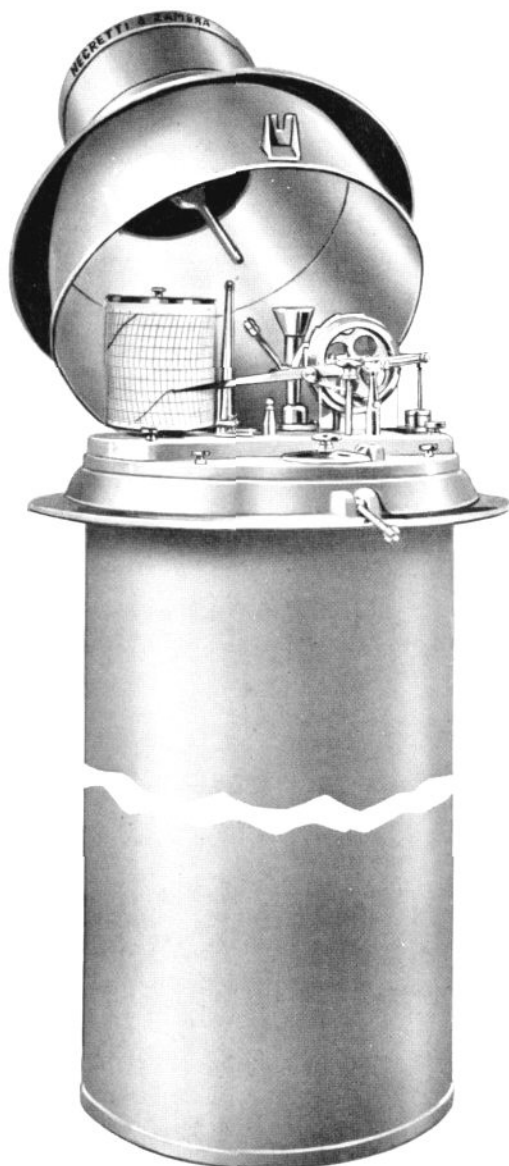
M 2110	Recording Rain Gauge as above, with pen, ink, and 100 charts .. .. .	£20 0 0
M 2111	Ditto, metric scale to 25 mm. .. .. .	£20 0 0
	Charts .. .. . extra per 100	£0 12 0
	Capacity .. .. .	Unlimited.
	Funnel .. .. .	8" diameter.
	Pen Travel .. .. .	3" = 1" of rainfall.
	Daily Drum (8-day Clock) : Time Scale	0.45" per hour.
	Weekly Drum : .. .. . " "	1.54" per day.
	Overall Height .. .. .	28"

**Note.**—As the record from this instrument is "step by step," it is not suitable for measuring the duration of gentle rain, and the records are, therefore, not accepted by the British Rainfall Authorities. However, on account of the capacity being unlimited and no syphon—automatic or otherwise—being necessary, it is suitable for tropical countries, and where the gauge has to be left for some considerable time unattended.





## RAIN GAUGES



M 2112

**Recording Rain Gauge, "Float" Pattern.** This instrument is designed to give a record of rainfall of great accuracy over an open reading chart (0.5" of rainfall = 5" pen travel), and to contain a large volume of rain before any hand syphoning is necessary.





## RAIN GAUGES

The rain is collected in a 10" diameter funnel and is led through a pipe to the float chamber. The float operates the pen arm through a chain and pulley mechanism. As the float rises, the pulley rotates and lifts the pen arm through a ratchet device ; immediately the pen reaches the top of the chart, a pawl, operating on a ratchet, is tripped and the pen falls to the bottom of the chart. An oil-filled dashpot damps the fall. This cycle is repeated until the float chamber is partially or entirely full, when a knob is pressed by hand, and all accumulated water in the gauge is rapidly syphoned out.

The cover is surmounted by a funnel of the "Snowdon" type, with 10" diameter turned brass ring.

Stainless steel, gun metal, phosphor bronze and copper are largely used in the construction of this Gauge to avoid any possibility of corrosion or deterioration after years of exposure to adverse conditions.

Charts printed on waterproof paper to avoid buckling and stretching.

**M 2112 Recording Rain Gauge**, with pen, ink, and 100 charts. . . £87 0 0

Charts on waterproof paper . . . . . extra per 100 0 15 0

Maximum Capacity . . . . .	12" of rainfall.
Funnel Diameter . . . . .	10"
Float Diameter . . . . .	5½"
Pen Travel . . . . .	5" = 0.5" of rainfall.
Daily Drum (8-day Clock) : Time Scale . . . . .	0.6" per hour
	or
6-Hour Drum (2-day Clock) : Time Scale . . . . .	2.55
Height above ground . . . . .	1' 8"
Depth below ground . . . . .	3' 4"







## EVAPORATION GAUGES



**Piche's Evaporimeter.** A glass tube about 9" long  $\times$  0.6" diameter is graduated in ccm. A metal clip holds a disc of porous paper, from which the water in the tube evaporates, and the alteration of level indicates the degree of evaporation.

M 2113	Piche Evaporimeter . . . . .	£0 12 6
M 2114	Box of 150 Discs . . . . .	£0 1 6

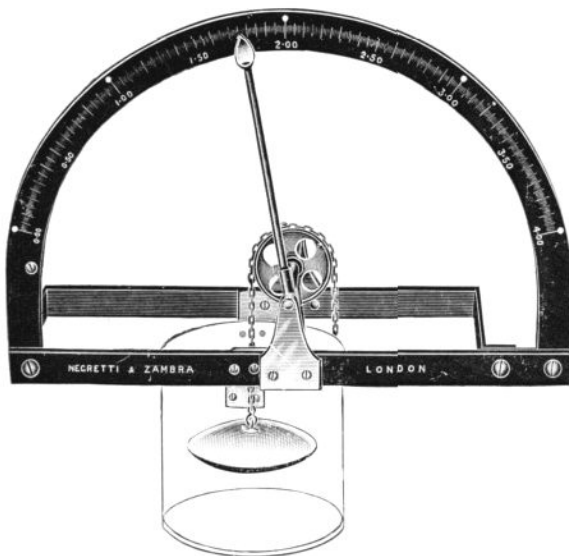
**Evaporimeter.** A copper vessel with 8" or 20 cm. diameter turned brass rim is fitted with a wire guard to prevent animals from interfering with the water.

A glass measure is graduated in .01" or .1 mm. in relation to the brass rim, and is used for measuring the water in the gauge.

M 2115	Evaporation Gauge . . . . .	£2 5 0
--------	-----------------------------	--------

M 2113

**Index Type.** A copper float rises and falls in a copper cylinder, which acts as a still water chamber. A brass chain attached to the float operates a brass wheel and turns an index hand attached to the axis; the float is correctly counterpoised. The index hand moves over an arc  $9\frac{1}{2}$ " radius; the scale of 0 to 4.00" subdivided to .01" engraved on a brass strip attached to the iron frame. The wrought-iron frame is designed to fit on the corner of the recognised tank.



M 2116

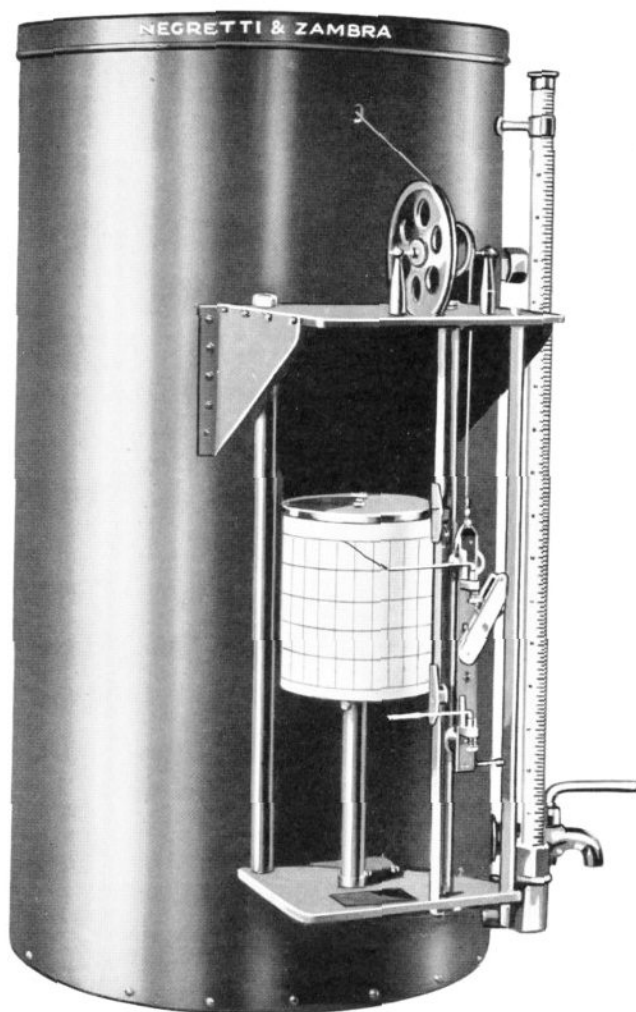
M 2116	Index Evaporation Gauge . . . . .	£12 0 0
M 2117	Tank, of galvanized iron, $\frac{1}{8}$ " thick, measuring 6-ft. $\times$ 6-ft. $\times$ 2-ft., with braced ends and still water chamber . . . . .	£13 10 0

(Price dependent upon market price of material).





## PERCOLATION GAUGE



M 2118

The travel of the float is approximately 24" for 1" of percolation : the first pen travels on the chart 5" for 0.5" of percolation, and the second pen comes into operation at 0.5" to 1". A cock is provided for emptying the tank.

The clock makes one revolution in 24 hours. Time scale, 0.6" per hour.

**M 2118 Percolation Gauge, with pens, ink, 100 Charts.**

**Price on Application.**

This Gauge is used in conjunction with the investigation of percolation of rainfall through the earth.

A specimen piece of ground of known area is selected, under which is installed a large trough. The Gauge is installed in a tunnel and the trough collects the water and records on the clock-driven chart the amount of percolation.

The Gauge consists of a copper tank 18" in diameter  $\times$  3 feet high ; a gauge glass is provided for measuring accurately the volume of water in the tank.

A copper float, 8" diameter, moving in the tank, operates one or more pen arms by means of a cable and pulley device. Friction or corrosion in the mechanism is avoided by the careful design and selection of materials. The



### SUNSHINE RECORDERS

The instruments for recording bright Sunshine are :—

- “ Campbell-Stokes ” pattern, where the sun’s rays are focussed by means of a glass sphere upon specially-prepared and printed cardboard strips.
- “ Jordan ” pattern, where the sunlight enters a hole in a light-tight circular box, and leaves a trace on a specially-prepared sensitised chart.
- Electrical pattern, where the intensity of the sun’s rays is measured by a thermopile and a millivoltmeter.

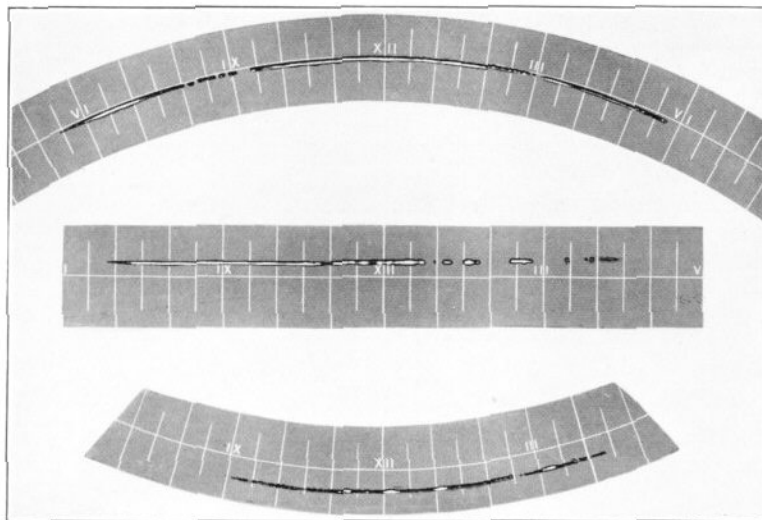
In order that all returns of sunshine should be absolutely comparable, the Campbell-Stokes pattern has been adopted as Standard by such authorities as the British Meteorological Office, the Canadian Meteorological Service, the Union of South Africa, and most of the British Colonies.

The Jordan pattern is Standard for some other parts of the world.

The setting up of a Sunshine Recorder is all-important for accurate records :—

- (a) The base must be perfectly level.
- (b) The frame carrying the charts must be tilted and clamped to the correct latitude of the place of observation.
- (c) The instrument must be correctly in the meridian of the station.

Instructions for setting either by compass (making due allowance for magnetic deviation) or by the clock (allowing for the equation of time) are published in most text-books.



Specimen traces of Cards of Campbell-Stokes Recorder.

SUNSHINE RECORDERS



M 2119

**Campbell-Stokes Pattern, "Universal" Type.** The instrument consists of baseplate, standard, semi-circular arc, brass casting for holding the recording cards generally known as the bowl, and a glass sphere.

The base is a heavy polished slate slab.

The standard is a brass upright, with plate and clamp for fixing the arc at the correct latitude.

The semi-circular arc, which carries a graduated scale of latitudes, has bosses at each end accurately drilled and tapped to take the securing bolts and locking nuts for the sphere.

The bowl is machined with three concentric grooves to take the three patterns of cards as follows:—

Equinoctial (Straight)	.. ..	width 1.56"
Summer (Long Curve)	.. ..	,, 1.26"
Winter (Short Curve)	.. ..	,, 1.26"

The edge of the bowl should be cut so that when it is adjusted for its mean latitude, the plane of the cut shall be approximately horizontal.

The sphere is of well-annealed glass, refractive index 1.512. Focal length 2.95". Diameter 4".

**M 2119 Campbell-Stokes Sunshine Recorder, "Universal" Type** .. .. . £15 15 0  
 (Supply of Cards for one year, see M 2122.)



### SUNSHINE RECORDERS

**Campbell-Stokes Pattern, British Meteorological Office Specification.** This instrument is designed for temperate latitudes, *i.e.*, 35°/65°, where the sphere is carried on a small pillar.

The standard carrying the arc is provided with a slot and clamp for adjustment of the bowl between these latitudes. The support of the pillar is provided with a screw and nut for adjustment of the height of the sphere.

In other respects the specification conforms with the foregoing.

**M 2120 Sunshine Recorder, M.O. Pattern,** for temperate latitudes . . . . . **£15 15 0**

**Tropical Pattern, British Meteorological Office Specification.** The Recorder corresponds generally to that described on page 60, with the following modifications.

The baseplate is of heavy iron casting, with sloping sides to permit the rain to run off.

The brass standard has the latitude scale engraved reading from 5° through 0° to 45°; the stud holes for securing the base of the casting allow for a slight adjustment of the upper portion of the recorder.

The sphere, of the same specification as the foregoing, is drilled with two holes; cemented on are two brass caps, accurately centred so that if the sphere be turned on its centres there shall be no visible eccentricity. These brass caps are fitted to pivots on the end of the semi-circular arc—the lower pivot is finished to the accurate length and screwed up tightly, the other pivot consists of a screw and locking nut.

**M 2121 Sunshine Recorder, M.O. Pattern,** for tropical latitudes **£18 10 0**

**M 2122** A supply of Cards lasting one year consists of 150 Long, 150 Short Curve, and 100 Straight . . . . . **£1 10 0**

**M 2123** A Template of celluloid for totalling the trace . . . . . **£0 2 0**

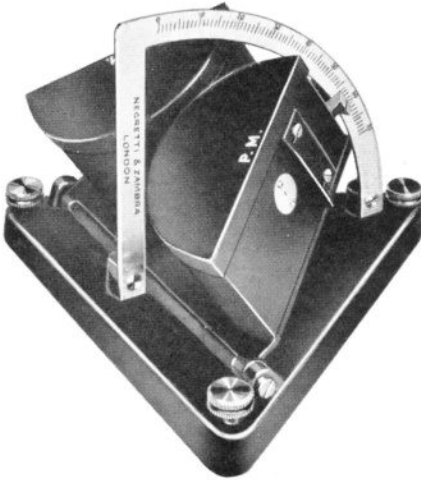
**M 2124** Glass Sphere to standard specification. . . . . **£5 5 0**

Test of the Meteorological Office . . . . . **£0 3 0**





SUNSHINE RECORDERS



M 2125



M 2127

**Jordan's Photographic Pattern.** This instrument consists of two brass hemispherical cylinders with detachable covers, with a pinhole on the east and on the west, the sunlight entering the holes and leaving the trace on the sensitised chart fitted in each cylinder.

The two cylinders are mounted upon a brass baseplate, which is adjustable for latitude and is clamped to a brass arc graduated 0° to 70°. The plate and arc are bolted on to a cast-iron baseplate provided with 3 levelling screws.

The charts are coated with a special solution of sensitivity sufficient to record the sun's rays but not so as to fog the rest of the chart. The record is a narrow band of dark blue, and is fixed by rinsing the chart in water; the trace is tabulated after the chart is rinsed.

M 2125	Sunshine Recorder, Twin-cylinder Pattern	.. .. .	£7 10 0
M 2126	Charts, per packet of 100 each A.M. and P.M.	.. .. .	£0 12 6

**Jordan Sunshine Recorder.** This is a simple model with single cylinder, having two pinholes and detachable cover.

Mounted on a cast-iron base, with pivot and clamp for latitude. Brass scale plate and index from 20/70°, and spanner for clamping.

The single sensitised chart is printed for A.M. and P.M. records.

M 2127	Jordan Recorder, Single-cylinder Type	.. .. .	£2 5 0
M 2128	Charts, sensitised	.. .. . per 100	£0 7 6







## SOLARIMETER

Instruments for measuring Solar Radiation, comprising the Solarimeter and Pyrheliometer, consist of a sensitive thermopile connected with a millivoltmeter of either the indicating or the recording type.

**The Solarimeter** uses a thermopile of the Moll pattern modified by Gorczynski, with its sensitive surface located horizontally and hermetically enclosed in a heavy brass cylinder with hemispherical cover of special flint glass. The millivoltmeter has a scale of 100 divisions, and a statement of the value of one division, in calories per  $\text{cm}^2$  per minute, is issued with each instrument. These two parts are fitted into a stout box, and the apparatus is kept indoors, being taken out-of-doors only when a reading is to be taken.

**I 2129 Solarimeter**, for Direct Reading . . . . . **£12 10 0**

**Recording Solarimeter** consists of that same thermopile as that described above, used with a recording millivoltmeter.

The thermopile, under hemispherical glass cover of 30 mm. or 50 mm. diameter, is mounted on a small holder which is fixed out-of-doors at the most convenient place ; it is connected by electric cable with the Recorder.

The recording apparatus is a millivoltmeter having a drum making one revolution in 13 or 26 hours ; the chart measures  $10 \times 40$  cm., and the pen arm leaves a dotted trace. A statement of the value of one division, in calories per  $\text{cm}^2$  per minute, is issued with the Recorder.

**M 2130 Recording Solarimeter**, with small (30 mm.) thermopile holder, 100 charts, pen, ink, etc. . . . . **£23 7 6**

**M 2131** Ditto, ditto, with large (50 mm.) thermopile holder . . . . **£26 10 0**

**Pyrheliometer** consists of a Moll thermopile in a brass tube, with a series of three Langley diaphragms. The tube has a sighting device and provision for vertical adjustment. It is connected by electric cable to a millivoltmeter having 100 divisions—a statement of the value of one division in calories per  $\text{cm}^2$  per minute is furnished.

**M 2132 Pyrheliometer** . . . . . **£19 10 0**





**NEPHOSCOPES  
FOR CLOUD OBSERVATION**



**M 2133**

**The Finemann Pattern.** This consists of a disc of black glass mounted on a tripod stand fitted with three levelling screws. A vertical pointer, which can be raised or lowered by rack and pinion, is attached to a collar which can be rotated independently of the mirror. A scale of millimetres engraved on the edge of the pointer gives the height of the tip above the glass surface. The black glass disc is engraved with concentric circle and radii 25 mm. apart.

The case is of stout wood with hinged cover, in which are fixed three brass plates on which the instrument can be used.

**M 2133 Finemann Nephoscope** . . . . . **£10 10 0**

**The Besson Pattern** is for direct vision, and has a brass "comb" mounted on a tall rotatable upright.

The upright is of brass rod about 9-ft. long, mounted by means of rings and clamps to a post in such a way that it may rotate freely.

The cross-piece is about 3½-ft. long, furnished with 6 equidistant vertical spikes.

**M 2134 Besson Nephoscope** . . . . . **£8 5 0**





## THERMOMETERS

The equipment of a normal station consists of the following thermometers :—

Dry Bulb Thermometer.  
 Wet Bulb            ,,  
 Maximum            ,,  
 Minimum            ,,

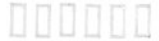
And at some stations :—

Solar Maximum Thermometer.  
 Grass Minimum        ,,  
 Earth Thermometer.

“ The accurate measurement of the temperature of the air in the open is one of the most difficult of all meteorological measurements, for it is so readily affected by effects of radiation. Radiation from the sun, the clouds, the sky, the ground and surrounding objects passes in straight lines through the air without appreciably affecting its temperature, for air is very transparent to radiant heat, especially if it is dry. But the instrument that is used to measure the temperature of the air is some kind of thermometer, and is made of material which intercepts radiant heat to an appreciable extent. In consequence, the reading of the instrument may differ from that corresponding with true air temperature by any amount up to 50° F., or even more. Such differences depend partly upon the nature of the thermometer, partly upon the amounts of the different kinds of radiation experienced, and partly upon the wind velocity and other extraneous factors. The reading of a thermometer freely exposed in the open may thus bear no determinable relation to the temperature of the particles of air in which it is placed. It is usual, therefore, to provide some form of thermometer shelter or “ screen,” which will serve to support the thermometers and to protect them from the weather and accidental damage, and at the same time shield them from radiation without impairing the free passage of air over the bulbs of the thermometers.” <sup>(1)</sup>

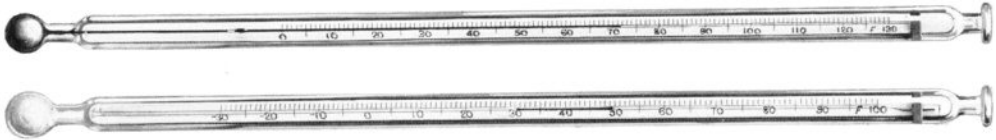
The Stevenson Screen should be erected 4-ft. above the ground, preferably over a grass plot and with the door facing due north (south in Southern Hemisphere), or preferably somewhat east of north, so that the sun may not shine on the instruments.

<sup>(1)</sup> “ The Dictionary of Applied Physics ”  
 —Meteorological Instruments—by R. Corless, O.B.E., M.A.





THERMOMETERS

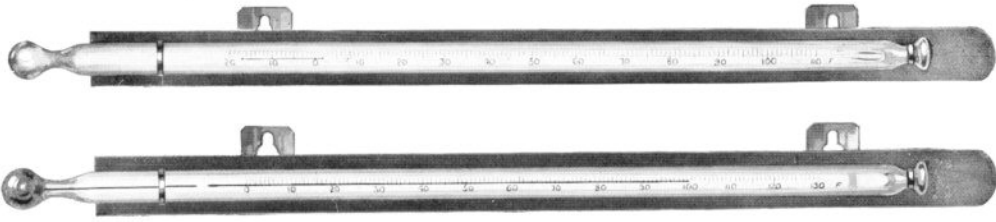


M 2135,6

**M 2135 Standard Maximum Thermometer**, British Meteorological Office pattern. Tube protected by an outer glass sheath, and overall length of 13½". Bulb of normal glass, stem of British lead glass supported inside the sheath by a ring of rubber, fitted with maximum constriction. Sheath permanently fused on to the thermometer at a point between the bulb and lowest graduation, and having a button-shaped top. Range 0/130° F., divided on the stem in single degrees, figured every 10° . . . . . **£1 2 6**

**M 2136 Standard Minimum Thermometer**, British Meteorological Office Specification as above, tube filled with rectified spirits of wine, and fitted with a floating index. Range -30/+100° F. . . . . **£1 2 6**

The construction of this type of thermometer with an outer, hermetically sealed, glass sheath renders the divisions and figures indelible under all conditions. Further, the temperatures in the Screen are not vitiated by the presence of any superfluous wood or metal mounts.



M 2137,8

**M 2137 Standard Maximum Thermometer**, specification as above, mounted on mahogany stock with two brass hanging plates, centres 9½" apart . . . . . **£1 7 6**

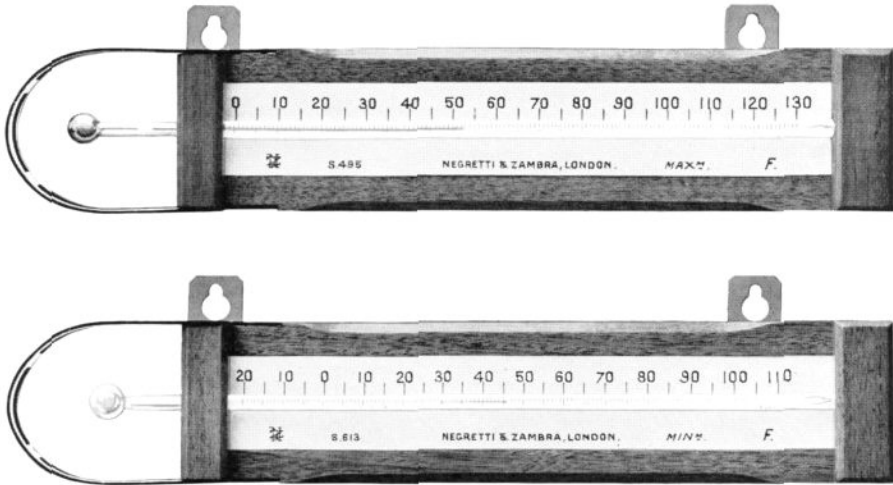
**M 2138 Standard Minimum Thermometer**, specification as above, mounted on mahogany stock, with two brass hanging plates, centres 9½" apart . . . . . **£1 7 6**

(Note.—The range of the Maximum and of the Minimum Thermometers M 2137,8 used by the Australian Meteorological Service is 0/140° F.)





THERMOMETERS



M 2139,43

- M 2139 Standard Maximum Registering Thermometer.** Tube 12" long, fitted with opal glass scale in mahogany mount ; bulb protected by brass guard, overall length 13½" ; bulb of normal glass, stem of British lead glass fitted with maximum constriction. Range, 0/130° F., divided on stem in single degrees, figured every 10° on scale. Mount fitted with two brass hanging plates 8½" apart . . . . . £1 7 6
- M 2140** Ditto -15/+55° Cent. . . . . £1 7 6
- M 2141** Ditto, Canadian pattern -40/+120° Fahr. . . . . £1 10 0
- M 2142** Ditto, Tropical. Range 25/150° F. or -5/+65° C. . . . . £1 7 6
- M 2143 Standard Minimum Registering Thermometer.** Specification as above. Stem filled with rectified spirits of wine, and fitted with floating index. Range -20/+110° F. . . . . £1 7 6
- M 2144** Ditto -30/+45° Cent. . . . . £1 7 6
- M 2145** Ditto, Canadian pattern -70/+110° Fahr. . . . . £1 10 0
- M 2146** Ditto, Tropical. Range -5/+130° F. or -20/+55° C. . . . . £1 7 6

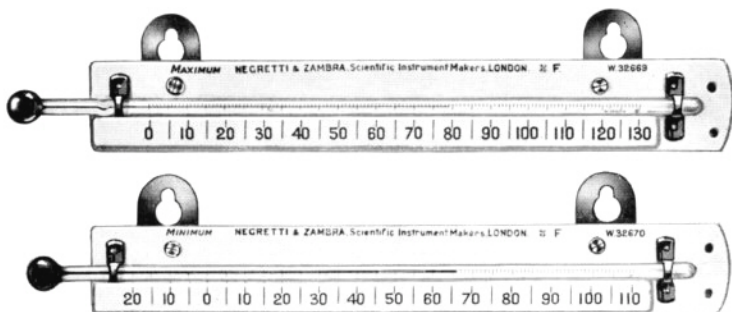
Certificates of the National Physical Laboratory for any of the above (excepting Nos. 2141, 2145) . . . extra £0 3 0

Ditto for Nos. 2141, 2145, where the test includes one at the freezing point of mercury . . . . . extra £0 7 6

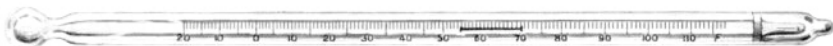




### THERMOMETERS



- M 2147 **Standard Maximum Thermometer**, Secondary or "Public School" Pattern. Tube  $10\frac{1}{4}$ " long, with porcelain scale and brass mount for suspension. Range 0/130° F. . . . . £0 17 6
- M 2148 Ditto, -15/+55° Centigrade . . . . . £0 17 6
- M 2149 **Standard Minimum Thermometer** as above. Range -20/+110° F. . . . . £0 17 6
- M 2150 Ditto, -30/+45° Centigrade . . . . . £0 17 6



**Minimum Thermometer**, Terrestrial Radiation (or Grass Minimum), British Meteorological pattern. Tube protected by outer glass sheath; overall length  $12\frac{1}{2}$ ". Bulb of normal glass with stem and sheath of British lead glass; tube filled with rectified spirits of wine, and fitted with glass index; sheath permanently fused to the thermometer at a point between the bulb and the lowest graduation.

Range -30/+100° F., divided on the stem in single degrees, and figured every 10°, safety cavity to 150° F.

- M 2151 **Terrestrial Radiation Thermometer** . . . . . £1 1 0
- M 2152 Ditto, -35/+40° Centigrade . . . . . £1 1 0



**Minimum Thermometer**, as above, with bulb blown in the shape of a link to give a larger surface of exposure.

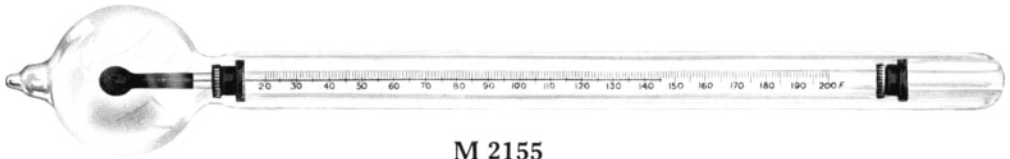
- M 2153 **Terrestrial Radiation Thermometer** . . . . . £1 7 6
- M 2154 Ditto, Centigrade . . . . . £1 7 6

Certificates of the National Physical Laboratory for any thermometer on this page . . . . . extra £0 3 0





THERMOMETERS



M 2155

- M 2155 Solar Radiation Thermometer.** Maximum Registering Thermometer, with bulb and 1" of stem coated with dull lamp black enclosed in a glass sheath completely exhausted of air. Tube, length 12", bulb of normal glass, stem of lead glass fitted with a maximum constriction and sheath of the same material. Tube supported in the sheath by two gland fittings of vulcanite. Range 20/200° F., divided on the stem and figured every 10° . . . . . £1 15 0
- M 2156** Ditto, -5/+95° Centigrade . . . . . £1 15 0
- M 2157** Ditto, fitted with small U-tube gauge to show that the vacuum in the sheath is maintained . . . . . £2 2 0
- (For Certificates of the National Physical Laboratory, see below.)*

**M 2158 Actinometer (Marie Davy).** An Actinometer is used for ascertaining approximately the quantity of heat which the earth receives from the sun, and consists of a pair of thermometers mounted in a hermetically sealed sheath, one bulb being left bright and the other coated with lamp-black. Range 20/200° F., mounted on a base of polished hard wood, with holes for the thermometers, £3 17 6

**M 2159** Ditto, -5/+95° C., £3 17 6

**M 2160 Actinometer Thermometer,** bright or black bulb as above, £1 12 6

Certificate of the National Physical Laboratory for the above thermometers:—

- (a) For corrections to the thermometer before being sheathed, extra £0 5 6
- (b) Ditto, for test in sheath against their standard instrument, extra £0 8 6



M 2158

**THERMOMETERS**



**M 2161**

**Earth Thermometer**, British Meteorological Office Pattern. Tube fused into outer glass protecting sheath. Overall length 12" x 0.9" diameter. Range 20/100° F., divided on the stem in single degrees and figured every 10°; the lower end is embedded in paraffin wax of melting point 120° F. A stout piece of rubber tubing, with boxwood plug and brass screw-eye, is securely bound round the upper end of the sheath; two rubber rings are provided.

- M 2161 Earth Thermometer**, M.O. Pattern as above £1 10 0
- M 2162 Ditto**, -5/+40° Centigrade . . . . . £1 10 0

Certificate of the National Physical Laboratory,  
extra £0 3 0

**Tube for Earth Thermometer**, Ordinary Type. Wrought-iron tubing 1½" bore, with wooden plug at lower end. Painted one coat of black enamel. Japanned copper cover; the necessary length of brass chain is provided.

- |                  |         |        |        |         |         |
|------------------|---------|--------|--------|---------|---------|
|                  | 1-ft.   | 2-ft.  | 4-ft.  | 6-ft.   | 12-ft.  |
| <b>M 2163</b> .. | £0 17 6 | £1 1 0 | £1 8 6 | £1 16 0 | £2 18 6 |

**Tube for Earth Thermometer**, British Meteorological Office Pattern. Mild steel tubing 1¼" bore, with solid steel cone at lower end; rubber disc 1" diameter cemented in the steel casting. A mild steel flange 3" in diameter x ⅛" thick is brazed on the tube 12½" and 48½" respectively above the rubber disc; brass chain attached to cap of copper 3" long, provided with a brass handle and brass eye. The tube is painted two coats red lead paint and one coat of black enamel.

- |                            |         |        |
|----------------------------|---------|--------|
|                            | 1-ft.   | 4-ft.  |
| <b>M 2164</b> .. . . . . . | £1 15 0 | £2 2 0 |

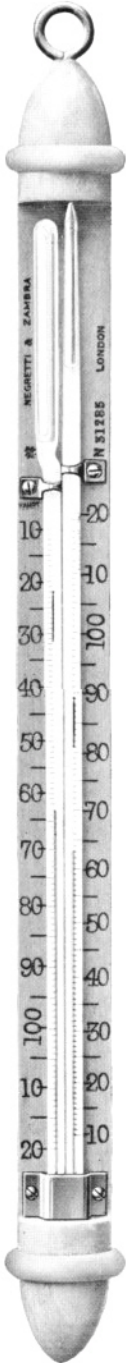
**Earth Thermometer, Right-angle Form**, British Meteorological Office Specification. Tube of British lead glass, with 8" scale and 4" or 8" stem at right angles. Bulb of normal glass, diameter 0.5", length between 0.45" and 0.55". Range 20/100° F., divided on the stem in single degrees and figured every 10°.

- M 2165 Right-angle Thermometer** . . . . . £0 12 6

Certificate of the National Physical Laboratory,  
extra £0 3 6



THERMOMETERS



M 2166

**M 2166 Maximum and Minimum Thermometer,** Six's Pattern, for letting down a tube and registering earth temperatures. The tube is divided on the stem and mounted on a turned boxwood stick with brass rings top and bottom, and rubber protecting rings. The length overall is 11½", diameter 1¼". Range +10/+120° F. . . . . **£1 2 6**

**M 2167** Ditto. Range -10/+50° C... . . . . **£1 2 6**  
 Certificate of the National Physical Laboratory . . . . . extra **£0 4 6**

**M 2168 Pocket Maximum and Minimum Thermometers,** in polished, velvet-lined mahogany case. Tubes divided on the stems ; divisions and figures on nickel-silver scales mounted on boxwood.  
 Maximum 30/130° F., and 0, 55° C.  
 Minimum -20/+110° F., and -30/+45° C.  
 Small Size 7½" × 2¾" × 1" . . . . . **£3 10 0**

**M 2169** Ditto, Large Size 10½" × 3¼" × 1" . . . . **£4 15 0**  
 Certificate of the National Physical Laboratory . . . . . extra **£0 6 0**



**THERMOMETERS**

**Standard Thermometer, 21" long, with finest quality tube mounted on opal glass, on which are permanently fired the divisions and figures, the tube being also divided on the stem. Fitted on polished mahogany frame, with the highest quality finish.**



**M 2171**

**RANGES**

Type.	° Fahrenheit.	Sub-divided to	Each.	With N.P.L. Cert. Extra.
<b>M 2170</b>	-30° to 120° F.	0.2°	<b>£3 15 0</b>	<b>£0 14 0</b>
<b>M 2171</b>	+10° ,, 160° F.	0.2°	<b>£3 12 6</b>	<b>£0 15 6</b>
<b>M 2172</b>	+30° ,, 250° F.	0.5°	<b>£3 17 6</b>	<b>£0 11 6</b>

Type.	° Fahrenheit.	Sub-divided to	Each.	With N.P.L. Cert. Extra.
<b>M 2173</b>	-30° to 50° C.	0.1°	<b>£3 15 0</b>	<b>£0 15 6</b>
<b>M 2174</b>	-10° ,, 70° C.	0.1°	<b>£3 12 6</b>	<b>£0 11 0</b>
<b>M 2175</b>	0° ,, 120° C.	0.2°	<b>£3 17 6</b>	<b>£0 11 0</b>

**Standard Thermometer, British Meteorological Office Pattern. Tube protected by an outer glass sheath, and overall length 12½". Bulb of normal glass, stem of British lead glass supported inside the sheath by a ring of rubber ; sheath permanently fused on to the thermometer at a point between the bulb and the lowest graduation. Range -15, +115° F., divided on the stem in single degrees and figured every 10°.**

**M 2176 Standard Thermometer, Mark I. £1 0 0**

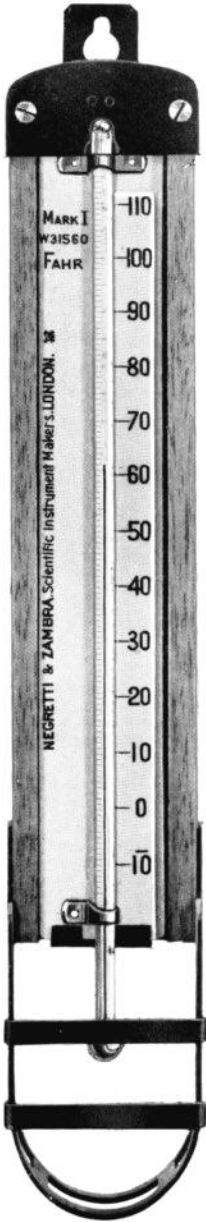
Certificate of the National Physical Laboratory . . . . . extra **£0 2 6**



**M 2176**

**THERMOMETERS**

**Ordinary Thermometer**, British Meteorological Office Pattern, Marks I., II., and III. Tube 10<sup>3</sup>/<sub>4</sub>" long, filled with mercury, fitted on porcelain scale plate with raised side ; bulb of normal glass, stem of English lead glass, divided on the stem in single degrees and marked every 5°, figured every 10° on the raised side of the porcelain scale plate.



M 2177 & 2180

- M 2177 **Thermometer**,  
Mark I. Range -15/+115° F. £0 13 6
- M 2178 Ditto, Mark II. Range -40/+85° F. £0 15 0
- M 2179 Ditto, Mark III. Range 0/130° F. . . £0 13 6

Certificate of the National Physical Laboratory :

Mark I.	Mark II.	Mark III.
£0 2 6	£0 10 6	£0 2 6

**Note.**—A pair of these thermometers, one being fitted with wick and muslin, constitute the Wet and Dry Bulb Hygrometer used by the British Meteorological Office, the Australian Meteorological Service, the Canadian Meteorological Service, etc.

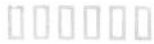
**Protector for Marine Screen Thermometer**, British Meteorological Office Specification. This frame provides a support for thermometers ordinary as above, and is a mahogany stock fitted with brass guard and turned-up brass fitting to support the base of the porcelain scale ; it has also a top fitting and a brass hanger.

- M 2180 . . . . . £0 17 6

**Protector for Sea-water Thermometer**, British Meteorological Office Specification. This frame provides a protecting support to the above thermometers when used for sea-water observations. It resembles the above in all respects, except that in place of the guard there is a brass reservoir into which the bulb of the thermometer will dip.

- M 2181 . . . . . £1 1 6





## THERMOMETERS

**Deep Sea Thermometer.** The Negretti & Zambra original patent "Reversing" or "Turnover" pattern indicates the temperature only at the spot where it is reversed.

The action is that when it descends into the sea it acts as an ordinary thermometer, the mercury rising and falling according to the temperature of the stratum through which it passes. When, however, the prearranged depth is reached, and a reverse motion given to the line so as to pull the apparatus to the surface, the column of mercury breaks automatically, and that which is cut off at the constriction or appendix remains to indicate the actual temperature at the moment of reversal and at the prearranged depth.

The thermometer consists of a tube and bulb made of glass of known constants, such as Borosilicate, of a length suited to the range of scale and graduations as described later, and with two cavities, of which the lower is to accommodate surplus mercury if the thermometer is heated above the scale value. The upper cavity takes the surplus mercury when the thermometer, after reversal, passes through layers of water at a temperature higher than that at the reversal. This surplus must not fall and join the main column or it would falsify the reading, and therefore the tube is made so that it will hold the maximum amount which may expand during any one sounding. The latest type of cavity takes the form of a loop, which adds great strength to the thermometer where it is most needed.

Various forms of constriction have been tried, but that which has, up to now, met with the greatest success, is in the form of an appendix which is visible upon all N. & Z. Deep Sea Thermometers. Upon reversal, the mercury starts to flow from the point of the appendix and then breaks at the point where this joins the main column. Experience shows that this form of "break" gives the most exact reproductions of readings, which is, of course, the vital point of a Reversing Thermometer.

The bulb and stem are protected against pressure effects up to at least 3 tons per square inch (470 kgms. per sq. cm.) by an outer glass sheath with mercury round the bulb to conduct changes of temperature rapidly to the thermometer.





## THERMOMETERS

### Auxiliary Thermometer.

The auxiliary or side thermometer is fitted to the latest pattern Deep sea Thermometers for the reason that a correct reading of the column of mercury trapped during reversal can only be obtained when read at the same emperature as when the thermometer was reversed.

The side thermometer shows the present temperature of the trapped mercury, and a correction must be applied which depends on :—

- (a) The difference in temperature " T " between the side thermometer and the temperature indicated by the trapped mercury.
- (b) The volume of the trapped mercury " V ."
- (c) The coefficient of apparent expansion of mercury in the glass, of which the thermometer is made " A."

With regard to (a), it is assumed that the temperature of the trapped mercury, when reversed, is as indicated by the column when read. This simplifies the calculation somewhat, and the error introduced is negligible.

(b) The volume of mercury is expressed in units of that volume which would occupy the space between two successive degree marks of the reversing thermometer. The volume which would give a reading on the reversing thermometer at 0° is stated on the thermometer, and the total volume for determining the correction is obtained by adding the reading in degrees if above zero, and subtracting it if below.

The thermometer is also marked with the coefficient of apparent cubical expansion of mercury in the glass of which it is made.

Taking the symbols given in (a), (b) and (c), the correction to be applied is :  $T \times V \times A$ .

EXAMPLE :—

The reversing thermometer reads 12° ;

the side thermometer reads 17° ;

the volume at 0° is 95 ;

the coefficient of expansion of mercury in the glass is 1,6100 ;

the correction is  $(17 - 12) \times (95 + 12) \times \frac{1}{6100}$

$$= \frac{5 \times 107}{6100} = 0.09 \text{ approx.}$$

As the reversing thermometer when read was at a higher temperature than when reversed, this correction is to be subtracted from 12°, and the temperature at reversing thus becomes 11.91°.



THERMOMETERS



M 2185



M 2182



M 2186



## THERMOMETERS

### SPECIFICATION OF THE N. & Z. DEEP SEA THERMOMETERS

	M 2182	M 2183	M 2184	M 2185
Overall Length . . . . .	25 cm.	32 cm.	32 cm.	32 cm.
Range of Scale . . . . .	-2/+25° C.	-2/+25° C.	-2/+12° C.	-2/+30° C.
Sub-divisions . . . . .	.5°	.2°	.1°	.2°
Approx. Scale Value of 1° C.	4 mm.	6 mm.	10 mm.	5 mm.
Correction given by N.P.L. to . . . . .	.1°	.05°	.02°	.05°
Price . . . . .	£2 10 0	£3 15 0	£4 0 0	£3 15 0
With Certificate of the National Physical Lab- oratory for Pressure and Temperature Tests . . . . .	£0 13 6	£0 16 6	£1 2 6	£0 16 6

## FRAMES

**Reversing Frame** constructed to take a pair of full-sized thermometers, consisting of two brass tubes attached by a chain to a spring release which is clamped on to the sounding line or wire. A heavy brass weight or messenger of stream-lined design runs down the line, impinges on a lever which, in turn, releases the clip holding the frame which causes the latter to turn completely over.

This is the simplest, most reliable, light and yet robust form of frame for the reversal of the N. & Z. Patent Deep Sea Thermometer.

- M 2186 Reversing Frame**, Marine Biological pattern, to take two thermometers in stout wooden case . . . . . **£4 10 0**
- M 2187** Ditto, with a single tube . . . . . **£3 10 0**

**Note.**—Particulars of other Reversing Frames, such as the “Magnaghi,” “Scottish” pattern, Wooden Float, etc., in separate pamphlet.

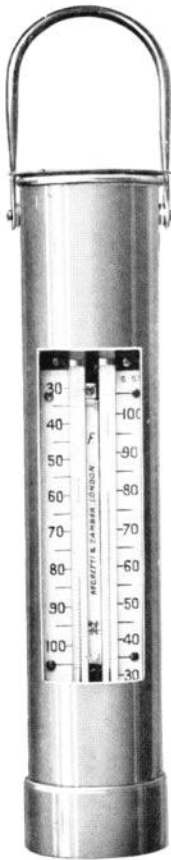




**THERMOMETERS**

**DEEP SEA THERMOMETER**

**Miller Pattern Deep Sea Thermometer**, registering the maximum and minimum temperatures, bulb protected against pressures up to 3 tons per square inch. Thermometer graduated on the stem as specified below ; opal glass scales on which the figures are permanently fired mounted on vulcanite back, in stout copper case. The instrument is supplied with a magnet for resetting the indices.



**M 2188 Miller Pattern Deep Sea Thermometer**, ranged +30/100° F. in 1° .. .. **£3 18 6**

**M 2189 Ditto**, -5/+40° C. in 0.5° divisions .. .. **£3 18 6**

With Certificate of the National Physical Laboratory for scale error and pressure test .. .. .. **£0 16 6**

**M 2188 SEA-WATER BOTTLE**

**Fishery Type Water Bottle**, constructed on the suggestions of Mr. D. J. Matthews, late of the Marine Biological Association.

It is made entirely of brass, and consists of a stout cylinder with two spring-controlled valves. These valves are set open before descent, and closed by a trip action operated by a sliding weight or messenger. The capacity is 20-ozs. = 483 c.c., and it is specially designed for the recovery of Plankton, the interior being coated to prevent any chemical action injuring the organisms.

In stout wooden case, with stream-lined shape messenger.

**M 2190 Fishery Water Bottle** .. .. .. **£13 10 0**



**M 2190**



THERMOMETERS



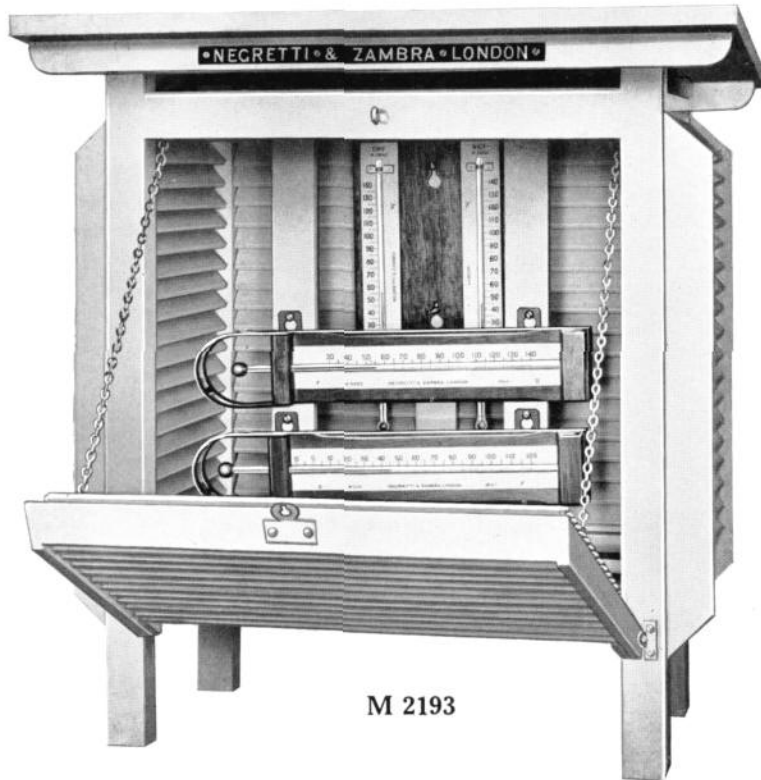
M 2191

**Surface Thermometer.** The bulb is reduced to the smallest dimension possible with a mercury-in-glass thermometer in order to reduce the thermal lag to a minimum. On to the glass bulb a copper foot is soldered with a special alloy ; this foot offers a comparatively large surface and forms a good conductor of heat to the bulb. Surrounding the bulb and copper foot is a reflector, polished inside and outside to prevent loss of heat by radiation or by air currents ; the reflector is sprung from the glass tube to ensure the copper foot being in good contact with the surface. This thermometer was designed and is used for taking the temperature of rocks, etc.

- M 2191 **Surface Thermometer**, mercury filled, lens tube, complete in wooden box. Range 0/100° Centigrade or equivalent Fahrenheit . . . . . £4 10 0
- M 2192 Ditto, in brass case with handle, complete in wooden box £6 15 0



SCREENS



M 2193

**M 2193 Standard Stevenson Screen.** Constructed throughout of best yellow pine with double louvres, 18 on each side ; inside dimensions 16" × 16" × 9" ; hinged door with 18 double louvres, brass hasp, staple and padlock. The bottom consists of three boards with ventilation spaces between them ; the roof is made in two parts, the inner of plain board drilled with ten holes ; the outer roof of selected timber, jointed and tenoned. Three uprights for the thermometers are fitted in the correct positions inside the screen. All parts are finished two coats of paint before assembly, and one coat of white enamel after completion . . . . . £5 10 0

**M 2194** Four Posts 5-ft. × 3" × 3", to serve as a stand . . . . . £2 0 0

**M 2193A Stevenson Screen,** British Meteorological Office Pattern £9 5 0

*Specification and Instructions for making this screen are in a pamphlet issued by H.M. Stationary Office. Price, 1/-.*





SCREENS

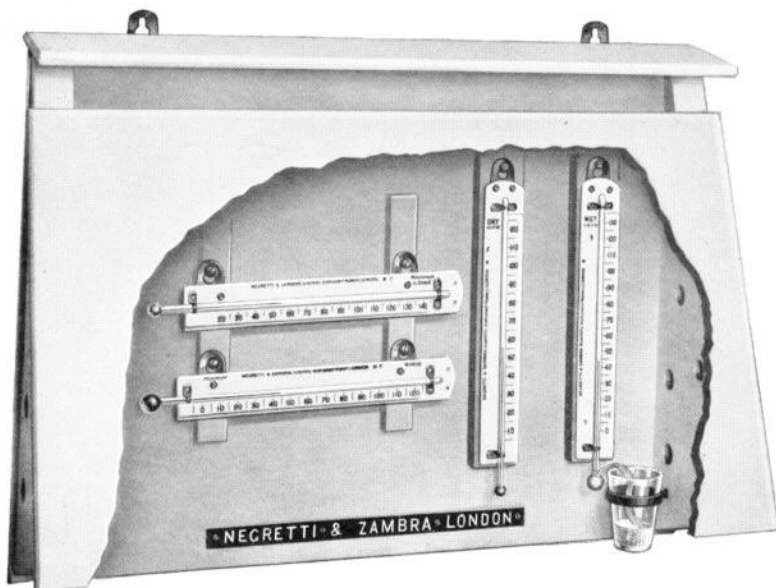
**M 2195 Large Stevenson Screen,** British Meteorological Office Specification. This Screen accommodates two recording instruments and the usual thermometers. The construction and dimensions are similar to those of the Standard Screen, except in regard to the length. The louvres of the back are made in two sections, and there are two doors to the front. . . **£18 0 0**

**M 2196 Shipboard Portable Screen.** Inside dimensions 13" × 11" × 15 $\frac{3}{4}$ ". Made of best yellow pine, sides and backs with ten single louvres, door with eight single louvres and with brass hinges and turn-button.  
 Bottom—three  $\frac{1}{2}$ " boards suitably arranged for ventilation, provided with fitting to take the water bottle receptacle. The roof of 1" material tapering to the ends, is fitted with a strong brass eye. An upright in the Screen carries the mount for the wet and dry bulb thermometers. Finished with two coats of paint before assembly and a coat of white enamel after completion. . . . . **£3 12 6**

**M 2197 Iron Stand for Stevenson Screen,** British Meteorological Office Specification. Consists of four uprights 4' 6 $\frac{1}{2}$ " high of angle iron 1 $\frac{1}{4}$ " ×  $\frac{3}{16}$ ", with angle iron cross pieces and diagonal ties of steel strip. A footplate 5" square at the base of each upright ; 18 bolts and nuts, with spanner for assembly. Finished by galvanizing the ends and side members after cutting and drilling. Packed in a wooden crate . . . . . **£2 10 0**



METEOROLOGICAL SETS



M 2198

**“ Public School ” Set.** This installation comprises a set of Secondary Standard Thermometers mounted on a screen of the Glaisher type.

The Maximum Thermometer is that described under M 2147.

The Minimum “ “ “ “ M 2149.

The Hygrometer “ “ “ “ M 2203.

The Screen is of hard wood, painted white and suitably battened to avoid warping, with hinged front, ledge for rain drainage, ventilated sides, and two stout brass back plates.

The complete set comprises the above, and  
 5” Snowdon Rain Gauge and Measure.  
 Meteorological Pocket Book.  
 Hints to Observers.

M 2198 “ Public School ” Set of Instruments . . . . . £7 7 0

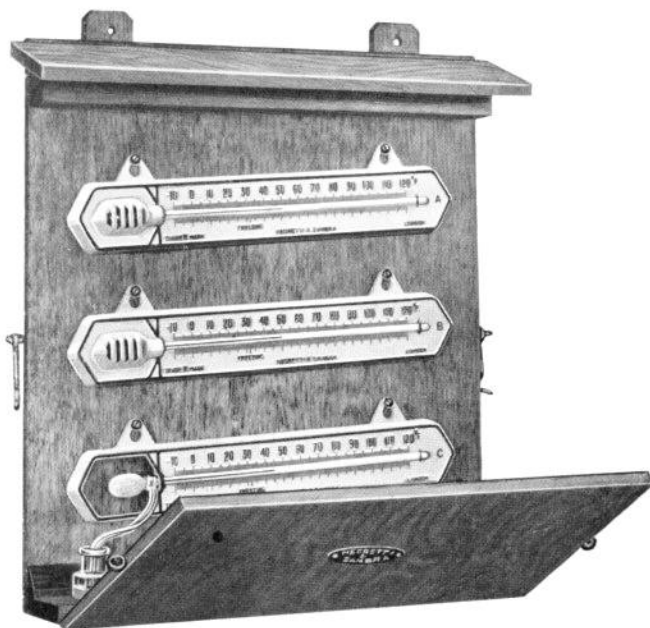
With National Physical Laboratory Certificates and  
 Meteorological Office Certificate for Rain Gauge. . . extra £0 15 0

**Note.**—As the readings of thermometers exposed in a Glaisher type differ from those in a Stevenson’s Screen, the British Meteorological Authorities do not accept readings from the above.





### METEOROLOGICAL SETS



M 2199

A simple outfit for educational purposes, consisting of three thermometers mounted on a screen of the Glaisher type.

The Maximum Thermometer is of the usual mercury-filled constricted type mounted on a die-cast metal frame, with figures and divisions in bold relief.

The Minimum Thermometer is of the usual red-coloured, spirit-filled type, with floating index. Mounted on a frame as above. The reading of this thermometer is also that of the dry bulb.

The Wet Bulb Thermometer is of the usual mercury-filled type mounted on frame as above.

The scales of all the thermometers are identical, avoiding confusion of differing scale values.

The Screen is of three-ply wood, well stained for protection against weather, provided with strong hinges and clips at side, and hinged cover. Printed instructions for manipulation, use, and relative humidities pasted inside the cover.

**M 2199 Complete Temperature Station** as above . . . . . **£2 2 0**



## HYGROMETERS

Hygrometers used for Meteorological Observations may be classified under the following main headings :—

- (a) Wet and Dry Bulb Hygrometers used in still or calm air.
- (b) Wet and Dry Bulb Hygrometers used where the air is in motion relative to the bulbs, such as the Whirling Hygrometer, Assmann Psychrometer, etc.
- (c) Dew Point Hygrometers, such as the Daniells', Régnaults', etc.
- (d) Hair Hygrometers used principally as recording instruments.

The tables commonly used with the Wet and Dry Bulb Hygrometer to obtain Relative Percentage Humidity, Vapour Pressures, Dew Point, etc., are as follows :—

**Wet and Dry Bulb Thermometer** exposed in a Stevenson Screen.

**Fahrenheit.** Hygrometric Tables, Meteorological Office Publication M.O.265.

Hygrometrical Tables—Glaisher.

**Centigrade.** Instructions Meteorologiques—Angot.

**Wet and Dry Bulb Thermometer** in moving air.

**Fahrenheit.** Psychrometric Tables, U.S. Department of Agriculture—W.B.235.

Ditto, abbreviated form, on celluloid plate—N. & Z.

**Centigrade.** Aspirations Psychrometer-Tafeln—Assmann.

Ditto, abbreviated form, on celluloid plate—N. & Z.

*(For Prices of above Tables, see page 137).*

A full discussion on Hygrometers will be found in :—

The Proceedings of the Physical Society of London, Vol. XXXIV., Part II.

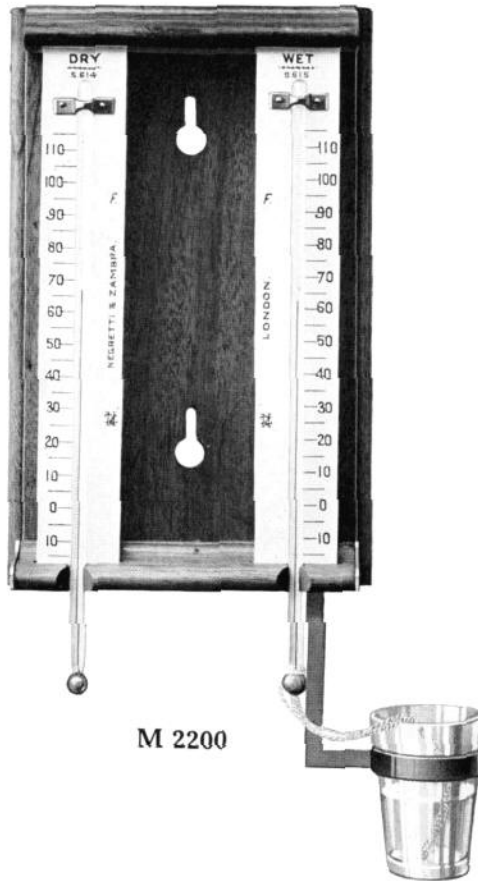
The Dictionary of Applied Physics, Vol. II.

Some Modified Forms of Hygrometers by Ezer Griffiths, F.R.S.

The Rationale of Glaisher's System of Hygrometry

by F. J. W. Whipple, M.A., F.Inst.P.

HYGROMETERS



M 2200

**Precision Hygrometer, Wet and Dry Bulb Type.** This instrument consists of a pair of thermometers mounted on a board, the bulb of one thermometer being covered with muslin kept moist by means of a wick dipping into a water reservoir.

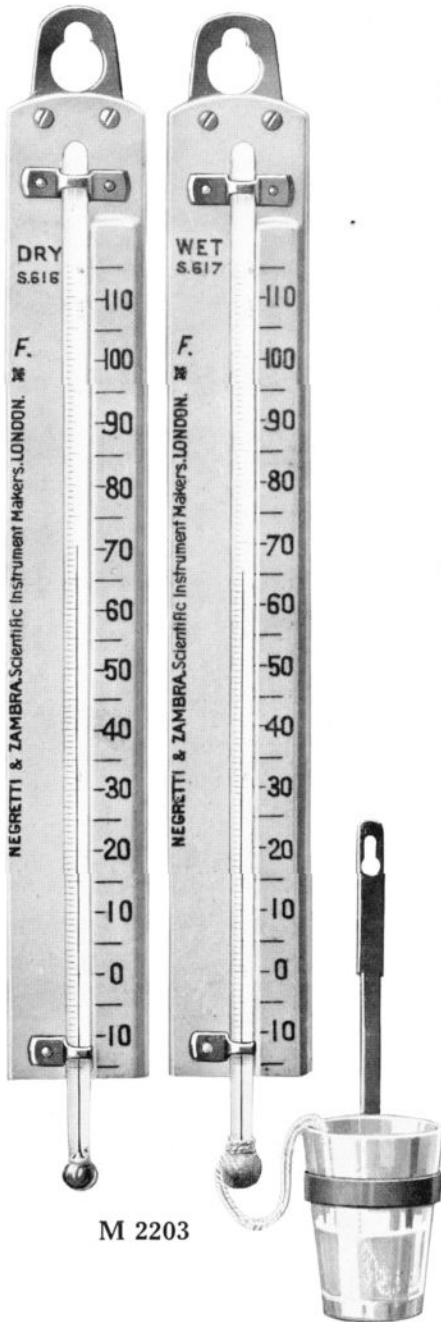
Tubes 10¼" long, with bulbs of normal glass and English lead capillary, fitted on opal glass scale plates on a mahogany mount with two holes for suspension.

Range -15/+115° F., divided on the stem in single degrees and figured on the scale every 10°. Glass water cup carried on bronzed brass bracket.

<b>M 2200</b>	<b>Standard Precision Hygrometer</b>	.. .. .	£2 10 0
<b>M 2201</b>	Ditto, -25/+45° Centigrade	.. .. .	£2 10 0
<b>M 2202</b>	Ditto, Tropical Ranges 10/140° F. or -10/+60° C.	.. .. .	£2 10 0

With Certificate of the National Physical Laboratory .. £0 6 0

**HYGROMETERS**



M 2203

**M 2203 Standard Hygrometer**, Secondary or "Public School" Pattern. Tubes 10¼" long, bulbs of normal glass and English lead capillary, each fitted on a porcelain scale plate with brass hanging back-plate. Range 20/130° F., divided on the stem in single degrees and figured every 10° on raised edge of scale plate. Glass water reservoir with bronzed brass bracket,

£1 11 6

**M 2204 Ditto**, -5/+55° Centigrade,

£1 11 6

The above with Tropical Ranges.

10 140° F.

-10/+60° C.

without extra charge

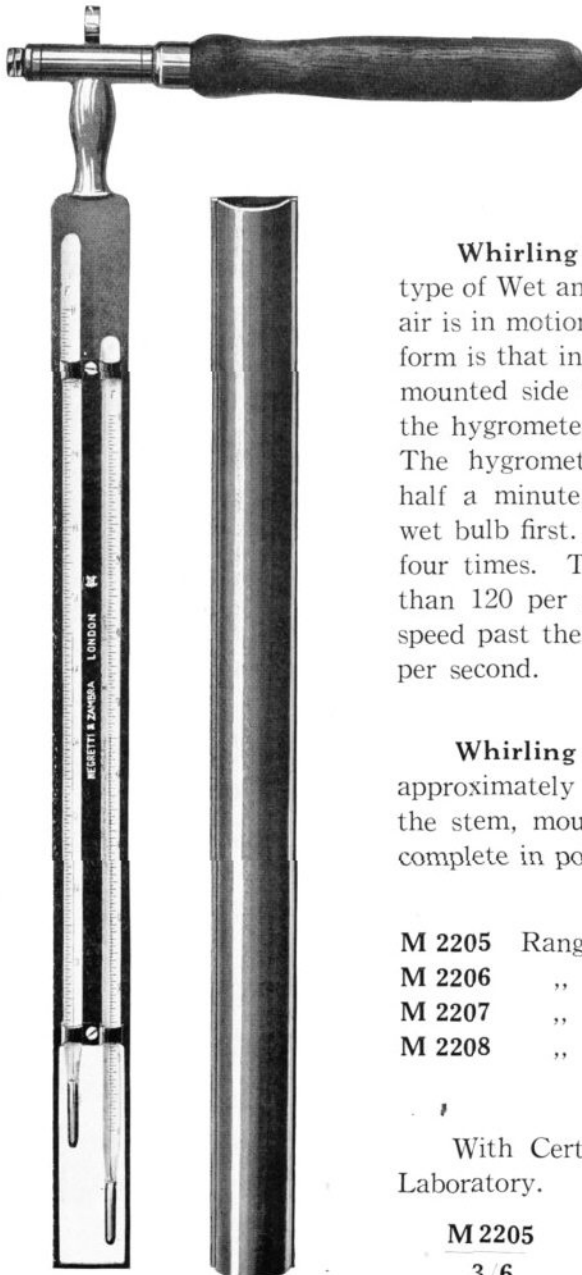
With Certificate of the National Physical Laboratory .. £0 6 0

**Standard Hygrometers**, used by the Meteorological Services of Great Britain, Canada, Australia, South Africa, etc., consist of two Ordinary Thermometers, as described on page 73.





**HYGROMETERS**



M 2205

**Whirling or Sling Hygrometer.** Of the type of Wet and Dry Bulb Hygrometer where the air is in motion relative to the bulb, the simplest form is that in which two thermometer tubes are mounted side by side with a handle, permitting the hygrometer to be whirled rapidly in the air. The hygrometer should be whirled for about half a minute, stopped, and quickly read—the wet bulb first. This should be repeated three or four times. The revolutions should be not less than 120 per minute in order to obtain an air speed past the wet bulb of not less than 15 feet per second.

**Whirling Hygrometer, Precision Type,** approximately 11" tubes, divided and figured on the stem, mounted on brass frame with handle complete in polished copper case.

M 2205	Range +10/110° F.	.. ..	£4 10 0
M 2206	,, 20/130° F.	.. ..	£4 5 0
M 2207	,, -10/+45° C.	.. ..	£4 10 0
M 2208	,, -5/+55° C.	.. ..	£4 5 0

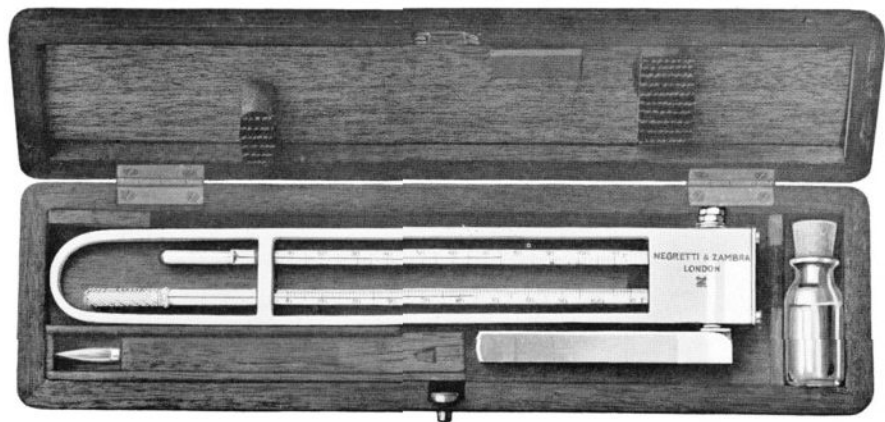
With Certificates of the National Physical Laboratory.

<u>M 2205</u>	<u>M 2206</u>	<u>M 2207</u>	<u>M 2208</u>
3/6	4/6	4/-	4/-





### HYGROMETERS



M 2209

**Pocket Whirling Hygrometer.** This pattern was designed for extreme portability, and is particularly adapted for field use in the taking of observations of humidity, etc., where the use of the wet and dry bulb instrument of fixed or hanging type is not possible.

The rate of revolutions should be not less than 260 per minute.

Tubes approximately 6" long, length of scale 4", accurately divided and figured on the stem. Mounted on aluminium frame, with folding handle. Complete with spare muslins, brush, etc., fitted in mahogany box. Size of box, 9<sup>3</sup>/<sub>4</sub>" x 2<sup>1</sup>/<sub>2</sub>" x 1".

M 2209	Range +10/+110° F.	.. .. .	£2 0 0
M 2210	,, -10/+45° C.	.. .. .	£2 0 0

**Pocket Whirling Hygrometer** as above, fitted in solid leather pocket case as being more durable and less liable to warping, etc., than wood.

M 2211	Range +10/+110° F.	.. .. .	£2 9 6
M 2212	,, -10/+45° C.	.. .. .	£2 9 6



HYGROMETERS



M 2213

**Whirling Hygrometer, Precision Type.** Specially adapted for standardizing and calibrating hair hygrometers, etc., and for general reference purposes.

Tubes about 12" long, divided and figured on the stem; mounted in a nickel-plated cylindrical case, slotted back and front, and provided with wood handle. A screwed-on guard is fitted over the bulbs for protection and removed when the instrument is in use.

The accessories comprise glass jar and spare muslins, a large glass bottle of distilled water, a small bottle of distilled water for immediate use, and printed tables of relative humidities. Complete in wood case measuring 16" x 7" x 2 3/4".

FAHRENHEIT.

Type.	Range.	Each.	With N.P.L. Certificates, Extra.	
			Class "A." To 0.1°F.	Class "B." To 0.2°F.
M 2213	10 to 110° F.	£6 10 0	£1 2 0	£0 3 6
M 2214	20 ,, 130° F.	£6 10 0	£0 16 6	£0 4 6

CENTIGRADE.

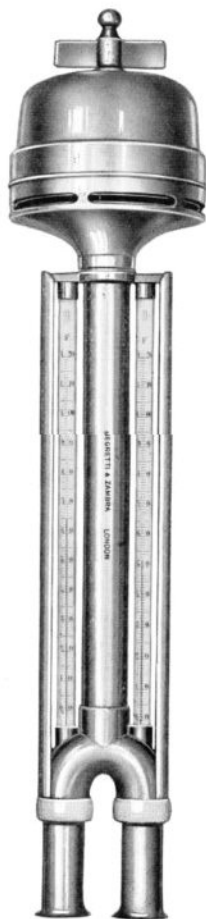
Type.	Range.	Each.	To 0.05°C.	To 0.1°C.
M 2215	-10 to 45° C.	£6 10 0	£1 2 0	£0 4 0
M 2216	-5 ,, 55° C.	£6 10 0	£0 16 6	£0 4 0



## HYGROMETERS

**The Assmann Type Hygrometer, or Psychrometer,** is for the purpose of obtaining humidity readings with the highest precision.

It consists of two very accurate thermometers divided and figured on the stem, with the bulbs mounted in two air ducts which form an inverted "Y" at the lower end of the instrument. A centrifugal fan, operated either by a clockwork movement *or* by an electric motor, draws the air past the bulbs. The motor can be supplied for 100 to 110 volts or 200 to 250 volts, D.C. or A.C. The bulbs are protected from the effect of radiation by two nickel-plated sleeves, which are insulated from the main frame of the instrument. The instrument is supplied complete with muslins, water filler, wind-shield, and bracket for supporting the instrument, and is fitted in a polished wood box, size 20" x 4½" x 4¾" deep.



M 2217

### FAHRENHEIT

Type.	Range.	Each.	With N.P.L. Certificates, Extra.	
			Class "A." To 0.1° F.	Class "B." To 0.2° F.
M 2217	10 to 110° F.	£17 10 0	£1 2 0	£0 3 6
M 2218	20 ,, 130° F.	£17 10 0	£0 16 6	£0 4 6

### CENTIGRADE

Type.	Range.	Each.	To 0.05° C.	To 0.1° C.
			£1 2 0	£0 4 0
M 2219	-10 to 45° C.	£17 10 0	£1 2 0	£0 4 0
M 2220	-5 ,, 55° C.	£17 10 0	£0 16 6	£0 4 0

(Price includes clockwork or electric motor.)

**Thermometers for Assmann Psychrometer, British Meteorological Office Specification.** Tubes, overall length, 11". Bulb of normal glass, stem of British lead glass. Range -15/+90° F. (or -25/+30° C.); number of degrees Fahr. to the inch not to exceed 17. Divided every degree and figured every 10°. The thermometer is fixed firmly in a cylindrical nickel-plated metal cap ⅜" diameter, 7/8" long; flange at top. Cylindrical nickel-plated metal collar ⅜" diameter, cemented over the stem of the thermometer 8¼" from the top of the metal cap.

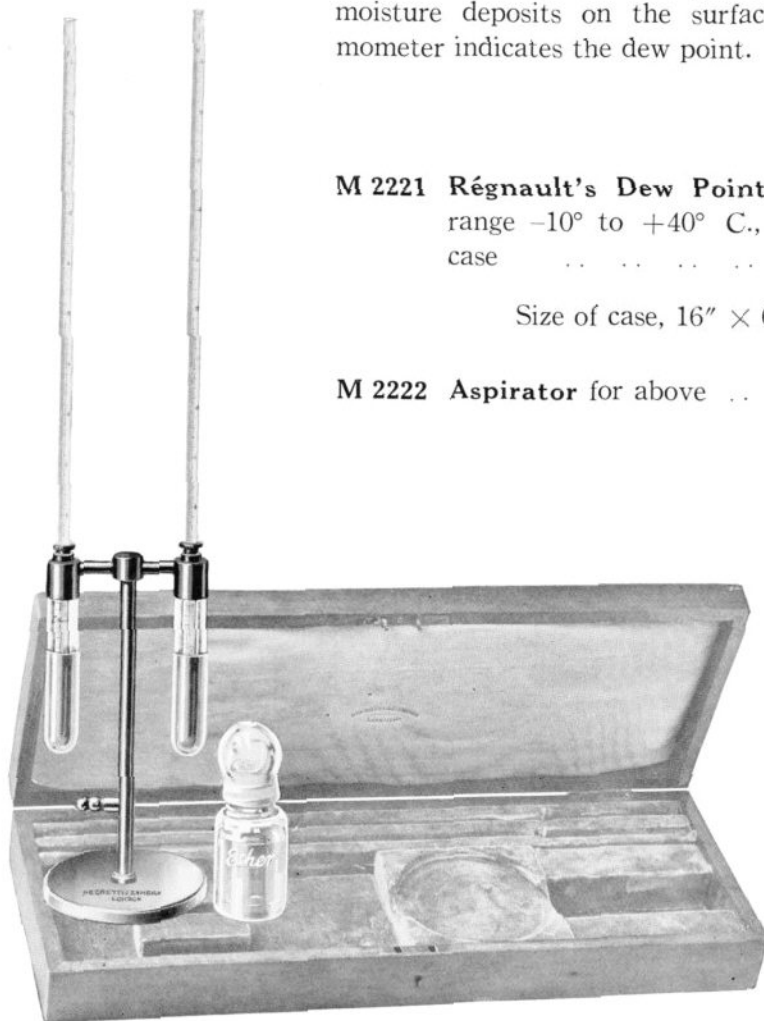
M 2220 **Thermometer** as above . . . . . £0 15 0



## DEW POINT HYGROMETER

**Régnault's Condenser Hygrometer**, in which the two thermometers are inserted in glass sheaths with the bulbs in polished silver thimbles. One thimble is filled with ether. Air is drawn past the dry bulb by means of an aspirator, or suction pump, and the thermometer indicates the air temperature.

Simultaneously, the air is drawn through the ether of the dew point thermometer, thus evaporating the ether and cooling the thimble until moisture deposits on the surface. This thermometer indicates the dew point.



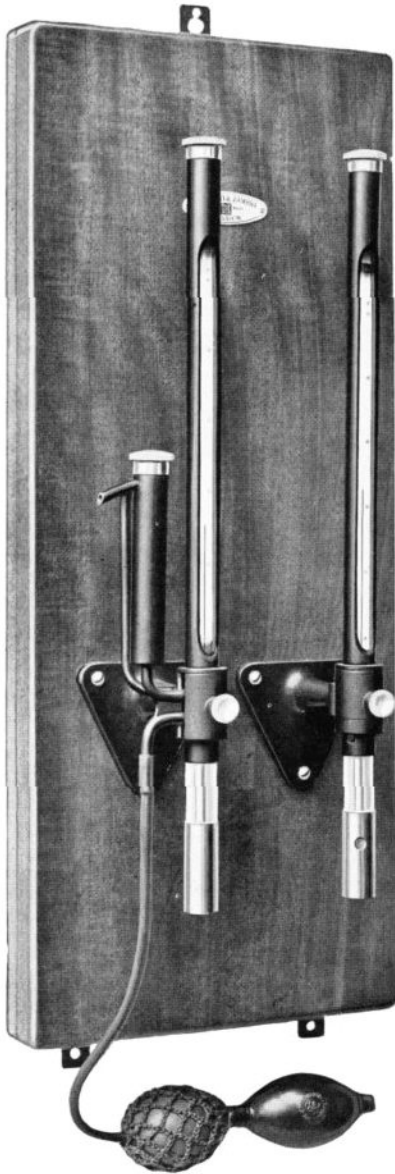
**M 2221 Régnault's Dew Point Hygrometer**,  
range  $-10^{\circ}$  to  $+40^{\circ}$  C., in mahogany  
case . . . . . **£8 0 0**

Size of case,  $16'' \times 6'' \times 2\frac{1}{2}''$ .

**M 2222 Aspirator** for above . . . . **£1 15 0**



## HYGROMETERS



**Dew Point Hygrometer of the Régnault Type** of specially robust design.

The thermometers are 15" long, mounted in nickel-plated sheaths, one bulb being immersed in a polished solid silver thimble. This thimble is connected to a filler containing ether, to which is attached a rubber pipe and bulb. Air being drawn through the ether by means of this rubber bulb, the thimble is rapidly cooled and moisture deposits, when the reading of the thermometer indicates the dew point or the temperature at which the existing air would become saturated.

The thermometers are graduated  $-10^{\circ}$  to  $+40^{\circ}$  C., and 3 to 55 mm. vapour pressure. The panel measures  $10" \times 24"$ .

**M 2223 Dew Point Hygrometer,**  
**£10 10 0**

Relative Percentage Humidity =

$$\frac{\text{Satd. Vapour Pressure at dew point} \times 100}{\text{Satd. Vapour Pressure at dry bulb tempt.}}$$

or

$$\frac{\text{Weight of moisture at dew point to saturate} \times 100}{\text{Weight of moisture at dry bulb tempt. to saturate.}}$$





## HYGROMETERS

The Hair Hygrometer or Hygroscope consists of a bundle of hairs or other organic tissue which changes its length when it absorbs moisture.

Although this type of Hygrometer cannot be regarded as an instrument of high precision, yet its chief merit is that it is a direct reading instrument and beyond a periodic adjustment it requires no attention.



M 2224

The instrument takes the form of a 4" diameter case, beneath which is a slotted tube in which the hairs are mounted. At the lower end of the tube an adjustment screw is provided to which the hairs are anchored. At the top end of the hairs a link piece is connected direct to a crank on the pointer spindle.

The primary scale indicates relative percentage humidity, the subsidiary scale—the dewpoint.

There are no springs, gears, or cords in the mechanism, and errors due to backlash, friction, etc., are thus reduced to a minimum.

The Hygroscope can be readily checked from time to time, either by wetting the hairs, in which case it should read approximately 95%, or better still, by means of the Wet and Dry Bulb Whirling Hygrometer previously described.

**M 2224 4" Dial Hair Hygrometer**, ranged 10/100% relative humidity,  
£3 10 0

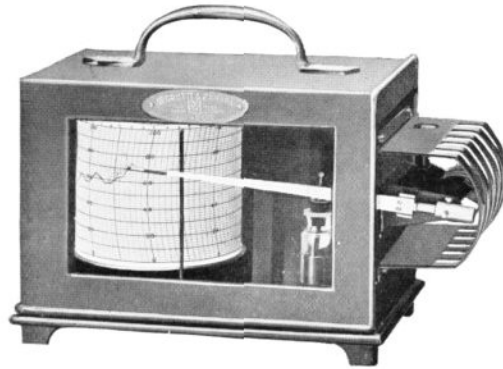
**M 2225** Ditto, with maximum and minimum electric contacts for small currents not exceeding 4 volts 0.2 amp.,  
£4 17 6







**RECORDING THERMOMETERS**



**M 2226**

**The Bimetallic Temperature Recorder** is one of the simplest instruments for recording temperature. The mechanism consists of a helix of bimetallic metal, which coils and uncoils with changes of temperature, thereby operating a pen recording on the typical clock-driven chart. The bimetallic type is of greater accuracy than the Bourdon tube type filled with alcohol ; it has a much smaller thermal lag and the helix operates direct on the pen-arm spindle without any levers or links. The control is amply sufficient to overcome the friction of the pen on the chart ; further, the scale value is constant for even increments of temperature.

**Recording Thermometer** with bimetallic element mounted on an iron frame and base, and protected by a slotted brass guard.

Daily (8-day Clock) or Weekly Drum, any of the standard ranges below.

Hinged glass-panelled cover of japanned metal, with padlock and key.

Clock Drum .. .. .	3.6" dia. × 3.6" high
Pen Travel.. .. .	3"
Chart .. .. .	3.6" × 11.8"
Time Scale .. .. .	0.45" per hour
" " .. .. .	1.54" per day
Temperature Scale .. .. .	33.3° F. (18.3° C.) per inch

**Standard Ranges**

0/ +100° F.	-10/ +45° C.
+30/ +130° F.	0/ +55° C.
+50/ +150° F.	+10/ +65° C.

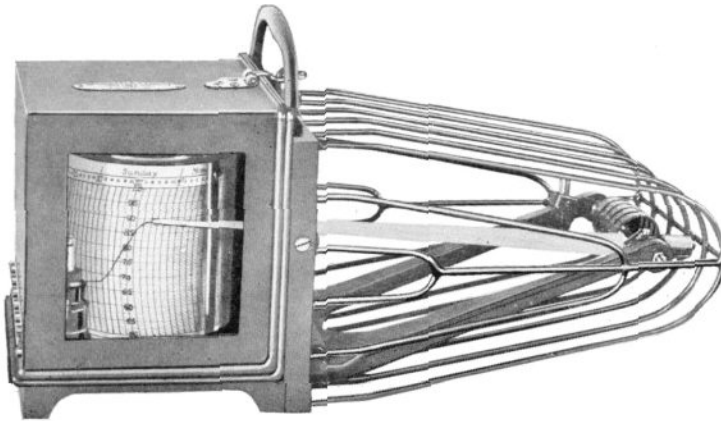
<b>M 2226 Recording Thermometer</b> as above, complete with 100 charts, ink and pen, etc. . . . .	<b>£7 0 0</b>
Charts .. .. . per 100	<b>£0 12 0</b>

**Note.**—The method adopted by N. & Z. for testing Recording Thermometers is shown on page 128.





**RECORDING THERMOMETERS**



**M 2227**

**Sensitive Type Recording Thermometer.** Element to previous specification placed well away from the case for greater accuracy and sensitiveness.

Daily (8-day Clock) or Weekly Drum, the standard ranges as below.  
Hinged glass-pannelled metal cover, strong wire protection to element.

Clock Drum .. .. .	3.6" dia. × 3.6" high
Pen Travel .. .. .	3"
Chart .. .. .	3.6" × 11.8"
Time Scale (daily) .. .. .	0.45" per hour
"    " (weekly) .. .. .	1.54" per day
Temperature Scale .. .. .	20° F. or 13.3° C. per inch
	and 33.3° F. or 18.3° C. " " "

**Standard Ranges**

+30/+90° F.	-5/+35° C.
0/100° F.	-10/+45° C.

<b>M 2227 Sensitive Type Recording Thermometer</b> as above ..	<b>£10 0 0</b>
Charts .. .. . per 100 .. .. .	<b>£0 12 0</b>

**Standard Thermograph,** British Meteorological Office Specification.  
Principle and construction as above.

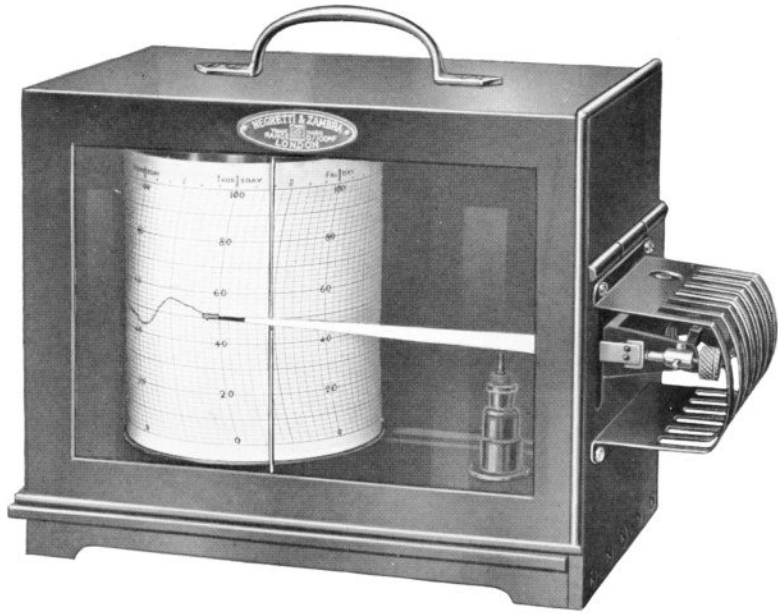
Pen Arm .. .. .	7.3" long, moving over 0.6" for every 10° F.
Clock Drum .. .. .	5.2" high × 11.5" circumference
Daily Clock .. .. .	Rotating once in 2 days
Weekly Clock .. .. .	" " " 7½ "

<b>M 2228 Standard Thermograph</b> as above .. .. .	<b>£10 0 0</b>
Charts .. .. . per 100 .. .. .	<b>£0 12 0</b>





RECORDING THERMOMETERS



M 2229

**Recording Thermometer, Large Size**, bimetallic movement similar to previous specifications, but with more open time and temperature scales.

Daily (8-day Clock) or Weekly Drum, any of the standard ranges below.

Hinged glass-panelled cover of japanned metal, with lock and key.

Clock Drum	.. .. .	5" dia. × 6" high
Pen Travel	.. .. .	5"
Chart	.. .. .	5.8" × 16.2"
Time Scale (daily)	.. .. .	0.6" per hour
" " (weekly)	.. .. .	2.06" per day
Temperature Scale	.. .. .	20° F. (11° C.) per inch

**Standard Ranges**

0/ +100° F.	-10/ +45° C.
+30/ +130° F.	0/ +55° C.
+50/ +150° F.	+10/ +65° C.

<b>M 2229 Recording Thermometer</b> as above, complete with 100 charts, pen, ink, etc.	.. .. .	£11 0 0
Charts	.. .. . extra per 100	£0 15 0





## MERCURY-IN-STEEL THERMOMETERS

### CONSTRUCTION.

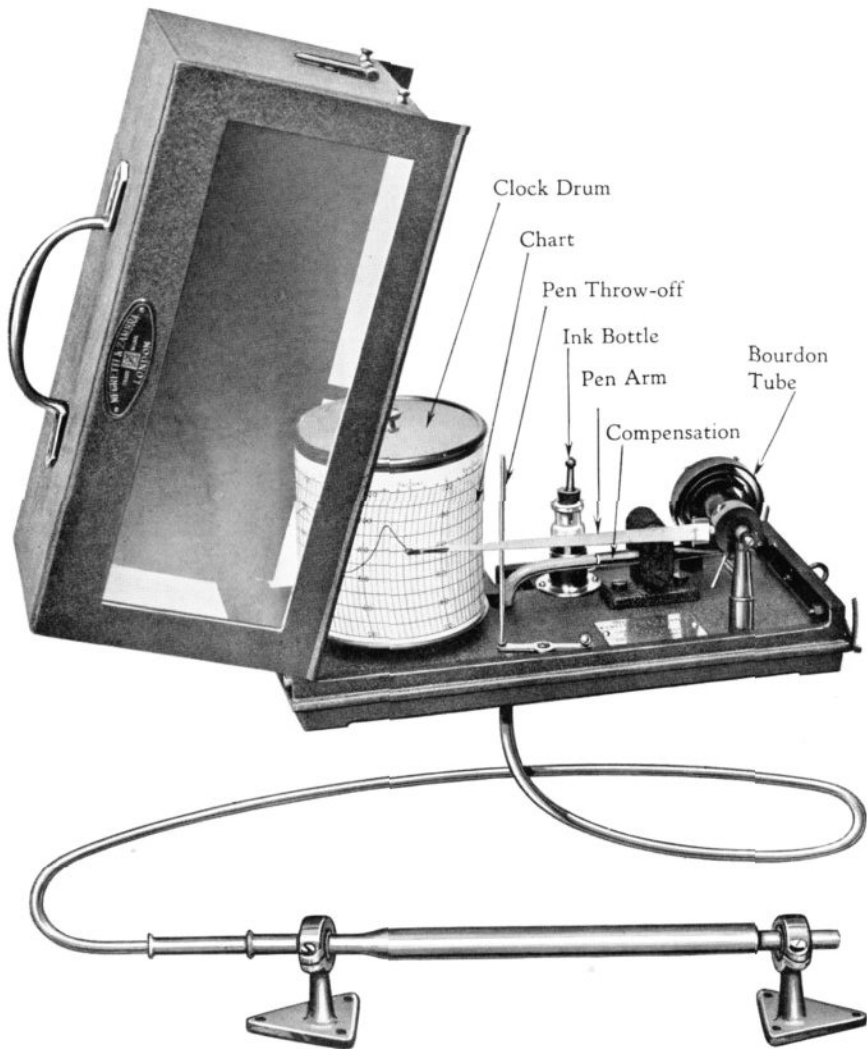
- Movement.** The movement consists essentially of three parts—bulb, capillary tubing and Bourdon tube, all made of steel. These are welded together to form one system and filled with mercury at a pressure of 1,000-lbs. per square inch, the steel being specially treated in the course of manufacture so that it may not be attacked by the mercury. One object of filling at such a high pressure is to provide sufficient control over the pen arm.
- Direct Action.** The axis of the pen arm is attached direct to the Bourdon tube without any levers, gears or hairsprings. The result is that there are no moving parts to get out of order or to cause friction and consequent inaccuracy.
- Materials.** Only the finest quality materials are used to give satisfactory service. All parts are tested and inspected before completion, and each instrument is separately calibrated against standards certified by the National Physical Laboratory.
- Capillary Tubing.** The capillary tubing is of specially drawn steel enclosed in an outer copper tubing, or is lead coated, for protection. This steel tubing, which is drawn in our own Works, has a bore of 0.006" with an area of 0.000028 square inches, and a mile of this tubing would contain only about  $1\frac{3}{4}$  cubic inches of mercury.
- Compensation for Temperature.** A compensator for air temperature changes is inserted in each length of capillary, and in long lengths of tubing these compensators are inserted at definite intervals along the length. Full details regarding these compensating links will be found in our "Notes on Distance Thermometers."
- Inspection.** No instrument is passed out until it has completed a duration test in the Inspection Department, where a full record of its performance is kept with check readings and calibration corrections, a copy of which can be had by the customer, if desired.





## RECORDING THERMOMETERS

N. & Z. Patent Mercury-in-Steel Pattern.



M 2230/2235

For recording the temperature of Rivers, Lakes, Sea Surface, etc. ; temperatures of the Air at Stations or on Aircraft ; temperatures of the Earth at various depths ; temperatures of the Wet and Dry Bulb Thermometers, etc.





## RECORDING THERMOMETERS

**Air Temperature Recorder.** Constructed on the Negretti & Zambra Patent Mercury-in-Steel principle described on page 97. The bulb is of small diameter and considerable length in order to obtain sensitivity, and is usually coated with copper. The capillary tubing is protected by well-annealed copper tubing, and may be any length up to 100 feet. The standard lengths of capillary are as stated—10 feet, 20 feet, and 30 feet. Very long capillaries are sometimes required when temperature errors, even with tubing of very fine bore, are not negligible. In such cases, compensation is provided by the introduction of one or more patent compensating links referred to on page 97.

With Daily (8-day Clock) or Weekly Drum, ranges as stated below.  
Hinged glass-panelled metal cover to case.

	Model A	Model B
Clock Drum .. .. .	3.6" dia. × 3.6" high	5" dia. × 6" high
Pen Travel .. .. .	3"	5"
Chart .. .. .	3.6" × 11.8"	5.8" × 16.2"
Time Scale (daily) .. ..	0.45" per hour	0.6" per hour
,,    ,, (weekly) .. ..	1.54" per day	2.06" per day
Temperature Scale .. ..	33.3° F. or 16.6° C. per inch	20° F. or 10° C. per inch

### Standard Ranges

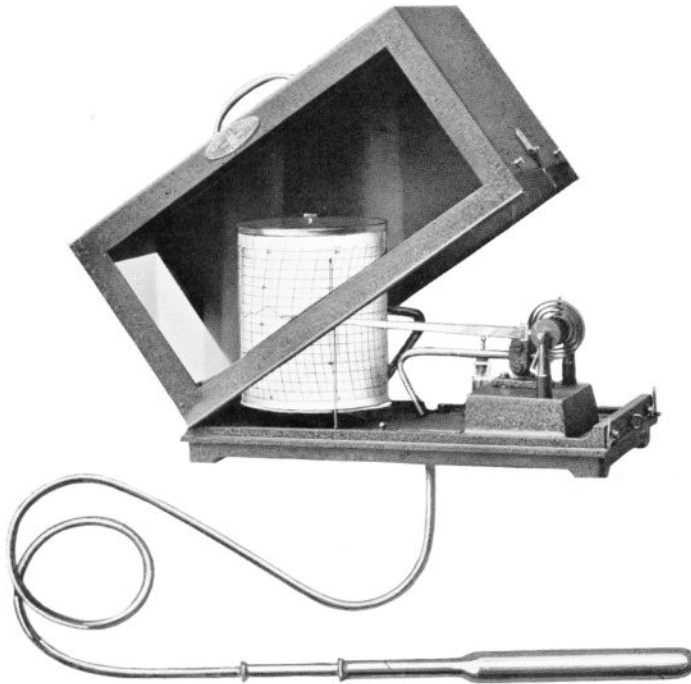
0/+100° F.	-10/+40° C.
+30/+130° F.	0/+50° C.
+50/+150° F.	+10/+60° C.

<b>M 2230</b>	<b>Air Temperature Recorder, Model A, with 10 feet capillary tubing, pen, ink, and 100 charts .. .. .</b>	<b>£15 10 0</b>
<b>M 2231</b>	<b>Ditto, 20 feet .. .. .</b>	<b>£17 10 0</b>
<b>M 2232</b>	<b>Ditto, 30 ,, .. .. .</b>	<b>£19 10 0</b>
<b>M 2233</b>	<b>Ditto, Model B, with 10 feet capillary .. .. .</b>	<b>£20 10 0</b>
<b>M 2234</b>	<b>Ditto, 20 feet .. .. .</b>	<b>£22 10 0</b>
<b>M 2235</b>	<b>Ditto, 30 ,, .. .. .</b>	<b>£24 10 0</b>
	Capillary, copper covered, beyond 30 feet .. .. per foot	£0 4 0
	Charts, Model A .. .. . extra per 100	£0 12 0
	,,    ,, B .. .. . ,, ,,	£0 15 0





## RECORDING THERMOMETERS



M 2236

**Earth Temperature Recorder.** Constructed on the Negretti & Zambra Patent Mercury-in-Steel principle as described on previous pages.

The bulb is of steel of small diameter and 10" or more in length, coated with lead for protection against corrosion; it is buried horizontally in the ground at the depth of which temperature records are required.





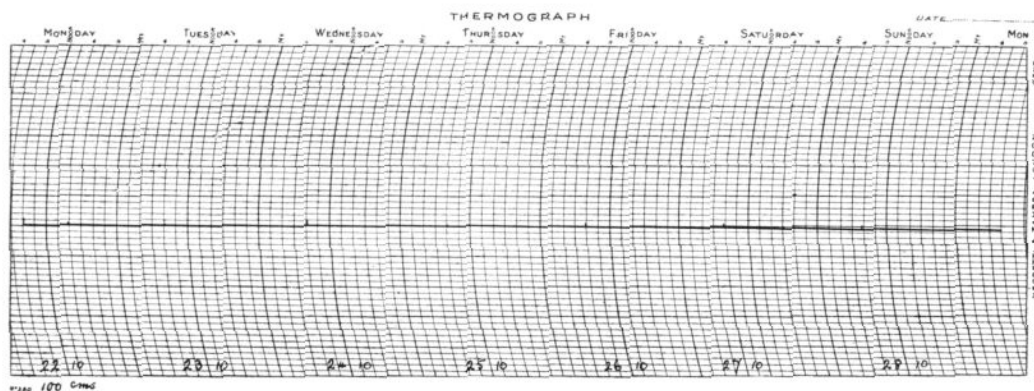


### RECORDING THERMOMETERS

The capillary is also lead coated to withstand the corrosive effect of chemicals in the ground. It may be any length up to 100 feet, and the standard instrument is supplied with 15 feet of capillary.

Daily (8-day Clock) or Weekly Drum.	
Range 20/120° F., or -10/+40° C.	
Hinged glass-panelled japanned metal cover to case.	
Clock Drum . . . . .	5" × 6" high
Pen Travel . . . . .	5"
Chart . . . . .	5.8" × 16.2"
Time Scale (daily) . . . . .	0.6" per hour
"    " (weekly) . . . . .	2.06" per day
Temperature Scale . . . . .	20° F. or 10° C. per inch

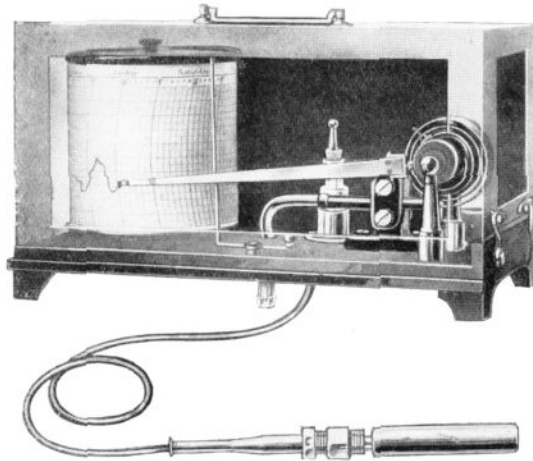
<b>M 2236 Earth Temperature Recorder</b> , with 100 charts, pen and ink . . . . .	<b>£23 0 0</b>
Capillary, lead coated, over 15 feet . . . . . per foot	<b>£0 4 9</b>
Charts . . . . . extra per 100	<b>£0 15 0</b>



The above reproduction (by kind permission of the Cotton Research Board, Egypt) is from one of a set of seven Model B Recorders, where the bulbs are buried at depths varying from surface to 1 metre. Where the surface graphs show marked daily amplitude, the above shows practically no deviation, and the perfect method of compensation is demonstrated by the fact that the Recorder and the capillary tube were subject to a daily variation of temperature of 20° Centigrade and more.



RECORDING THERMOMETERS



M 2237

**Sea Surface Temperature Recorder.** Constructed on the N. & Z. Patent Mercury-in-Steel principle.

**The bulb** is constructed to suit the requirements of the particular ship and local conditions, and three approved types are :—

- (a) In a wooden ship, the bulb, long and narrow and lead coated, was cut into the keel and protected by a brass plate ; a flange and screwed fitting was arranged on the inside of the ship, making a watertight connection against the sea. Method used in the S.S. "Discovery."
- (b) The bulb, long and narrow and lead coated, is screwed into the condenser water inlet pipe by means of a brass gland nut and fitting.
- (c) The bulb is a sliding fit in a brass pocket (or well), which is fitted by the owner or builder at any suitable spot—for preference, the condenser water inlet.

Method used by the Meteorological Service of Canada, the United States Weather Bureau, etc.

**The Capillary** is protected against corrosion by lead covering, and may be any length required.



### RECORDING THERMOMETERS

The Recorder may be Model A or Model B, with any Range required, but the popular Ranges are :—

- 5° to +35° C.
- 2½° ,, +25° C. for Polar Work.
- 20° ,, 100° F., with overload to 110° F.
- 30° ,, 90° F. ,, ,, 100° F.

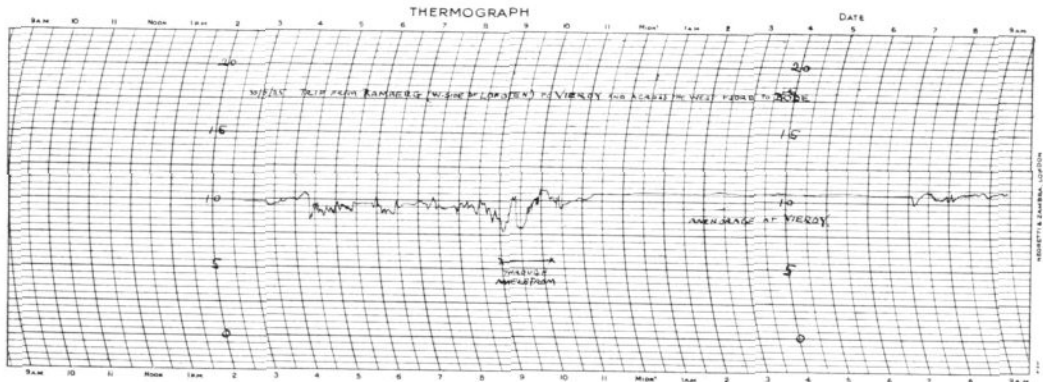
Daily (8-day Clock) or Weekly Drum.

Hinged glass-panelled metal cover to case.

	Model A	Model B
Clock Drum . . . . .	3.6" dia. × 3.6" high	5" dia. × 6" high
Pen Travel . . . . .	3"	5"
Chart . . . . .	3.6" × 11.8"	5.8" × 16.2"
Time Scale (daily) . . . . .	0.45" per hour	0.6" per hour
,, ,, (weekly) . . . . .	1.54" per day	2.06" per day

M 2237 Sea Surface Temperature Recorder, Model A, with 10 feet lead-covered capillary tubing, pen, ink and 100 charts **£17 2 6**

M 2238 Ditto, Model B . . . . . **£22 2 6**  
 Capillary beyond 10 feet, lead covered . . . . . per foot **£0 4 9**  
 Charts, Model A . . . . . extra per 100 **£0 12 0**  
 ,, ,, B . . . . . ,, ,, **£0 15 0**

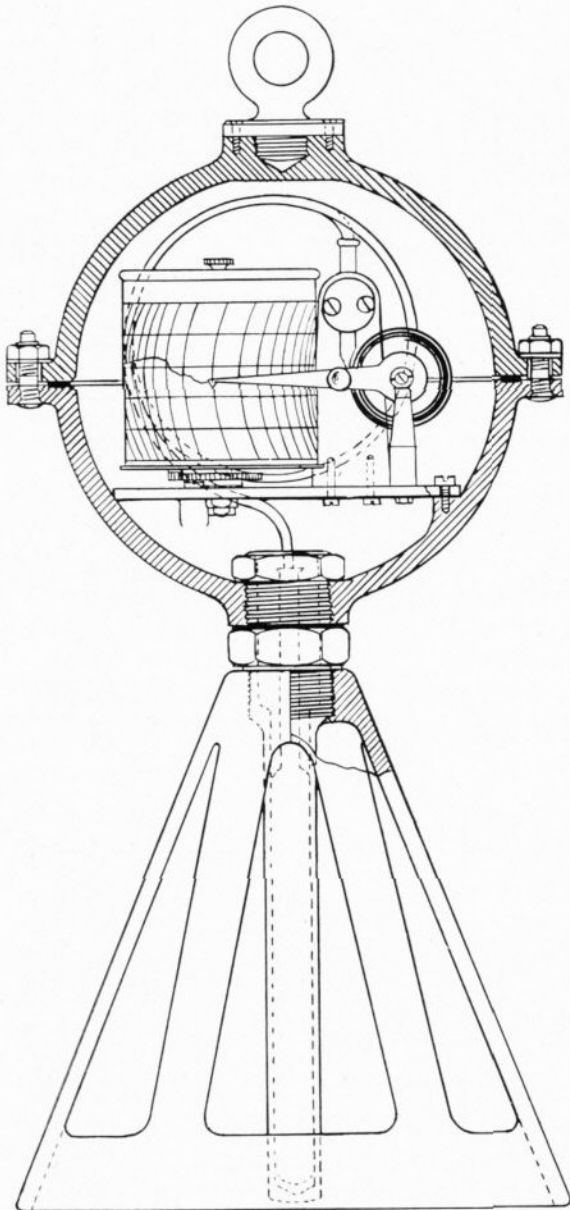


The above reproduction (by kind permission of Prof. Oscar Sund) is an actual chart off a Model B Recorder, Range -2½/ +22½° C., showing the passage through the Maelstrom.





### RECORDING THERMOMETERS



M 2239

**Deep Sea Temperature Recorder** constructed on the Negretti & Zambra Mercury-in-Steel principle, the mechanism being contained in a watertight sphere so that the apparatus may be totally submerged to a depth of approximately 300 metres (700 feet).

The movement is of the Type A described on page 97, with drum making one revolution in one week, two weeks, or 28 days, as desired, and is enclosed in a bronzed metal sphere held down with 12 bolts, making a seating with a rubber or composition joint.

Range  $-2\frac{1}{2}$  to  $+22\frac{1}{2}$ ° C.

The bulb of the thermometer is inserted in a gun-metal pocket to protect it from corrosion and from pressure effects, and is so arranged that it can be removed (with the mechanism) if required.

The apparatus weighs approximately 65-lbs. (30 kilograms), and will stand a pressure of 400-lbs. per sq. in. (28 kilograms per sq. cm.).

- Clock Drum .. 3.6" dia. x 3.6" high
- Pen Travel .. 3"
- Chart .. 3.6" x 11.8"
- Time Scale  
(weekly) .. 1.54" per day

M 2239 Deep Sea Temperature Recorder, with pen, ink, and 100 charts .. £48 0 0

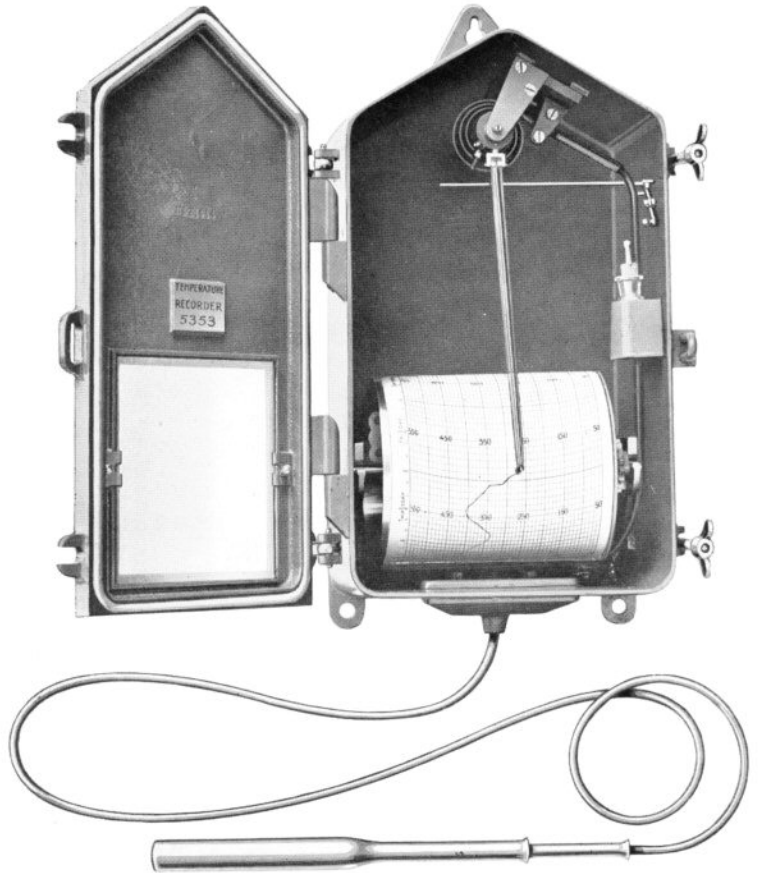


RECORDING THERMOMETERS

**Temperature Recorder with Horizontal Drum.**

Usually for meteorological purposes it is possible to place the recorder case where it is not subject to an excess of moisture or dust which might otherwise damage the clock mechanism, but as there are occasions when this is not possible, the Horizontal Drum Recorder is admirably adapted for the purpose.

The great advantage of this model is that the case is moisture-proof and dust-tight, so that it can be used in situations when the Vertical Drum Recorder would not be suitable: the charts resemble those of the foregoing instruments, having evenly-spaced divisions.



M 2240

Range 20 / 120° F., or -10 / +40° C.  
Daily (8-day Clock) or Weekly Drum.

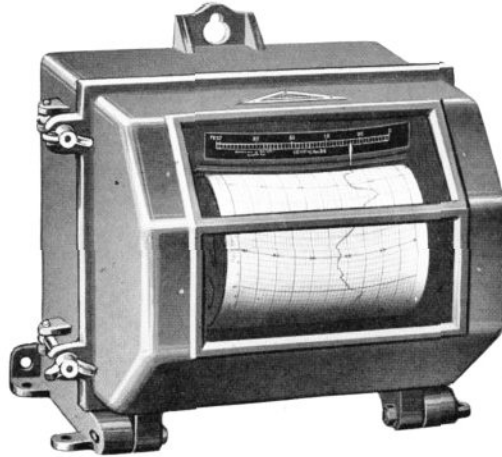
Clock Drum .. .. .	5" × 6"
Pen Travel .. .. .	5"
Charts .. .. .	5.8" × 16.2"
Time Scale (daily) .. .. .	0.6" per hour
" " (weekly) .. .. .	2.06" per day
Temperature Scale .. .. .	20° F. or 10° C. per inch

M 2240 H.D. Recorder, with 10 feet copper-covered capillary, plain bulb as illustrated, 100 charts, pen and ink, etc. .. £22 10 0

M 2241 Ditto, Duplex Pattern .. .. . £34 0 0  
 Capillary over 10 feet .. .. . per foot £0 4 0  
 Lead Covering to bulb .. .. . £1 0 0  
 " " " capillary .. .. . per foot £0 0 9  
 Charts .. .. . extra per 100 £0 15 0



## RECORDING THERMOMETERS



The **Electrical Recording Thermometer** is also sometimes employed for recording air and earth temperatures. The advantage of this instrument is that the recorder can be placed at practically any distance from the thermometer bulbs, whereas in the case of the **Mercury-in-Steel Recording Thermometer** (see pages 97 and 98), this distance is limited to 150 feet. On the other hand, the electrical movement is not so robust as the mercury-in-steel, and the instrument requires careful attention in order to obtain satisfactory results.

The principle employed is that the electrical resistance of a pure metal varies with changes of temperature. The Wheatstone Bridge method of measuring changes of resistance is adopted, with the galvanometer calibrated in degrees of temperature.

Three coils are arranged inside the Recorder and are wound with wire that is not affected by temperature. One other coil is wound with platinum wire or nickel wire, and is placed in the source of heat, the galvanometer being deflected as the temperature changes.

A small accumulator is required to operate the galvanometer, which is adjusted to the correct voltage by means of a variable resistance.

The Recorder is mounted in a cast-iron moisture-proof case, enamelled and stoved grey. The chart is mounted on a horizontal drum rotating once in seven days; width of temperature scale 5", length of chart 12".

The record is made by the clockwork depressing the inked pointer on to the chart at minute intervals. A scale is fitted above the chart showing the temperature scale. Where it is desired, two thermometer bulbs can be connected to the same recorder, giving two records on one chart. An automatic switch is fitted, the timing of which is arranged to make the two records distinguishable.

Thermometer bulbs can be supplied suitable for air or earth temperatures. The bulbs are connected to the Recorder by means of lead-covered cable.

Full particulars and quotations will be sent on request.







## RECORDING THERMOMETERS

### PHOTOGRAPHIC RECORDER

The **Photographic Temperature Recorder** has been produced to meet the demand for a thermograph capable of giving a record of temperatures, the accuracy of which cannot be questioned. As a properly-constructed mercury-in-glass thermometer provides one of the most reliable means of temperature measurement, this Recorder has been designed to enable a record to be obtained from such a thermometer.

One important application of such an instrument is in the measurement and recording of the temperature existing in the refrigerated hold of a ship, the temperature of which, during a prolonged voyage, is required to be maintained within certain specified limits. The Recorder is designed to meet this specific requirement, although it is adaptable for many other applications, and accordingly has been arranged for the recording of temperature over periods up to 30 days.

The main features of the Recorder are that the complete instrument is entirely self-contained, and it can be stowed away with cargo, and requires no attention during the period for which it is designed to record.

The record is obtained on a standard size film (Kodak No. 103, 10 exposures 4" × 5", giving a film length of over 50" × 4" wide), and consists of a series of accurate shadow photographs of the actual thermometer, taken at six-hourly intervals. The temperature can be read from each record as accurately as it could be taken by direct observation of the thermometer. The thermometer is of a form of which the accuracy can be certified by a standardising laboratory, such as the **National Physical Laboratory**.

The general construction of the Recorder is as follows :—

The mercury-in-glass thermometer is mounted in a slotted frame attached to a light-tight metal box, in which is housed a small electric bulb with a short filament (giving a source of light of reasonably small dimensions). A series resistance cuts down the current to approximately 2/3rds of its normal rating. Being considerably under-run, the possibility of its failure is thus extremely remote.

The light from the bulb is collimated by means of a lens, actually rectangular in shape, but having a diameter slightly larger than the length of thermometer stem of which the photograph is taken. A sharp image, free from parallax errors, is obtained on the film, which is arranged to be in actual contact with the thermometer stem on its outer face; this is divided and marked in the usual manner. The particular type of stem employed results in the shadow photo being evenly illuminated, the appearance of the record being similar to an ordinary camera photograph of the thermometer.



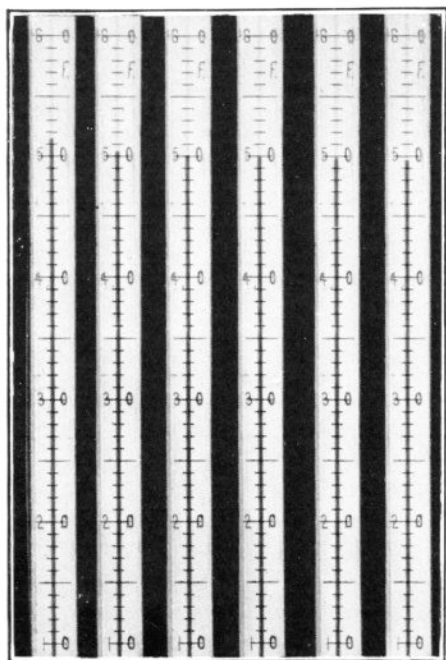




## RECORDING THERMOMETERS

### PHOTOGRAPHIC RECORDER *(continued)*

A special form of clock operates two electric contacts at a six-hourly interval, one completing the lamp circuit producing the required exposure, the other subsequently bringing into operation a small electric motor, which winds the roll film on to a 4" diameter drum by a uniform amount after each exposure, so that unexposed film is brought opposite the thermometer prior to the next exposure. The film is outside the light-tight box in which the lamp is housed, but is itself in a light-tight compartment of the instrument case.



Full-size reproduction of a portion of actual record.

The necessary energy is obtained from suitable dry cells housed in the instrument case; an external switch allows the photographic part of the instrument to be started and stopped when desired.

The bulb of the thermometer projects beyond the bottom of the instrument case, which, however, is arranged to afford ample protection and adequate ventilation.

The complete instrument is entirely self-contained in a wooden case, which is again enclosed in a wooden crate for transport purposes. Total weight, 100-lbs.; measurements, 22" x 18" x 19".

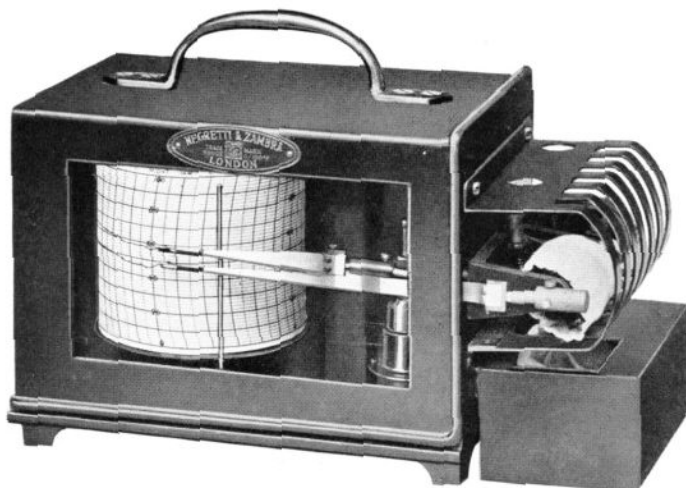
- M 2242 **Photographic Temperature Recorder**, 30 days' run, photographs every six hours, 120 exposures.
- M 2242A Ditto, for meteorological observations, 5 days' run, photographs every hour, 120 exposures.
- M 2242B Ditto, 15 days' run, photographs every 3 hours, 120 exposures.

Prices on Application.



RECORDING HYGROMETERS

**The Bimetallic Recording Hygrometer** is similar in construction to the Recording Thermometer described on page 94, with the addition of a second pen arm and bimetallic coil for the wet bulb readings. One pen traces the air temperature, and the other the wet bulb temperatures; this pen is usually set a recognised number of degrees lower than the true temperature to avoid the pens fouling each other. The coil of the latter system is



M 2243

surrounded with a muslin sleeve, and wick, dipping into a tank filled with distilled water, provides the necessary irrigation.

The instrument records the dry bulb or air temperatures with precision, but the record of the wet bulb temperatures can only be regarded as approximate, due to the fact that a film of moisture does not completely surround the bimetallic strip and to the region of dead air inside the coil.

The instrument is of value in reproducing similar conditions of humidity over any particular period, but not for giving a true indication of relative humidities.

Daily (8-day Clock) or Weekly Drum, any standard range as below.  
Hinged glass-panelled metal cover to case.

Clock Drum .. .. .	3.6" dia. × 3.6" high
Pen Travel .. .. .	3"
Chart .. .. .	3.6" × 11.8"
Temperature Scale .. .. .	33.3° F. (18.3° C.) per inch
Time Scale (daily) .. .. .	0.45" per hour
"    " (weekly) .. .. .	1.54" per day

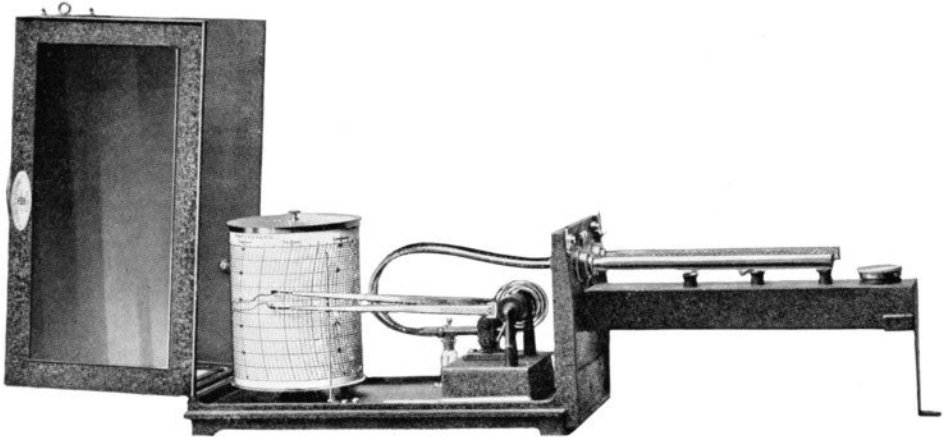
<b>M 2243 Bimetallic Recording Hygrometer</b> , with 100 charts, pens and ink, etc. .. .. .	£12 10 0
Charts .. .. . extra per 100	£0 12 0

Standard Ranges

0/100° F.	-10/+45° C.
30/130° F.	0/+55° C.
50/150° F.	+10/+65° C.



## RECORDING HYGROMETERS



**M 2244**

The **Mercury-in-Steel Recording Hygrometer** is of greater precision than the Bimetallic Type, due mainly to the fact that the wet bulb is of cylindrical form, so that a close-fitting wick sleeve can be used and an ample surface of evaporation is provided. The wick sleeve is attached to several wicks, which dip into the tank and ensure a film of moisture surrounding the bulb ; these wicks are readily renewable.

The bulbs are protected against corrosion by pure tin close-fitting sheaths. The mechanism is that of the N. & Z. Patent Mercury-in-Steel principle, fully described on page 97.

Daily (8-day Clock) or Weekly Drum, any of the standard ranges below.  
Hinged glass-panelled cover to case, with padlock and key.

Clock Drum .. .. .	5" dia. × 6" high
Pen Travel .. .. .	5"
Chart .. .. .	5.8" × 16.2"
Time Scale (daily) .. .. .	0.6" per hour
"    " (weekly) .. .. .	2.06" per day
Temperature Scale .. .. .	20° F. or 10° C. per inch

<b>M 2244</b>	<b>Recording Hygrometer</b> , with 100 charts, pens, ink, and six spare wick sleeves .. .. .	<b>£32 0 0</b>
	Charts .. .. . extra per 100	<b>£0 15 0</b>

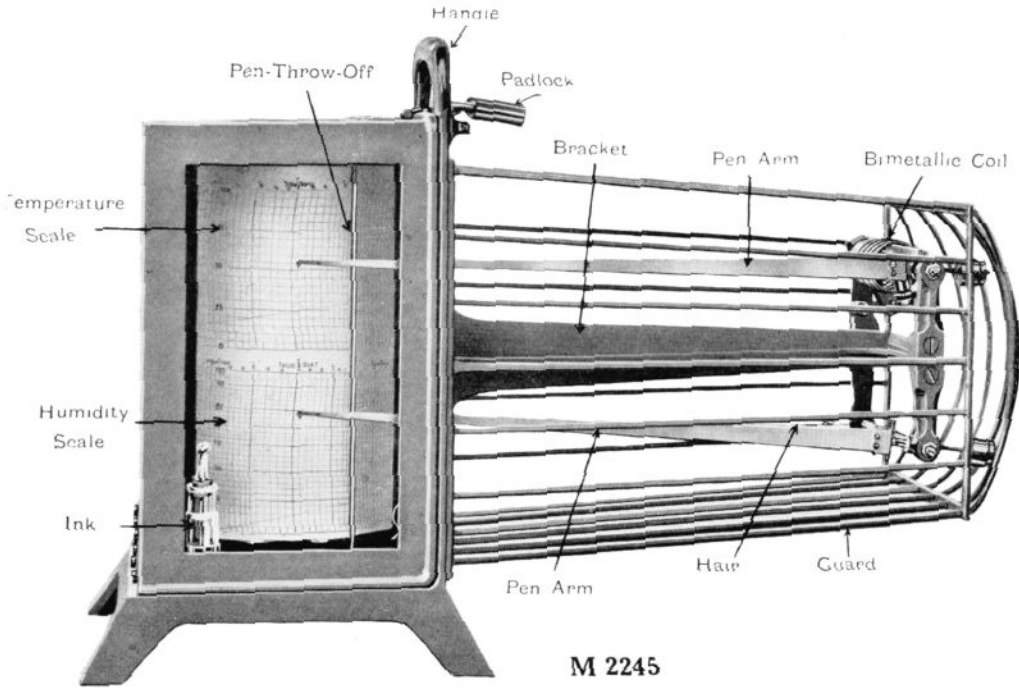
### Standard Ranges

0/100° F.	-10/+40° C.
30/130° F.	0/+50° C.
50/150° F.	10/+60° C.





RECORDING HYGROMETERS



The **Combined Temperature and Humidity Recorder** records on one chart the changes in both temperature and humidity.

The thermometric element is of the Bimetallic Type described on page 94, and the pen records on the upper part of the chart.

The hygrometric record is obtained from the action of a human hair, as described on page 114, and is on the lower part of the chart.

Daily (8-day Clock) or Weekly Drum, the ranges as below.

The pen arms and movements, situated well away from the case, are protected by a stout wire frame.

Hinged glass-pannelled cover to case, with padlock and key.

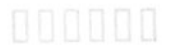
Clock Drum	.. .. .	5" dia. × 7" high
Pen Travel	.. .. .	3" each scale
Chart	.. .. .	7" × 16.2"
Time Scale (daily)	.. .. .	0.6" per hour
" " (weekly)	.. .. .	2.06" per day
Temperature Scale	.. .. .	33.3° F. (18.3° C.) per inch
Humidity Scale	.. .. .	10 to 100% in 3 inches

<b>M 2245 Combined Temperature and Humidity Recorder,</b>		
complete with 100 charts, pens and ink, etc.	.. .. .	£15 0 0
Charts	.. .. . extra per 100	£0 15 0

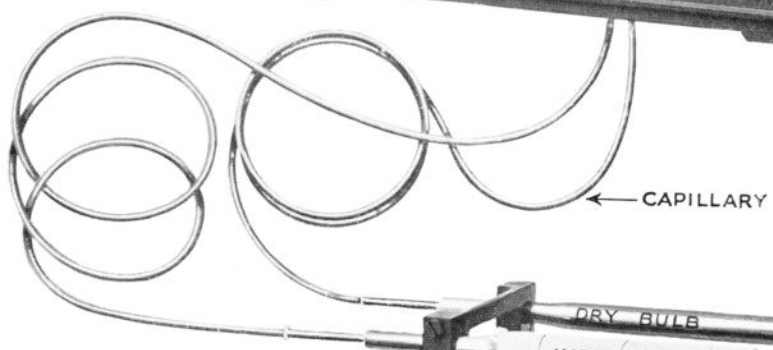
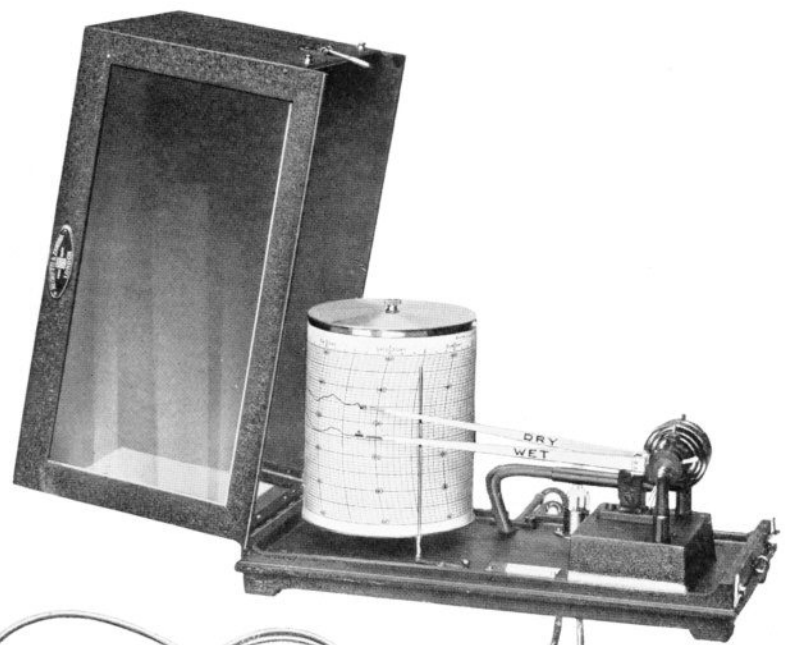
Ranges

10/110° F. } 10/100% Humidity {	-15/40° C.
30/130° F. }	0/55° C.

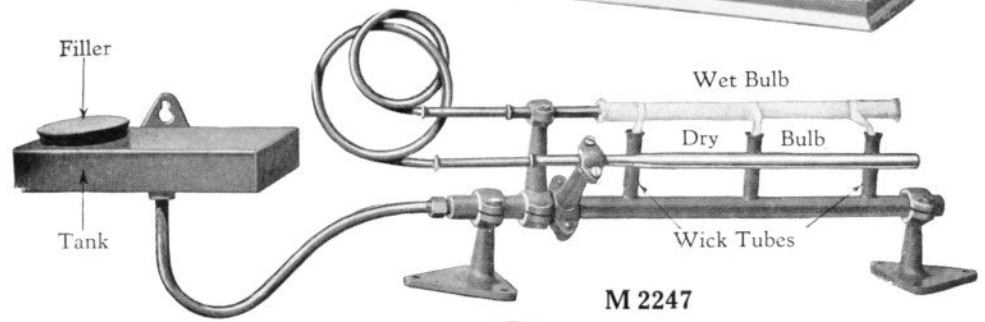




### RECORDING HYGROMETERS



M 2246



M 2247



## RECORDING HYGROMETERS

**Distance Recording Hygrometer.** The Patent Mercury-in-Steel principle described on page 97 is utilised in the design of this instrument so that the bulbs, tank, etc., may be located out in the open, and the Recorder placed in the Observation Room. It is admitted that the inside of a Stevenson Screen should be as free as possible from superfluous metal, etc., which may tend to vitiate the readings of the thermometers, and the particular advantage of this instrument is that only the bulbs of the apparatus are actually inside the screen. Both bulbs are coated with pure tin to prevent corrosion, and one is provided with a close-fitting sleeve and wicks, as described on page 110.

Two designs of tank and fitting are made. In one, the two bulbs are clamped to a casting which carries the water tank situated directly under the bulbs. In the other, the bulbs are held by adjustable brackets to a pipe which feeds the water to the wick tubes from a distant tank or from a float chamber. The tank as figured in M 2247 is mounted on a level with the bulbs, and placed any distance away. The float chamber is connected up with a tank any reasonable height or distance away. These two last methods have the advantage of removing the water tank from the vicinity of the bulbs.

Daily (8-day Clock) or Weekly Drum, standard ranges as below.  
 Capillary, any length required (standard length 10 feet).

	Model C	Model D
Clock Drum .. .. .	3.6" dia. × 3.6" high	5" dia. × 6" high
Pen Travel .. .. .	3"	5"
Chart .. .. .	3.6" × 11.8"	5.8" × 16.2"
Time Scale (daily) .. .. .	0.45" per hour	0.6" per hour
" " (weekly) .. .. .	1.54" per day	2.06" per day
Temperature Scale .. .. .	33.3° F. or 16.6° C. per inch	20° F. or 10° C. per inch

	Model C	Model D
<b>M 2246</b> Recording Hygrometer, Distance Type, with 10 feet capillary to each bulb, six spare sleeves, 100 charts, pens and ink .. .. .	£32 0 0	£37 0 0
<b>M 2247</b> Ditto, with Level Tank .. .. .	£33 0 0	£38 0 0
<b>M 2248</b> Ditto, with Float Chamber .. .. .	£33 10 0	£38 10 0
Extra Capillary .. .. . per foot	£0 4 0	£0 4 0
Charts .. .. . extra per 100	£0 12 0	£0 15 0

### Ranges

0/100° F.                      -10/+40° C.  
 30/130° F.                    0/50° C.





## RECORDING HYGROMETERS

**Recording Hair Hygrometer.** This is practically the only instrument which gives a direct record of humidity without reference to Tables, and although its accuracy is not so great as a Recording Wet and Dry Bulb Hygrometer, yet a direct record is of the greatest value for innumerable purposes.

The instrument is based on the well-known form of De Saussure's Hair Hygrometer. The hairs, numbering about 15, are specially selected and treated to remove fatty substance. Each hair is loaded with a known weight before the bundle is clamped together: this ensures uniform loading when in operation. The hairs are contained in a well-ventilated cylindrical brass tube, the top end being anchored to an adjustable screw in the cap. The other end of the hairs operates through a connecting link to a crank on the pen-arm spindle, which is mounted in jewelled bearings.

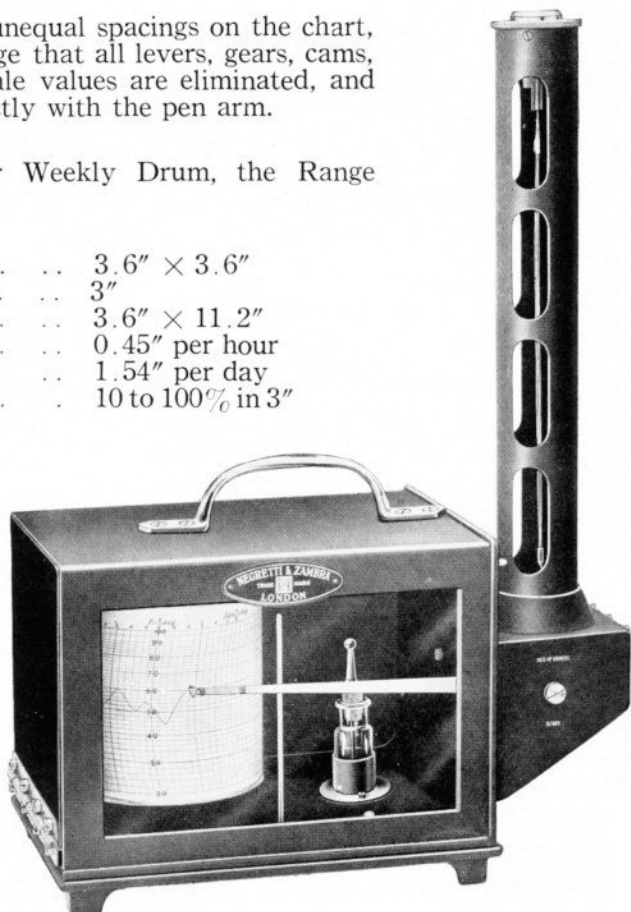
The design necessitates unequal spacings on the chart, but offers the great advantage that all levers, gears, cams, etc., for levelling out the scale values are eliminated, and the hairs are coupled up directly with the pen arm.

Daily (8-day Clock) or Weekly Drum, the Range 10/100% relative humidity.

Clock Drum .. .. .	3.6" × 3.6"
Pen Travel .. .. .	3"
Chart .. .. .	3.6" × 11.2"
Time Scale (daily) .. .. .	0.45" per hour
" " (weekly) .. .. .	1.54" per day
Humidity Scale .. .. .	10 to 100% in 3"

**M 2249 Recording Hygrometer**, complete with 100 charts and ink .. .. **£9 0 0**

Charts, extra per 100 **£0 12 0**



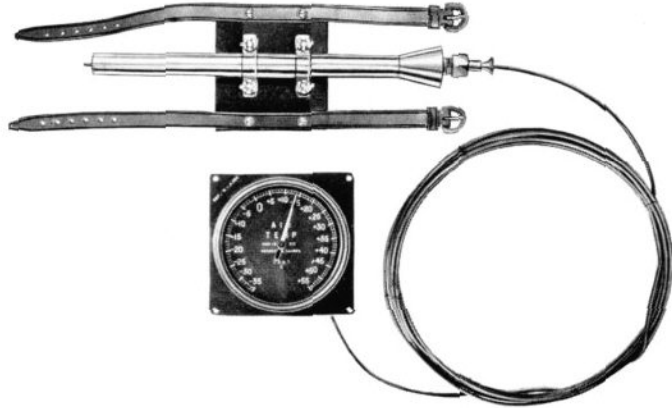
M 2249







AIRCRAFT APPARATUS



M 2250

**Air Temperature Indicator.** As the measurement of ordinary temperatures is extremely important in the accumulation of meteorological data, both for the accurate determination of heights and in connection with aircraft performance, a thermometer is frequently mounted on the aeroplane. This Indicator is on the Negretti & Zambra Patent Mercury-in-Steel system described on page 97.

The bulb is of steel 1/4" in diameter and approximately 12" long ; it is inserted in a sunshield of polished nickel-silver which is mounted on a wood base 4" x 4 1/2", shaped to fit the strut and with two 15" straps. An alternative form has the bulb mounted vertically in a louvred shield, with the necessary straps for mounting on to a strut.

The capillary is enclosed in a braided covering, about 3/16" diameter.

The Indicator is mounted in an aluminium case with flange 5" square.

The dial is of aluminium, ranged -35/+55° C., white figures on black background.

<b>M 2250</b>	<b>Air Temperature Indicator</b> , with 5" case, and bulb as illustrated, with 10 feet capillary . . . . .	<b>£15 10 0</b>
	Capillary, beyond 10 feet . . . . . extra per foot	<b>£0 4 0</b>
	Luminized Pointer and Dial Markings . . . . .	<b>£0 18 0</b>
<b>M 2250A</b>	Ditto. 2 1/2" square flanged case, with 10-ft. capillary, and with vertical shield, latest Air Ministry pattern . .	<b>£12 10 0</b>





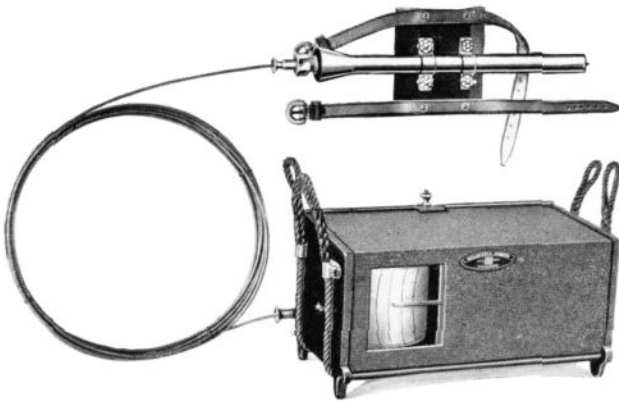
**AIRCRAFT APPARATUS**

**Air Temperature Recorder.**

This instrument is on the Negretti & Zambra Patent Mercury-in-Steel principle described on page 97, and similar to the foregoing instrument, except that the indicator is replaced by a recorder.

The usual Range is  $-30/+50^{\circ}$  Centigrade.

The mechanism is mounted on a light base, the case is of aluminium, and the lid of reinforced aluminium sheet all stoved black. The dimensions are  $11'' \times 5\frac{3}{4}'' \times 5\frac{3}{4}''$ .



**M 2251**

Daily Drum (8-day Clock)	.. .. .	3" dia. $\times$ $3\frac{1}{2}''$ high
Pen Travel	.. .. .	3"
Chart	.. .. .	$3.6'' \times 11.8''$
Time Scale	.. .. .	0.45" per hour
Temperature Scale	.. .. .	$26.6^{\circ}$ C. per inch

**M 2251 Air Temperature Recorder**, with 10 feet of capillary tubing, pen, ink, and 100 charts,

**£28 0 0**

**M 2251A** Ditto, with latest pattern vertical sun shield, as adopted by the British Air Ministry,

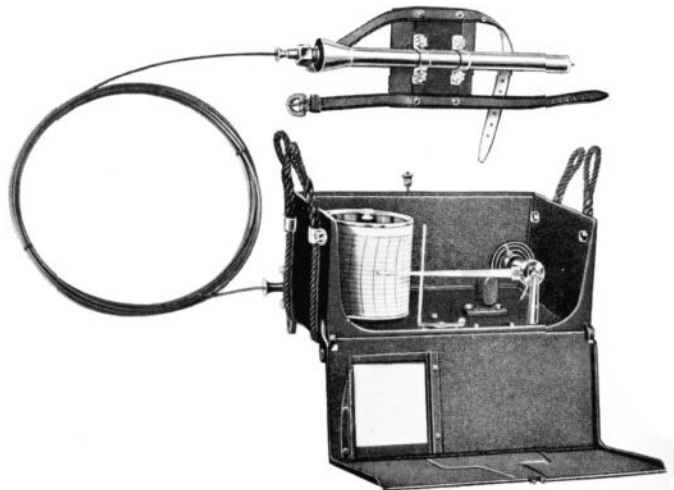
**£31 0 0**

Capillary, beyond 10 feet, extra per foot,

**£0 4 0**

Charts, extra per 100,

**£0 12 0**

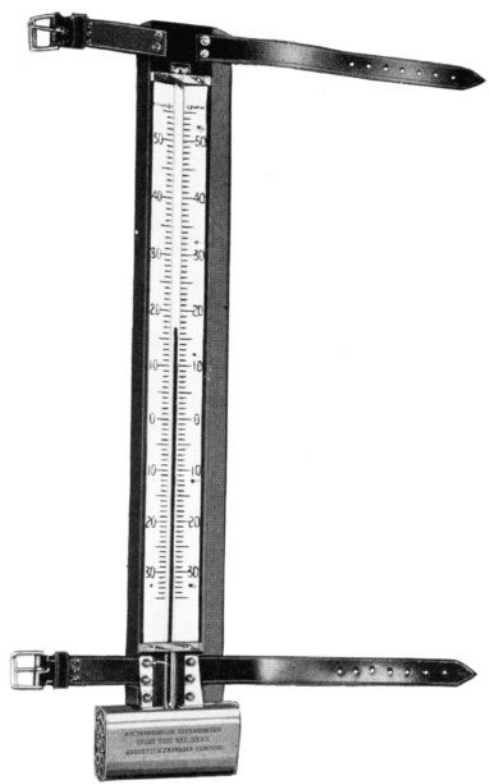


With front open, showing accessibility.





### AIRCRAFT APPARATUS

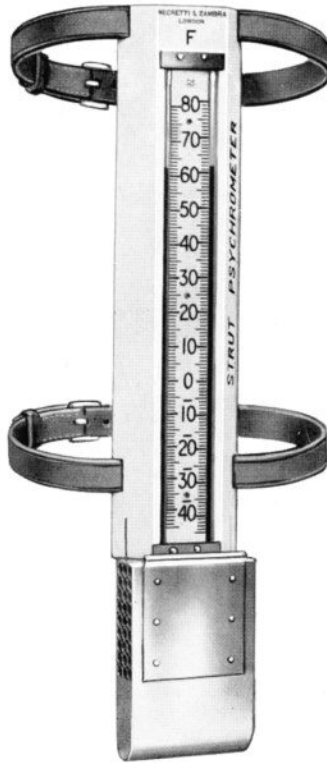


M 2252

**M 2252 Strut Air Thermometer.** The Thermometer serves the same purpose as the Indicator on page 115, but is of the Alcohol-in-Glass Type. The tube is of lens front, wide-bore type, filled with spirit coloured red for easy reading at a distance ; the bulb of "link" form to increased sensitivity. Range  $-35/+55^{\circ}$  C. The scale of duralumin about  $18\frac{3}{4}$ " long, graduated in degrees and figured boldly at every  $10^{\circ}$  C. The mount is of seasoned hardwood, shaped to fit the strut of the aeroplane, and covered with felt cloth. Two straps  $24" \times 1"$  are fixed to the mount. The sunshield is of polished nickel silver . . . . . **£4 5 0**



AIRCRAFT APPARATUS



M 2253

**Strut Psychrometer.** This instrument serves for the determination of temperature and humidity on aircraft. The tubes are of lens front, wide bore type, filled with spirit coloured red for easy reading at a distance, graduated on the stem  $-45^{\circ}$  to  $+80^{\circ}$  F. in single degrees ; the bulbs are of British normal glass ; scale plates of white metal about 18" long, graduated in degrees and figured boldly every 10°. The mount is of seasoned hardwood, shaped to fit the strut of an aeroplane, covered with felt cloth, and provided with two straps 21" long. The metal guard and tank, nickel finished, has a sliding shutter, giving access to the bulbs.

<b>M 2253 Strut Psychrometer</b>	.. .. .	<b>£11 0 0</b>
National Physical Laboratory Certificates to the Thermometers	.. .. .	<b>£1 0 0</b>



## UPPER AIR APPARATUS

**M 2254 Pilot Balloons** of good quality rubber, with necks ; capable of inflation without bursting to the following sizes, which are circumferences :—

48"	.. .. .	£0 0 6
70"	.. .. .	£0 0 9
90"	.. .. .	£0 1 6
150"	.. .. .	£0 4 6

**M 2255 Balloon Filler** for adjusting the volume of hydrogen so as to give the required free lift ; the gas pressure forces open a valve, and a spring closes it automatically, the supply then being cut off ; depression of the plunger liberates the gas. Four fillers—one of duralumin and three of brass, and two 5-gramme weights—constitute a set of fillers, Mark III. .. **£3 15 0**

**M 2256 Balloon Filler** for size 150", as above, made of brass and supplied in turned wooden container .. .. . **£1 3 0**

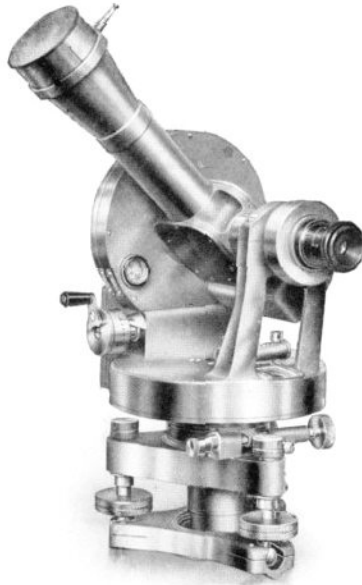
**M 2257 Balloon Release** comprises a rotor of stout cardboard, with wooden ends, mounted on a steel spindle about which it can rotate freely. Rotor and handle stained with creosote and two coats of shellac finish .. .. . **£0 15 0**

**M 2258 Slide Rule**, Mark II., for computation of the wind component velocities from the altitude and azimuth of the balloon, with or without tail and pendant. Scales engraved on white xylonite fixed to a mahogany stick.  $2.0\frac{3}{4}'' \times 2\frac{3}{16}''$ . Four special cursors are supplied. In leather case .. .. . **£4 10 0**





### UPPER AIR APPARATUS



M 2259

**M 2259 Balloon Theodolite.** Designed specially for observing pilot balloons (or *ballons-sondes*). The telescope is of the prismatic type : object glass 1.4" clear aperture, 10" focus with eyepiece  $\times 20$  ; it is set for infinity ; focussing by eyepiece on a specially-engraved glass diaphragm. The circles, horizontal and vertical, graduated to  $1^\circ$ , are operated by micrometer screws of one revolution =  $1^\circ$ . The drums are graduated into 10 parts to read 1/10th of a degree, or, if required, 60 parts to read one minute. Both circles are completely protected from dust, etc. The tripod is of extra length for convenience in observing. The case is of polished mahogany, and contains the instrument and all accessories. Measures 10"  $\times$  9"  $\times$  8 $\frac{1}{2}$ " .. .. .

£45 0 0

#### Weights.

Instrument .. .. .	12-lbs. (5.4 kgs.)
Case .. .. .	8-lbs. (3.6 kgs.)
Tripod .. .. .	15-lbs. (6.8 kgs.)

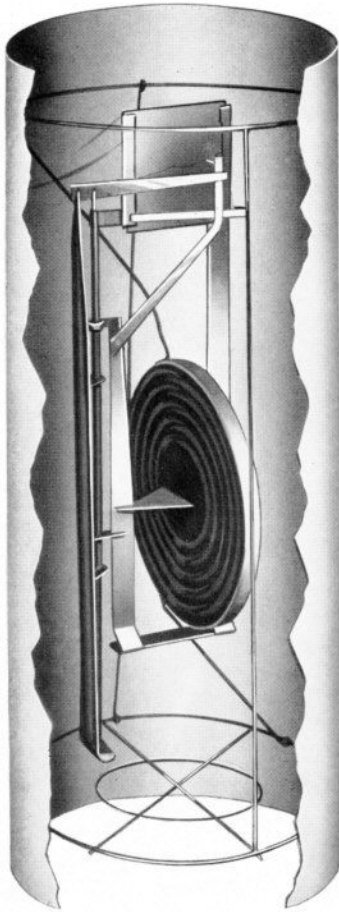
**M 2260 Fittings for Night Illumination.** One lamp beneath telescope eyepiece illuminating horizontal and vertical circles and micrometer drums, the second mounted on a telescope illuminates graticule internally. Current supplied by two-cell battery strapped on leg of tripod. Contact made without wire by spring plunger between tripod and instrument. Including dry battery .. .. .

£6 0 0





### UPPER AIR APPARATUS



M 2261

**Meteorograph.** The Balloon Meteorograph designed by Mr. W. H. Dines, F.R.S., is an extremely light apparatus for attachment to *ballons-sondes*. The mechanism consists of an aneroid diaphragm operating a scribe, which makes a scratch upon a thin piece of silver-plated metal 2.5 cm. square. A thermometric element of invar and nickel-silver also traces a record of the temperature on the same plate by means of another scribe. The distance between the two scribed lines at the different parts of the trace indicates the temperature corresponding with the different pressures.

The whole mechanism is mounted on a very light wire frame in an aluminium sheath, and weighs, complete, 71 grammes.

Each instrument must be calibrated before issue, a process which needs special plant and which is not included in the price. The resultant traces on a silvered metal plate are read by microscopic measurement.

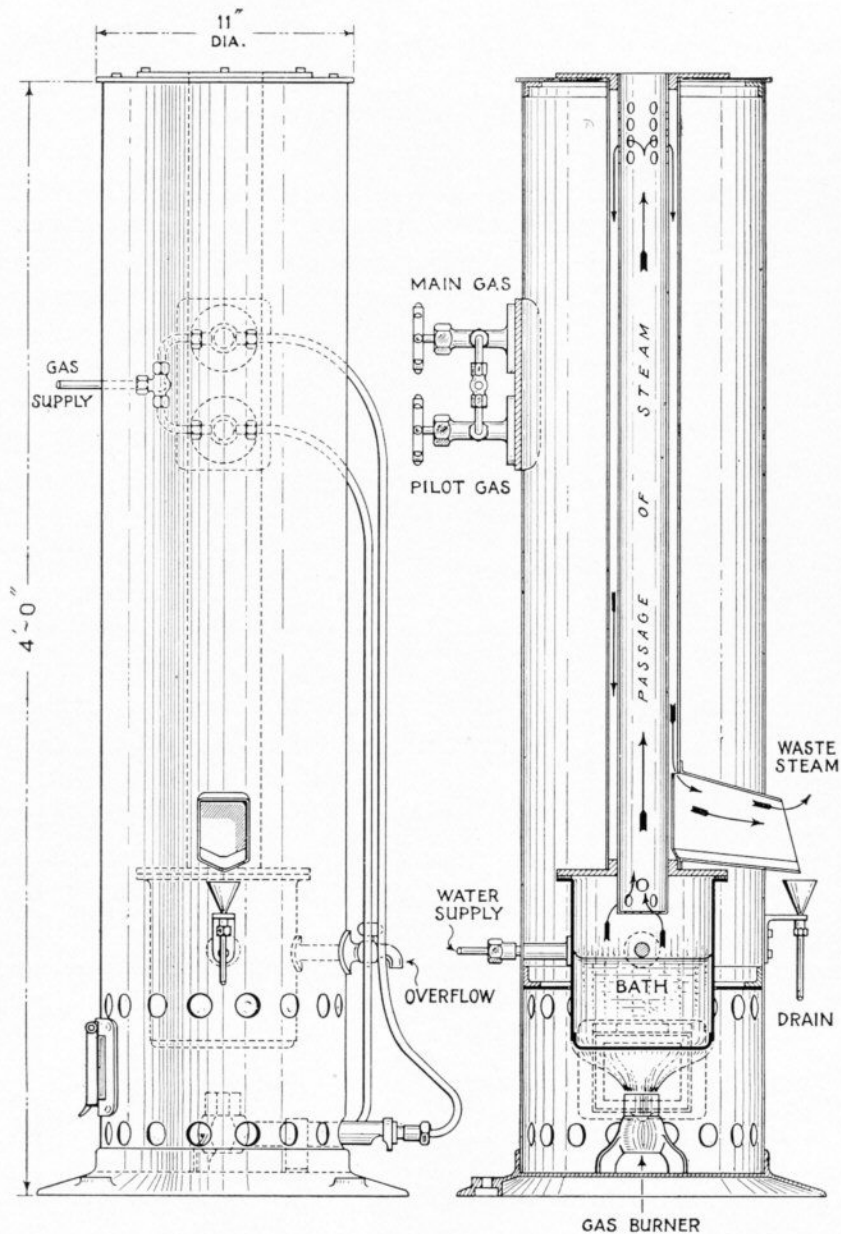
M 2261 Dines Meteorograph	.. .. .	£8 5 0
Calibration by the Meteorological Office	.. .. .	£0 12 6







### TEST APPARATUS



M 2262





## TEST APPARATUS

### THE HYSOMETER

The temperature of free steam provides a very definite temperature for the checking of a thermometer at or near 212° F. (100° C.), this being correct when the barometer reads 29.92 inches. A correction for the barometer reading is usually required.

The Hypsometer consists of a gas-heated bath, in which water is caused to boil. The steam from the bath passes up a long tube and down an outer tube to atmosphere, the important factor being that there will be no back pressure in the steam. The bulb and stem of the thermometer under test are inserted in the inner tube to the required depth of immersion. A temporary rubber joint may be made at the top where the thermometer enters the inner tube, but a leak of steam at this point is of no importance.

**M 2262 Hypsometer**, consisting of a brazed copper bath, 6" diameter, connected to an inner brass tube, 2" bore × 3' 0" long, the whole mounted on a cast-iron base with cylindrical sheet-metal casing 10" in diameter. Complete with special burner and needle valve, also water supply to bath, and connections as illustrated . . . . . **£35 0 0**

**M 2263 Hypsometer** of simple form, suitable for testing chemical thermometers, etc., 18" long, consisting of two concentric brass tubes mounted on a copper water container and ring type gas burner, without gas cocks . . . . . **£12 0 0**

**Portable Hypsometric Apparatus.** This is used in field surveys where a mercurial barometer cannot be carried. The principle is that described above, where a sensitive thermometer is inserted into a double cylindrical brass tube allowing a free passage for the stem from a small water boiler. The outfit comprises a brass spirit lamp and two thermometers graduated

180° to 212° F. in 0.2, or 80° to 100° C. in 0.1,

together with an additional thermometer for air temperatures. These parts are packed into a well-made solid leather case with cap and sling.

**M 2264 Hypsometrical Apparatus**, complete as above . . . . **£11 15 0**

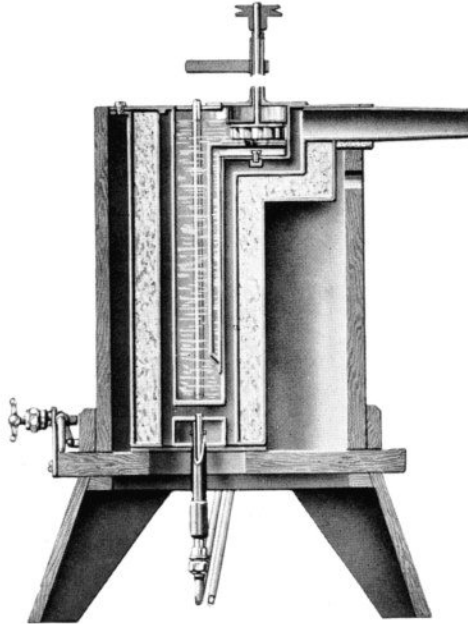
**M 2265 Extra Thermometer** for boiling points as above . . . . **£0 18 6**





**THERMOMETER TESTING APPARATUS**

**BENCH TYPE—GAS HEATED**



**M 2270**

The Bench Type of **Thermometer Testing Apparatus** is somewhat similar to the standard type described on the previous pages, except that the bath is of smaller volume with the object of more rapid control of the temperature. The bath is 2" diameter  $\times$  12" long. The burner is of a concentric type with an inner flame or pilot, controlled by a needle valve. The outer flame is the main burner for rapid heating and is also controlled by a needle valve. A centrifugal pump is provided at the top of the bath with a round belt pulley for driving from an electric motor or shafting. For the purpose of rapid cooling, a needle valve controls the supply of water running through cooling pipes in the bath. The whole apparatus is mounted in a polished wood case for bench fixing. Test Thermometers are described on the following page.

**M 2270** Bench Type **Gas - heated Thermometer Testing Apparatus**, as described above, with alloy, but without thermometer and motor. Range 400° F. to 1000° F. (200° C. to 540° C.) . . . . . **£60 0 0**

*The above apparatus is not suitable for Oil unless provision is made for an overflow.*



### TEST THERMOMETERS

**Test Thermometers** are very suitable for standardising Electrical Resistance or Distance Thermometers, and where great accuracy is required without total immersion. The bulb is of a comparatively large volume and the bore of the indicating column of mercury is of large area. The capillary tube leading from the bulb to the indicating tube is of very small diameter. This construction makes for greater accuracy in partially-immersed thermometers and reduces their emergent stem corrections.

These thermometers are calibrated for 4" immersion, and the lower ranges are graduated in both Centigrade and Fahrenheit degrees.



#### DOUBLE SCALE

Type.	Range.	Sub-divided.	Each.	With N.P.L. Certificate Extra.
M 2271	-40° to +140° F. and -40° to 60° C.	0.5° F. 0.2° C.	£1 18 6	£1 5 6
M 2272	0 to 250° F. and -18° to 120° C.	0.5° F. 0.2° C.	£1 15 6	£1 5 6
M 2273	200° to 500° F. and 93° to 260° C.	0.5° F. 0.2° C.	£2 2 0	£1 5 6

#### SINGLE SCALE

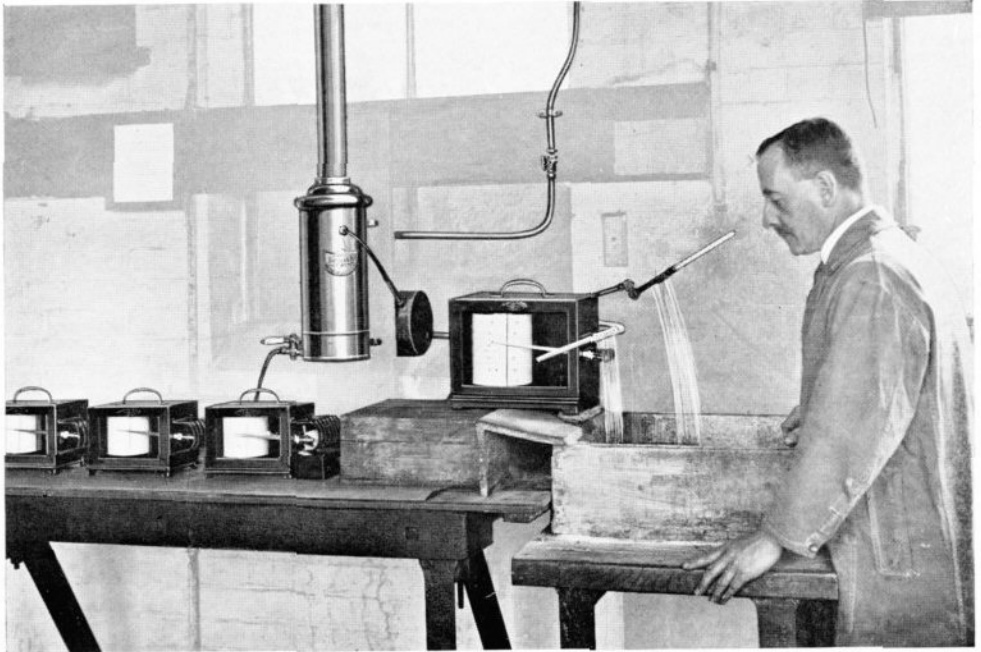
M 2274	200° to 950° F.	2.0° F.	£2 10 0	£1 1 6
M 2275	90° to 510° C.	1.0° C.	£2 10 0	£1 3 0

M 2272

Each Thermometer is supplied in a Cardboard Case.



## TEST APPARATUS



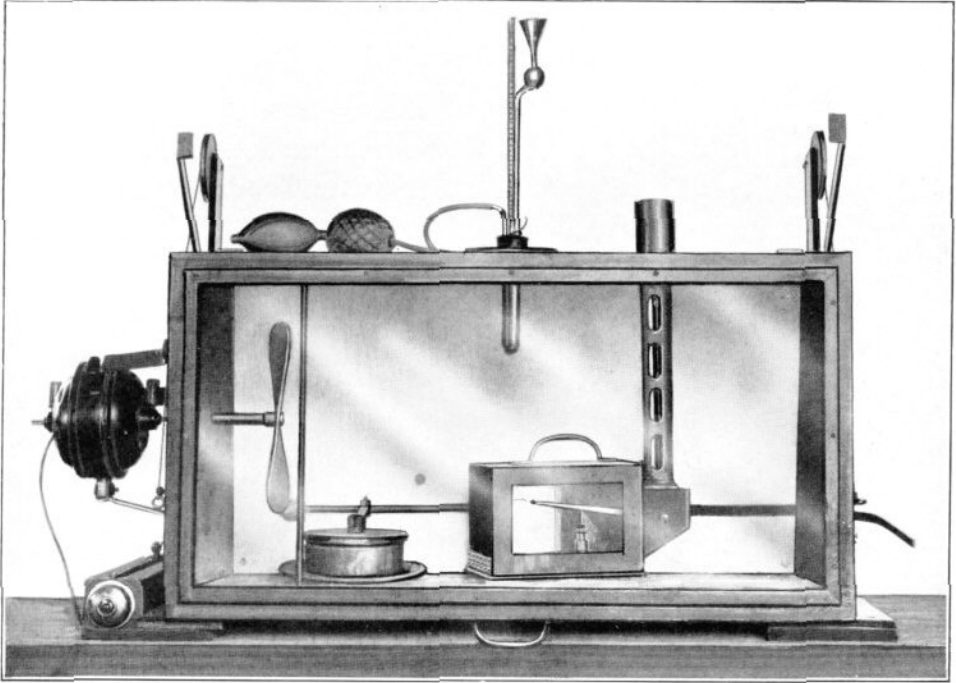
The checking of a Bimetallic Recorder is not a very simple affair, but it can be carried out roughly by placing a Standard Thermometer close to the coil and comparing the readings.

For a proper test of this type of instrument, we employ at our Works the method shown in the above illustration, where a current of water at the desired temperature flows over both the bimetallic coil and the standard thermometer, the errors of which are known. The result is that the bimetallic coil is subjected to identically the same temperature as that of the standard thermometer, and, consequently, the instrument is calibrated to within fine limits.

The above applies to temperatures above 60° F., and below this point we have a special refrigerating chamber arranged with a series of pipes and ventilating fan. Alcohol is forced through the pipe system and flows over the bimetallic coil, the temperature of which is measured by a standard thermometer. At the same time the air is thoroughly circulated by means of the fan, and by these means we are able to ensure that the scale at low temperatures is absolutely correct.



TEST APPARATUS



M 2276

The apparatus for testing Hygrometers consists of a chamber constructed of wood and varnished inside with a non-hygroscopic varnish. The chamber is fitted with a balanced hinged door, with two glass windows intercepted with an air space. Inside the chamber an electrically-operated fan is provided for rapid circulation of the air, and means provided for drying the air with sulphuric acid contained in a lead jar with a glass lid operated from outside the chamber.

The dew point apparatus is provided for ascertaining the humidity of the chamber, and this consists of a silver thimble into which a standard thermometer is inserted, and cooling is obtained by means of ether poured in through the funnel shown in the illustration. The ether is evaporated by means of the rubber bellows, and deposition of moisture on the silver thimble is observed through the glass windows.

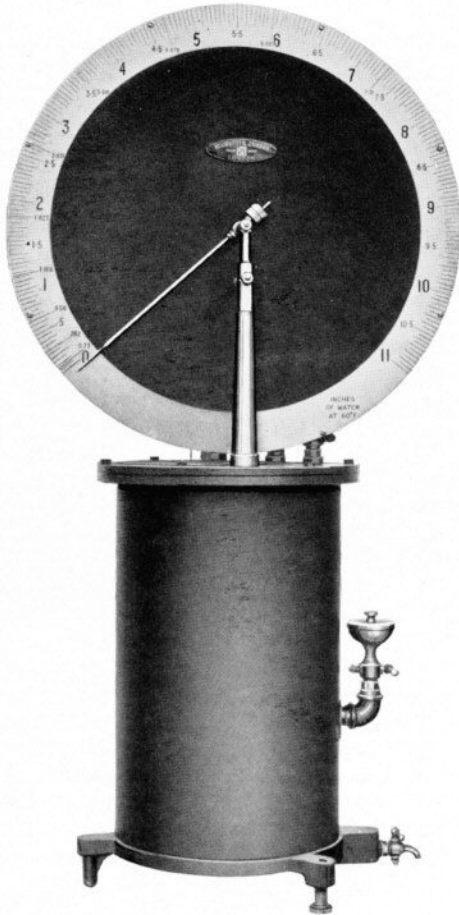
The method of obtaining relative humidity by means of the dew point apparatus is considered more accurate than the wet and dry bulb hygrometer, and all hygrometers are tested by this means.

The instrument shown inside the chamber is an N. & Z. Recording Hygrometer, and comparisons are made with the dew point apparatus.

**M 2276 Hygrometer Testing Apparatus** . . . . . Price on application



TEST APPARATUS



M 2277

**Water Manometer** for the calibration of Anemometers of the Pressure Tube Type, Air Speed Indicators, and for ascertaining static pressure of gas or air in the pipe lines.

The 14" engraved brass dial is ranged from 0 to 11" W.G., subdivided to .05" water pressure. 1" W.G. is represented by approximately 3" pointer travel.

The mechanism of this instrument consists of two concentric brass chambers mounted on a cast brass plate. Both the inner and outer tubes are half filled with water, and when pressure is applied to the outer chamber, the water in the inner chamber rises, the amount of which is measured by means of a float, chain, and pulley mechanism. The pointer spindle is mounted on hardened point bearings, with ample protection.

An inlet connection is provided at the top of the chamber, and a water level plug and small draining cock is provided for the adjustment of the zero position.

M 2277 Water Manometer . . . . . Price on application







### TEST APPARATUS

#### STANDARD MANOMETER

For the purpose of measuring pressure up to a few inches or feet head of water with precision, this apparatus has been designed by **Negretti & Zambra**, and is used as a standard of reference for all precision gauges for small pressure or suction.



M 2278

The apparatus consists of a standard scale calibrated in inches or millimetres. The vernier is operated by a rack and pinion, and attached to it is a concentric tank containing distilled water. A flexible tube leads from the tank to a chamber into which is inserted a hinged float and a sensitive spirit level.

The air pressure pipe is led to the float chamber for pressure measurement, and to the concentric chamber for suction.

In operation, the concentric chamber is adjusted to read zero on the standard scale. The float chamber is then adjusted so that the spirit level reads zero. If a pressure of 4" head of water is required, the concentric chamber is racked up to 4" on the scale, and set with precision by means of the vernier. If the pressure in the float chamber is exactly 4" head of water, then the spirit level still reads zero.

This "Null" method of obtaining the head of a liquid column is of the greatest precision, and the limit of accuracy depends upon the standard scale used.

M 2278 **Standard Manometer**, Range 0 to 6", reading to .002",  
as described above . . . . . **£16 10 0**

M 2279 Ditto, Range 0 to 4 feet, reading to .002" . . . . . **£48 0 0**





## TEST APPARATUS

### TEST BAROMETERS

For the purpose of measuring pressure below normal atmospheric pressure with precision, such as for instance in the calibration of Aneroids, etc., this Standard Test Barometer is used.

The bore of the glass tube is 0.5", and the Range is 32" to 5" barometric pressure, reading to .002". The cistern is of cast iron, with a connecting pipe for coupling to a pump or receiver.

In order to make the barometer reasonably safe in transport, the cistern is fitted with a needle valve, which shuts off the connecting pipe, so that when the barometer is inverted there is no loss of mercury. The barometer is transported in an inverted position in a special crate with carrying handle.

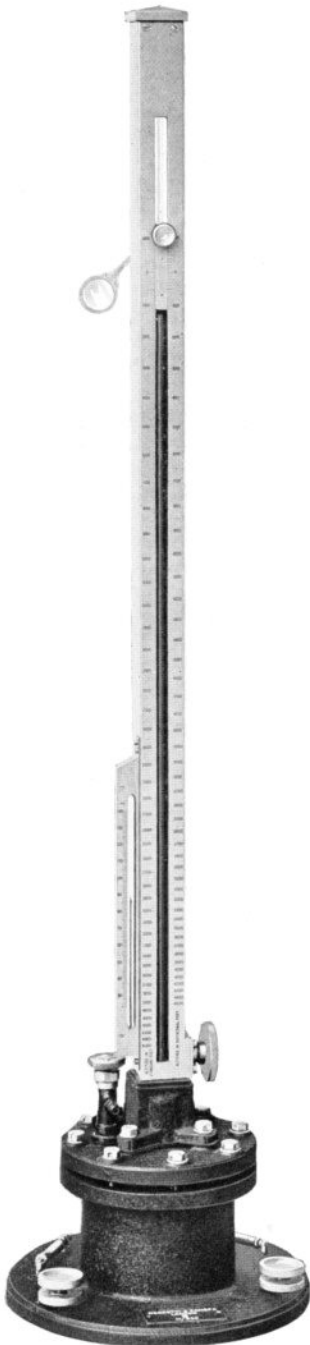
The instrument is fitted with a thermometer for temperature corrections.

*As supplied to the British Air Ministry.*

**M 2280 Test Barometer**, Range 32" to 5", and in altitude to 40,000 feet, as described above and illustrated. Complete in crate . . . . **£54 0 0**

**M 2281 Test Barometer**, Range 800 mms. to 130 mms., and in altitude to 12,000 metres. Ditto . . . . **£54 0 0**

With National Physical Laboratory Certificate for Pressure Scale, extra, **£1 15 0**



**M 2280**

In the calibration of this Barometer, it should be stated whether the altitude is to be graduated from Airy's Table, Isothermal, or I.C.A.N. Tables.





## TEST APPARATUS

**Test Barometer** designed primarily for the testing of Aneroids and Barographs to 8" mercury and approximately 30,000 feet altitude.

The bore of the glass tube is 0.25" internal diameter.

Portability is arranged as follows :—

A spring plunger, which closes the end of the glass tube, is screwed into the base of the iron cistern. When the barometer is received and put into action, this plug is removed (the instrument being held with the cistern uppermost), and in its place is inserted another plug without the spring arrangement.

The brass tube is fitted with one vernier which will slide over the whole range of the scale by hand, and fine adjustment is provided by means of a milled-head screw concentric with the tube.

The cistern is of special close-grained cast iron, with a cast-iron flange screwed on the base, and drilled with holes suitable for bolting the instrument to a bench.

A thermometer, with a range of 0/120° F. or C., as required, is fitted to the instrument.

The Barometer is supplied in a special box, with rubber packings to prevent undue shocks in transit.

**M 2282 Test Barometer** as above . . . . . **£28 10 0**

## ANEROID TESTING SET

Consisting of :—

Standard Barometer No. 2280 or No. 2281.

Vacuum Chamber No. 2284 or No. 2289.

Thermal Chamber.

A Wooden Box with a metal box inside to contain the instrument under test ; round the metal box is an air duct in which heating unit and cooling coils are provided, an electric fan circulating the air.

Regulation Resistance for heating unit.

Vacuum Tank of welded steel 6" diameter × 10" deep.

Hand or Power-driven Exhaust Pump of the oil seal type, fitted with a flywheel.

Full set of fine adjustment valves, copper connecting pipe, etc.

**M 2283 Complete Testing Set** . . . . . Price on application

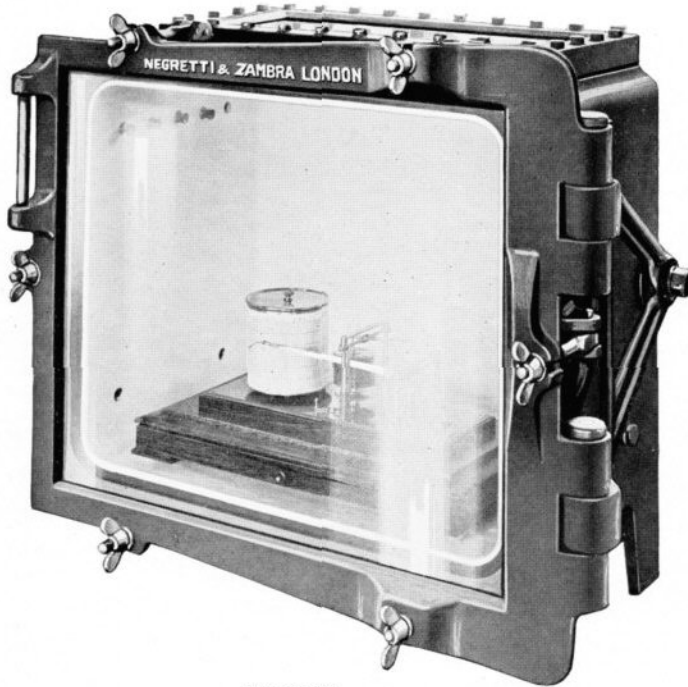


**M 2282**





TEST APPARATUS



M 2284

*As supplied to the British Air Ministry.*

**Vacuum Chamber** for testing Aneroids, Barographs, etc., within the Range of 34" to 9" of barometric pressure. The chamber is of cast iron, with a 1" plate-glass window at the top, and a 1 $\frac{1}{4}$ " plate-glass panelled door in front. The door is on special hinges, and a joint is made between the plate glass and the chamber with a rubber ring. Six wing nuts are provided for holding the door closed. Wire guard, if required, at additional cost.

A connection is made for exhaust, also terminals for any electric connections that may be required for heaters, etc., when carrying out temperature tests under a vacuum.

Inside dimensions 20 $\frac{1}{2}$ " wide  $\times$  17" high  $\times$  13" deep. Weight approximately 4 $\frac{1}{2}$ -cwts.

M 2284	Vacuum Chamber	.. .. .	£67 10 0
M 2285	Needle Valve with union (two required)	.. .. . each	£0 11 6
M 2286	Copper Tubing, $\frac{1}{4}$ " o/d. $\times$ 22 S.W.G.	.. .. . per foot	£0 0 6
M 2287	Couplings, Brass	.. .. . each	£0 0 8
M 2288	Tee-piece with unions	.. .. . "	£0 2 0





TEST APPARATUS



M 2289

**Vacuum Chamber** for testing Aneroids, etc. The Chamber is of welded steel sheet, with a heavy cast-iron flange to which a plate-glass door is hinged.

The hinged frame which carries the plate-glass front is of cast iron, with a brass bezel supporting the plate glass ; the whole is held down with four wing nuts.

The plate-glass window is  $\frac{1}{2}$ " thick, sufficient to withstand an internal vacuum down to 8" of mercury. A special wire guard can be provided at additional cost, where tests are required to be taken at a lower vacuum.

Two connections are provided—one to connect to the barometer and the other to the control cocks. Three control cocks are provided, but in the event of the vacuum tank being dispensed with, two cocks only are necessary.

**M 2289 Vacuum Chamber** . . . . . £24 0 0

DIMENSIONS :— $9\frac{1}{4}$ " diameter  $\times$  11" long. Glass window  $9\frac{1}{8}$ " diameter.

**Note.**—It is important in the use of this Chamber to prevent any scratchings on the glass face which might cause fracture when the instrument is used under a high vacuum.



FAHRENHEIT AND CENTIGRADE CONVERSION TABLE

°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.
-40	-40	10	-12.2	60	15.6	110	43.3	160	71.1
-39	-39.4		-12	60.8	16	111	43.9	161	71.7
-38.2	-39	11	-11.7	61	16.1	111.2	44	161.6	72
-38	-38.9	12	-11.1	62	16.7	112	44.4	162	72.2
-37	-38.3	12.2	-11	62.6	17	113	45	163	72.8
-36.4	-38	13	-10.6	63	17.2	114	45.6	163.4	73
-36	-37.8	14	-10	64	17.8	114.8	46	164	73.3
				64.4	18				
-35	-37.2	15	-9.4	65	18.3	115	46.1	165	73.9
-34.6	-37	15.8	-9	65	18.3	116	46.7	165.2	74
-34	-36.7	16	-8.9	66	18.9	116.6	47	166	74.4
-33	-36.1	17	-8.3	66.2	19	117	47.2	167	75
-32.8	-36	17.6	-8	67	19.4	118	47.8	168	75.6
-32	-35.6	18	-7.8	68	20	118.4	48	168.8	76
-31	-35	19	-7.2	69	20.6	119	48.3	169	76.1
		19.4	-7	69.8	21				
-30	-34.4					120	48.9	170	76.7
-29.2	-34	20	-6.7	70	21.1	120.2	49	170.6	77
-29	-33.9	21	-6.1	71	21.7	121	49.4	171	77.2
-28	-33.3	21.2	-6	71.6	22	122	50	172	77.8
-27.4	-33	22	-5.6	72	22.2	123	50.6	172.4	78
-27	-32.8	23	-5	73	22.8	123.8	51	173	78.3
-26	-32.2	24	-4.4	73.4	23			174	78.9
-25.6	-32	24.8	-4	74	23.3	124	51.1	174.2	79
						125	51.7	175	79.4
-25	-31.7	25	-3.9	75	23.9	125.6	52	176	80
-24	-31.1	26	-3.3	75.2	24	126	52.2	177	80.6
-23.8	-31	26.6	-3	76	24.4	127	52.8	177.8	81
-23	-30.6	27	-2.8	77	25	127.4	53	178	81.1
-22	-30	28	-2.2	78	25.6	128	53.3	179	81.7
-21	-29.4	28.4	-2	78.8	26	129	53.9	179.6	82
-20.2	-29	29	-1.7	79	26.1	129.2	54		
						130	54.4	180	82.2
-20	-28.9	30	-1.1	80	26.7	131	55	181	82.8
-19	-28.3	30.2	-1	80.6	27	131	55	181.4	83
-18.4	-28	31	-0.6	81	27.2	132	55.6	182	83.3
-18	-27.8	32	0	82	27.8	132.8	56	183	83.9
-17	-27.2	33	0.6	82.4	28	133	56.1	183.2	84
-16.6	-27	33.8	1	83	28.3	134	56.7	184	84.4
-16	-26.7	34	1.1	84	28.9	134.6	57	185	85
				84.2	29			186	85.6
-15	-26.1	35	1.7	85	29.4	135	57.2	186.8	86
-14.8	-26	35.6	2	86	30	136	57.8	187	86.1
-14	-25.6	36	2.2	87	30.6	137	58.3	188	86.7
-13	-25	37	2.8	87.8	31	138	58.9	188.6	87
-12	-24.4	37.4	3	88	31.1	138.2	59	189	87.2
-11.2	-24	38	3.3	89	31.7	139	59.4	190	87.8
-11	-23.9	39	3.9	89.6	32			190.4	88
		39.2	4			140	60	191	88.3
-10	-23.3			90	32.2	141	60.6	192	88.9
-9.4	-23	40	4.4	91	32.8	141.8	61	192.2	89
-9	-22.8	41	5	91.4	33	142	61.1	193	89.4
-8	-22.2	42	5.6	92	33.3	143	61.7	194	90
-7.6	-22	42.8	6	93	33.9	143.6	62		
-7	-21.7	43	6.1	93.2	34	144	62.2	195	90.6
-6	-21.1	44	6.7	94	34.4			195.8	91
-5.8	-21	44.6	7			145	62.8	196	91.1
				95	35	145.4	63	197	91.7
-5	-20.6	45	7.2	96	35.6	146	63.3	197.6	92
-4	-20	46	7.8	96.8	36	147	63.9	198	92.2
-3	-19.4	46.4	8	97	36.1	147.2	64	199	92.8
-2.2	-19	47	8.3	98	36.7	148	64.4	199.4	93
-2	-18.9	48	8.9	98.6	37	149	65	200	93.3
-1	-18.3	48.2	9	99	37.2			201	93.9
-0.4	-18	49	9.4			150	65.6	201.2	94
				100	37.8	150.8	66	202	94.4
0	-17.8	50	10	100.4	38	151	66.1	203	95
1	-17.2	51	10.6	101	38.3	152	66.7	204	95.6
1.4	-17	51.8	11	102	38.9	152.6	67	204.8	96
2	-16.7	52	11.1	102.2	39	153	67.2		
3	-16.1	53	11.7	103	39.4	154	67.8	205	96.1
3.2	-16	53.6	12	104		154.4	68	206	96.7
4	-15.6	54	12.2					206.6	97
				105	40.6	155	68.3	207	97.2
5	-15	55	12.8	105.8	41	156	68.9	208	97.8
6	-14.4	55.4	13	106	41.1	156.2	69	208.4	98
6.8	-14	56	13.3	107	41.7	157	69.4	209	98.3
7	-13.9	57	13.9	107.6	42	158	70		
8	-13.3	57.2	14	108	42.2	159	70.6	210	98.9
8.6	-13	58	14.4	109	42.8	159.8	71	210.2	99
9	-12.8	59	15	109.4	43			211	99.4
								212	100



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INDEX.

- Actinometer, 69
- AIR METERS, 7
- Air Temperature Recorders, 98/9, 116
- "    "    Indicator, 115
- "    Thermometer (Strut), 117
- Aircraft Thermometers, 115-118
- ANEMOMETERS, 5-22
- "    Cup, 5, 6
- "    Counter, 5
- "    Dial, 13
- "    Dines', 16
- "    Electrical, 6
- "    Exposure of, 4
- "    Recording, 14-19
- "    "    Direction, 11, 21
- "    Test Apparatus, 130
- Anemo-Biograph, 14
- "    with Direction Recorder, 19
- Anemoscope, 21
- Aneroid Barometers, 30-37
- "    "    Precision, 33
- "    "    Test Apparatus, 132-135
- Aspirated Hygrometer, 90
- Assmann Hygrometer, 90
- Balloons, 119
- "    Fillers, 119
- "    Release, 119
- "    Slide Rule, 119
- "    Theodolite, 120
- BAROMETERS, 23-29
- "    Aneroid, 30-37
- "    Cases for, 27
- "    Fortin, 25-27
- "    Kew, 28
- "    Mountain, 29
- "    Recording, 38-44
- "    Station, 28
- "    Student, 29
- "    Test, 132
- "    Test Apparatus, 133
- BAROGRAPHS, 38-44
- "    Test Apparatus, 133/4
- Baro-Thermograph, 43
- Baro-Thermo-Hygrograph, 44
- Besson Nephoscope, 64
- Bimetallic Thermographs, 93-96, 109-111
- Boiling Point Apparatus, 122/3
- Books, 137
- Bradford Rain Gauge, 48
- Camden Measure, 49
- Campbell-Stokes Recorders, 59-61
- Chambers, Vacuum, 134/5
- Combined Anemo-Biograph and Wind Direction Recorder, 19
- Combined Barometer and Thermometer, 43
- "    Barometer, Thermometer and Hygrometer, 44
- "    Hygrometer and Thermometer, 111
- Conversion Tables, 136
- Counter Anemometer, 5
- Cup Anemometer, 5
- Deep Sea Thermometers, 74-78
- "    "    "    Recording, 104
- Dew Point Hygrometer, 91/2
- Dial Anemometer, 13
- "    Rain Gauge, 48
- Diaphragms for Aneroids, 30
- Dines' Anemometer, 16
- "    Meteorograph, 121
- Earth Thermometer, 70
- "    Temperature Recorder, 100
- Electrical Anemometer, 6
- "    Recording Thermometer, 106
- Evaporation Gauge, 57
- "    Tank, 57
- Evaporimeter, 57
- Fillers, Balloon, 119
- Finemann Nephoscope, 64
- Float Pattern Rain Gauge, 55
- Fortin Barometers, 25-27
- Gauge, Percolation, 58
- "    Evaporation, 57
- "    Rain, 45-56
- "Gold" Slide, 28
- Grass Minimum Thermometers, 68
- Hair Hygrometer, 93
- "    Recording, 114
- Head, Wind "Direction, 10
- "    "    Velocity, 12
- "    "    Combined, 18
- HYGROMETERS, 84-93
- "    Aspirated, 90
- "    Dew Point, 91/2
- "    Hair, 93
- "    Recording, 109-114
- "    Standard, 85/6
- "    Strut, 118
- "    Test Apparatus, 129
- "    Ventilated, 87-90
- "    Wet and Dry, 85-90
- "    Whirling, 87-89
- HYGROGRAPHS, 111-114
- Hyetograph, 50
- Hygroscope, 93
- Hypsometer, 122/3
- Index Gauge, 57
- Kew Barometer, 28
- Manometer, 130
- Marine Barometer, 28
- "    Screen, 73
- "    Biological Frame, 77
- Magnaghi Biological Frame, 77
- Mast for Anemometer, 22
- Maximum Thermometers, 66-69
- Measures, Rain, 49





INDEX—continued.

- Meteorograph, 121  
 Mercury-in-Steel Thermometers, 97-105  
 " " Hygrometers, 110, 112/3  
 Micro-Barograph, 41  
 Miller Deep Sea Thermometer, 78  
 Minimum Thermometers, 66-69  
 Mountain Barometer, 29  
 " Rain Gauge, 48
- Natural Syphon Gauge, 52  
 Nephoscopes, 64
- Percolation Gauge, 58  
 Photographic Temperature Recorder, 107  
 Piche Evaporimeter, 57  
 Pitot Tubes, 8, 9  
 Pluviometers. *see Recording Rain Gauges.*  
 Pocket Thermometers, 71  
 Precision Aneroid, 33  
 Protectors, Thermometer, 73  
 Psychrometers. *see Hygrometers.*  
 "Public School" Set, 82  
 Publications, 137  
 Pyrheliometer, 63
- RAIN GAUGES, 45-56  
 " " Dial, 48  
 " " Measures, 49  
 " " Recording, 50-56  
 Recording Anemometers, 14-19  
 " Barometers, 38-44  
 " Hygrometers, 109-114  
 " Rain Gauges, 50-56  
 " Thermometers, 94-108
- Régnauld's Hygrometer, 91/2  
 Release, Balloon, 119  
 Reversing Thermometers, 74-77  
 " Frames, 77  
 Robinson Anemometers, 6  
 Rule, Slide, 119
- SCREENS, 80-83  
 Scottish Frame, 77  
 Seathwaite Rain Gauge, 47  
 Sea Water Bottle, 78  
 Sea Surface Temperature Recorder, 102  
 SETS, Meteorological, 82/3  
 Shipboard Screen, 81  
 Six's Thermometer, 71  
 " Deep Sea Thermometer, 78  
 Slide Rule, 119  
 " "Gold," 28  
 Snowdon Gauge, 46/7  
 Solar Thermometers, 69  
 Solarimeters, 63  
 Stands for Screens, 81  
 Standard Barometers, 23-29  
 " Thermometers, 72/3  
 Station Barometers, 27/8  
 Stevenson's Screens, 80/1
- Strut Thermometer, 117  
 " Psychrometer, 118  
 SUNSHINE RECORDERS, 59-62  
 Support for Mast, 22  
 Surface Thermometer, 79
- Tables, Conversion, 136  
 " Hygrometric, 137  
 Tank, Evaporation, 57  
 Taper Measures, 49  
 Temperature Recorders. *see Thermographs.*  
 TEST APPARATUS, 122-135  
 " Thermometers, 127  
 Theodolite, 120  
 Thermo-Hygrograph, 111  
 THERMOMETERS, 66-79  
 " Air Temperature, 115  
 " Deep Sea, 74-78  
 " Earth, 70  
 " Electrical, 106  
 " Maximum, 66-69  
 " Minimum, 66-69  
 " Mercury-in-Steel, 97  
 " Pocket Maximum and  
 " Minimum, 71  
 " Radiation, 68/9  
 " Sea Water, 73  
 " Standard, 72/3  
 " Six's, 71  
 " Surface, 79  
 " Tables, 136  
 " Test, 127  
 " Test Apparatus,  
 " 124-126  
 " Wet and Dry Bulb,  
 " 85-90
- THERMOGRAPHS, 94-108  
 " Test Apparatus, 128  
 Tilting Bucket Rain Gauge, 53  
 Tubes, for Earth Thermometers, 70  
 " Pitot, 8, 9  
 " Venturi, 9
- UPPER AIR APPARATUS, 119-121
- Vacuum Chambers, 134/5  
 Vanes, Wind, 20  
 Venturi Tubes, 9  
 Vernier, 24
- Water Bottle, 78  
 Water Manometer, 130  
 Whirling Hygrometers, 87-89  
 Wind Direction Head, 10  
 " " Indicator, 10  
 " " Recorders, 11, 21  
 " Velocity Head, 12  
 " " Indicator, 13  
 " " Recorders, 14-19  
 " Vanes, 20





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