

**DESIGN AND CONSTRUCTION OF METEOROLOGICAL INSTRUMENTS
-THE NIGERIA EXPERIENCE**

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ABSTRACT

The Nigerian Meteorological Agency is at the midpoint of an unprecedented effort to engage in the design and fabrication of some conventional and automatic weather monitoring instruments that are also suitable for installation where power supply is an issue.

The goal of this undertaking, which include challenges, is to promote technology transfer and subsequently conserve foreign exchange, which the Agency normally spend on conventional Instruments Procurement.

The paper will address the agency's local manufacturing capability and the efforts being made in the design and development of semi-automatic weather monitoring instruments. Detailed design and construction of electronic wind speed and wind direction indicators is covered in this work.

INTRODUCTION

The Nigerian Meteorological Agency has its fabrication workshop in Lagos, where the operational headquarters is located. The workshop was originally established to maintain conventional meteorological instruments.

Shortly after the then Department of Meteorological Services under the ministry of Aviation became autonomous and transited to an agency (Nigerian meteorological Agency) in year 2002, the Director-General of the Agency, Mr. L.E. Akeh, introduced an awareness program by organizing lectures on service delivery and this led to an aggressive drive by members of staff to contribute their quota to the progress of the newly established Agency.

The Oshodi Workshop in Lagos, Nigeria manufactures basic meteorological equipment such as Rain Gauges, Class 'A' Pan Evaporimeter, Stillwell, Hook Gauges, Telecommunication masts, Automatic Weather Station couplers, anemometer masts, thermometer brackets, Stevenson screens for thermometers and thermo hygrographs, Wind vane called weather vanes, and other mechanical parts needed for maintenance of existing equipment.

The raw materials required to produce the above listed instruments are available in the local market. In the case of self recording rain gauge, more than 70% of the materials used are sourced locally, for accuracy of measurement and conformity to the World meteorological Organization standards, mechanical clock and the siphon chamber are being sourced from abroad to produce a complete tilting siphon rain gauges.

Work is in progress on the design and fabrication electronic weather observing instruments such as digital thermometer, Tipping bucket rain gauge, cup counter anemometer, humidity sensor and the wind monitor.

Effort to produce basic meteorological instruments locally by the Nigerian meteorological Agency is borne out of a desire to make available these instruments for use at cheap and affordable price to all users of environmental monitoring equipment in the country.

LOCAL MANUFACTURING CAPABILITY

The pictures below show some areas in which we have capabilities



Fig. 1.0 Technicians working in the workshop



Fig.2.0 A section of NIMET fabrication workshop at Oshodi



Fig. 3.0 some of the fabrication equipment in the workshop

WIND VANE

This instrument is designed for the indication of wind direction. For a given change in the direction of wind, it will rotate with minimum friction since it is balanced to avoid being tilted towards any particular direction.

The instrument consists of a horizontal arm with a rectangular flat aluminium plate at one end and a brass counterweight at the other end, mounted on a vertical spindle, which rotates freely on a frictionless ball bearing. The support for the bearing incorporates a ring carrying the four direction arms (N-W-S-E) and this is securely locked in position once oriented correctly with compass.



Fig. 4.0 Wind vane produced at the workshop

2.0 ORDINARY RAIN GAUGE

This instrument is made from galvanized sheet with soldered seams and its circular base provides extra stability. It has a brass rim of diameter 127mm and an inner can with a pouring lip and handle. The measuring jars or glass-collecting bottles are normally purchased to measure the amount of rain over a particular period of time.



Fig. 5.0 Production process of a simple rain gauge

In Nigeria, the use of this instrument is in high demand in rainfall stations, schools and research institutes for precipitation measurements. The cost of each imported rain gauge is roughly \$412 whereas a locally made one is \$200. Therefore, the low cost of local rain gauge has assisted the Agency to conserve foreign currency for procurement of modern technological equipment from hydro-meteorological equipment manufacturers from the developed countries.



Fig. 6.0 Component parts of a simple rain gauge



Fig.7.0 Finished products wrapped ready for installation.

3.0 STEVENSON SCREEN

The workshop also constructs large Stevenson Screen with suitable wood for use in our synoptic stations all over the country. The screen produced is a rectangular wooden box provided with doors at the back and front; the sides, back and front are double louvered. The base of the floor consists of overlapping boards; the roof is also double and is separated vertically by an air space. The front door is suspended and is securely mounted at the bottom with two hinges. When open, it is suspended in the horizontal position by two chains. The extra space available is normally used to house a bimetallic thermograph and air hygograph, resting on the centre board, one on each side of the thermometers. The top of the screen is covered with galvanized sheet, which is turned at the edges; the wooden screen is painted with white gloss that reflects from light, keeping the thermometer from heating above the air temperature. The model's double louvers features and a separated top minimizes the effect o direct solar radiation and yet allow airflow to ensure accurate temperature and humidity readings by the enclosed instruments.

Dimensions: 49cm(H) x99cm (W) x30cm (D).



Fig. 8.0 Stevenson Screen

6.0 CLASS A PAN EVAPORIMETER

We construct Class 'A' pan with gage 14 galvanized iron plate. The instrument is painted with silver coated gloss paint.

SPECIFICATIONS:

Material: Galvanized Iron

Construction: Heliarc welded

Size: 25cm(H) x 120cm Dia.

Material: Galvanized Iron

A complete evaporimeter consists of Class A Pan, Hook gauge and Stillwell.



Fig.9.0 Complete Evaporimeter



Fig.10.0 Class A Pan Evaporimeter under construction

7.0 HOOK GAUGE EVAPORIMETER

The hook gauge is made from brass and it consists of cast brass tripod frame and engraved brass component. It is graduated from 0 to 10mm and subdivided to 0.02mm by means of an engraved micrometer dial. The instrument is used to measure evaporation rate from a free water surface. Hook gauge rests on top of still well. The gauge is supported by its three arms and has a micrometer head for very accurate adjustment.



The gauge is normally placed in a still well and adjusted so that the point of the hook just breaks the water surface. The change in the water level is then read on the adjusted micrometer.

Fig. 11.0 The Hook gauge

8.0 STILL WELL

This is a cylindrically shaped instrument that rests on a cast brass tripod. It is normally installed in conjunction with the hook gauge at the center of Class A pan and provides a small area of water surface that is free from ripples thus permitting measurement of evaporation rate from a free water surface.



Fig. 12.0 Stillwell and the hook gauge

DIGITAL THERMOMETER

The effort being made in this direction is to start doing something that will give us the competence to come up with the design of low cost digital meteorological instruments in the no distant future. This is of course a work in progress that will still accommodate many design improvements as time goes on. The thermometer below is designed to display with no logging device.



Fig.13.0 Digital Thermometer

13.0 WIND DIRECTION AND WIND SPEED ANEMOMETER:

We are working on speed and direction sensor from base the parts. There is a pre-programmed microprocessor to decode the sensor input and display readings on a neat LED display. There is also an RS-232 interface to communicate with the PC.

This design only needs two wires from the interface to the sensors thus reducing cable costs. And this can be adapted to use optical fibre giving a total lightning safe unit.

The direction sensor uses the four inner reflective rings to get a 4-bit binary code; a latching buffer is added to only read position when the disc is in the center of a binary digit. The outer ring is used to enable the buffer, and also to give tachometer pulses for the wind speed instrument.

Reflective IR (Infra-Red) units are used with the PCB (Printed Circuit Board) mounted in the base of the housing.

WIND DIRECTION SENSOR

We were able to determine the direction of the wind by connecting 50Hz Astable multivibrator generates a triangular wave at 50Hz to the non-inverting input of the operational amplifier. The sensor converts the angular displacement into voltage value, which is fed into the inverting input of the Op-amp. The output of the Op-amp. is 50Hz pulse width modulated square wave whose width varies with angular displacement of the sensor. Another high frequency astable multivibrator is designed to generate frequency in multiples of 359Hz i.e. $359.9 \times 50 \times 10 = 179.5 \text{ kHz}$. This also takes care of one place of decimal counting. The output of this astable multivibrator and that of the Op-amp is fed to the AND gate whose output is a pulse train, the number of pulses per train depends on the width of the output of the operational amplifier which corresponds to the angular degree of the direction of the wind. The pulse train is now fed into BCD (Binary Coded-Decimal) counter that counts the number of pulses per train for each width of the operational amplifier output. As the width collapses, the counter resets and the process is repeated 50 times in one second (50Hz), which allows the display to appear as being stable. The output of the BCD Counter is fed from the BCD to seven-segment decoder, which decodes the readings and displays it on the seven-segment display.

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