



INSTITUTE of HYDROLOGY

LOW-COST

WEATHER

SENSORS

A LOW-COST AUTOMATIC WEATHER STATION

LOW COST SENSORS

IH Project No. 13/21 C 2

In the early 1980s ODA funded a project proposed by IH to develop a low-cost, simple to service, simple to operate, rain gauge. The idea for this, and for a series of low cost instruments, was conceived by the Applied Physics Section of IH through work overseas, the problems of instrument servicing becoming increasingly apparent. ODA funding for this development ended before the product was fully developed and before the earlier technique of using fibreglass for construction had been changed to the more versatile and cheaper process of vacuum-forming.

ODA subsequently funded the present project, the aims of which were to develop further low-cost sensor systems (wind, radiation and temperature in particular). While, initially, this was visualised as involving the development of several separate sensors, which could be combined into one structure, as the project advanced and ideas were explored on paper, and a few in hardware, it became clear that the better path was to combine the sensors into one single unit from the start, resulting in a low cost AWS. It is rare for just one of these variables to be measured on its own and by combining them a much cheaper product resulted. This was so because the same vacuum-forming technique developed for the rain gauge could be applied in an innovative new design of AWS. In this way a departure is possible from the conventional and ungainly AWS structures of masts cross-arms individual sensors and external cables.

Development, from this stage on, comprised designing the general structure of the system and making vacuum-forming moulds from which to draw-down a number of experimental mouldings in white, UV-resistant plastic sheet. The general appearance of the prototype is illustrated in the figures (see accompanying notes on registration of design). However, the system is not to a final stage ready for production. Thorough testing must now follow and modifications invariably result from this. It is probable that development will be completed within a further twelve months. At this stage a paper will be written on it and ODA will, of course, receive a copy.

Since the vacuum-formed raingauge development was completed and the unit put into commercial production, it has proved to be very popular with AWS manufacturers in the UK and several companies now market it as part of their AWS. Since the new AWS could have as big, or bigger, an influence on the AWS market, due to its much lower cost, portability, and departure from heavy, sometimes crude, structures, IH has taken the precaution to have the design registered before allowing it to enter the public domain. For this reason no papers have yet been written on it and it has not been on public view or on out-of-door test. Registration was completed recently. Some of the correspondence and figures concerning registration are appended since they give additional information to that set out above.

The raingauge was recently the subject of a study commissioned for ODA, by Maendoleo, of ODA-funded instrument/equipment developments. One of the study's recommendations was that the

arbitrary ending of funding of such developments after a set time (usually three years) was a mistake, since such projects generally take four or five years, at least, to complete. This has been the case for both the raingauge and the AWS and has left IH to find science budget funding to complete the work. This could have resulted in the project failing if money had not been made available for completion.

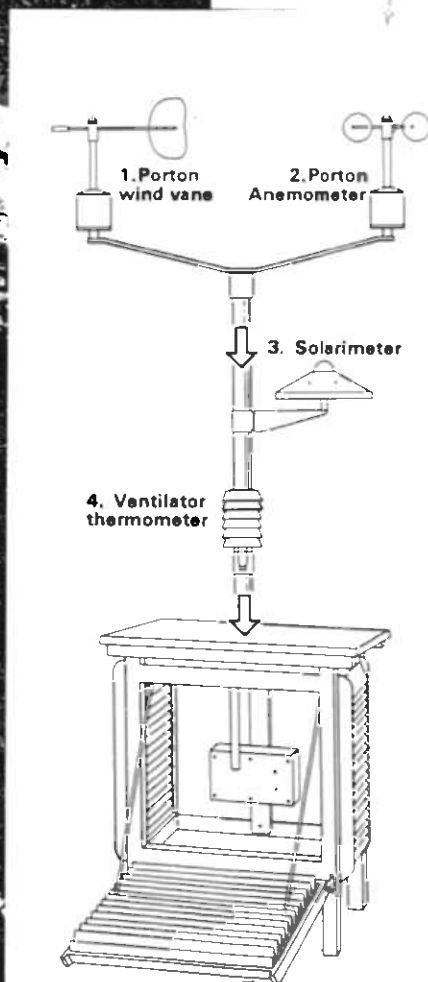
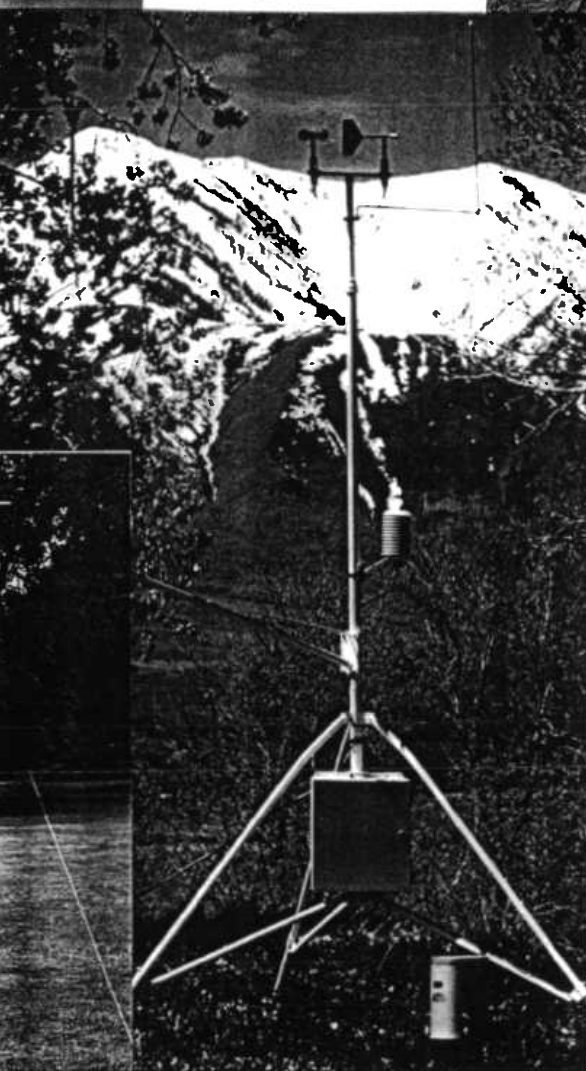
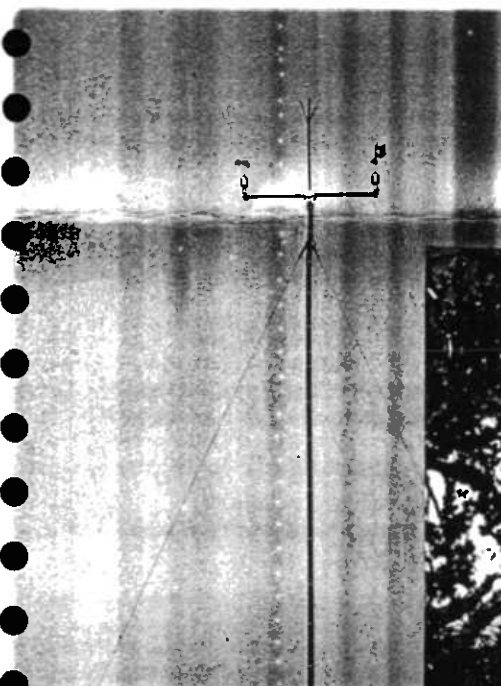
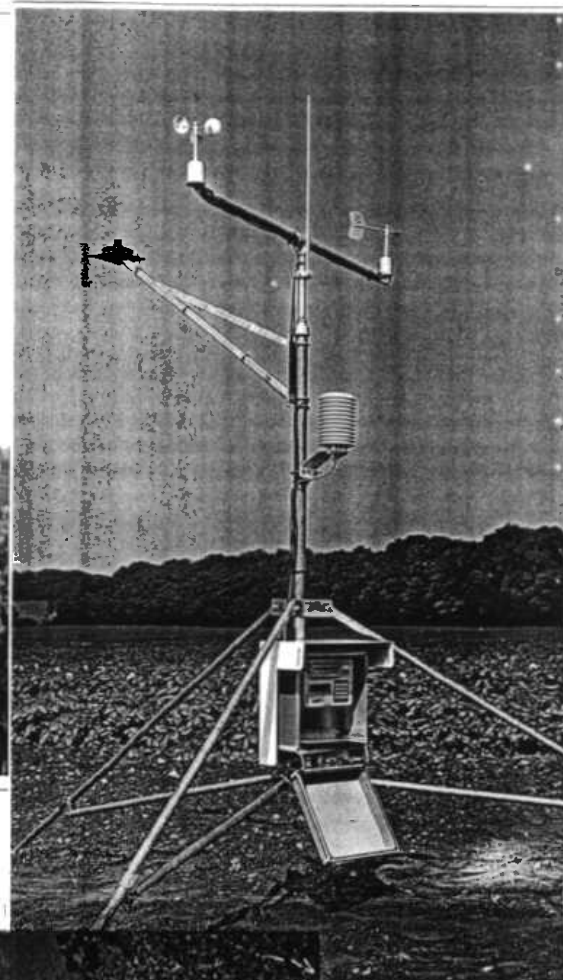
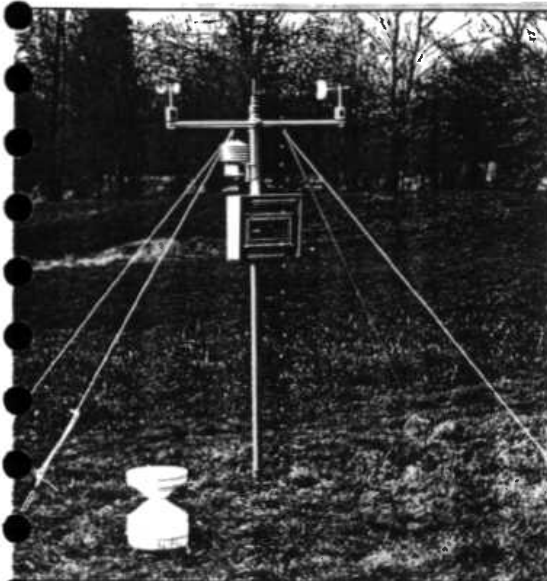
Finally, it is worth raising the general question of ODA's funding of instrument development. The ODA view now seems to be that they should not fund the development of any hydrological (or other) instrument in the future unless it is required specifically for an ODA-funded project. The problem here could be that if the instrument was anything but simple the lead-time for development would be too long, the project being over before development was completed. Much better, in practice, to anticipate future needs of instrumentation for developing contries and to have such instruments ready. Indeed it can be argued that by so doing the instrument designer can actually lead the researchers forward.

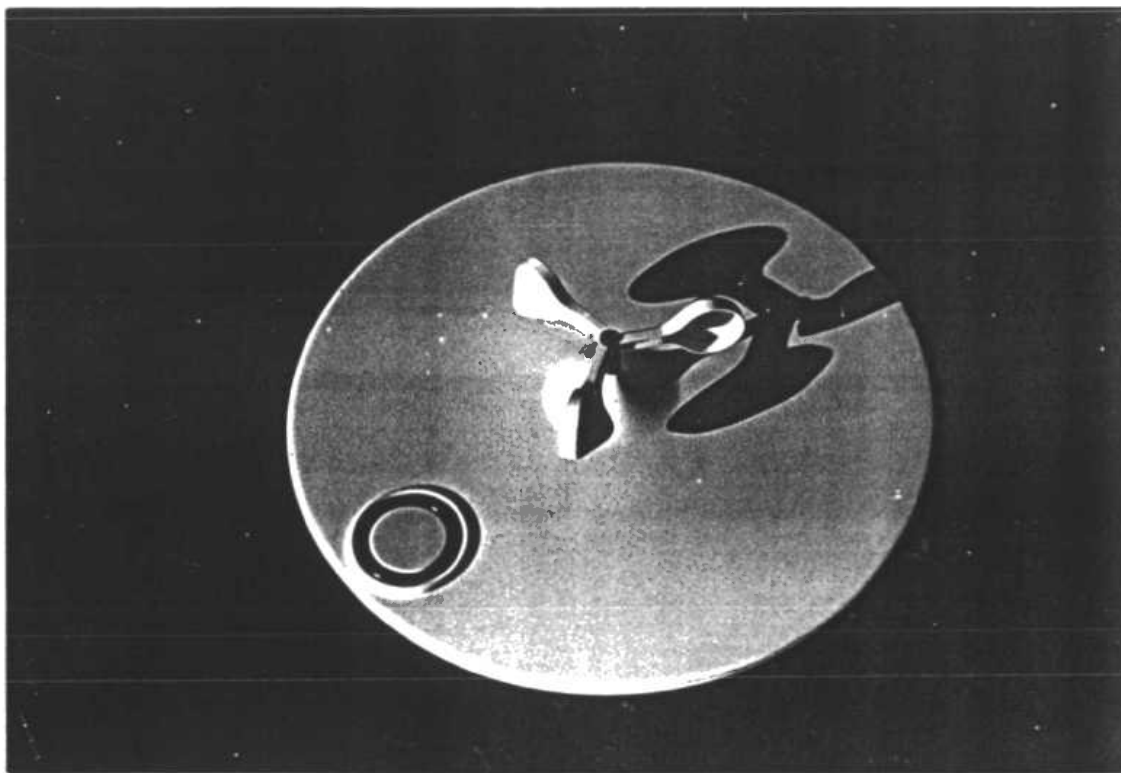
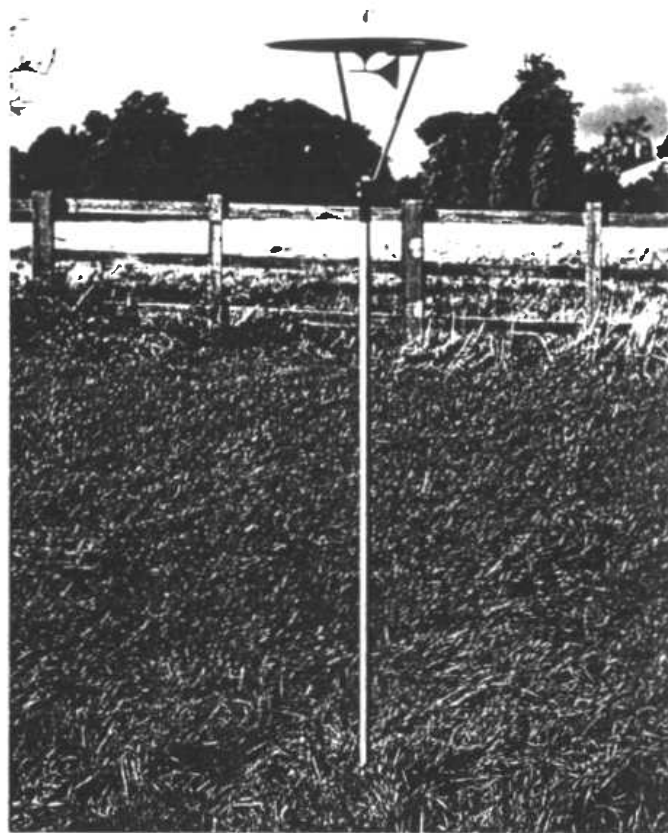
It is also the ODA view that "if there is a need for an instrument, British Industry will see it and develop it. If it does not develop it, there is no need for it". Sadly British Industry is well known for its very low spend on R and D. It is also not as much in contact with the researchers as somewhere like IH is. So even if a need existed it might not be seen. But more fundamentally, the cost of developing an instrument is very

high and no company, especially a small one - and most hydrological instrument manufacturers are small - would be prepared to risk it. Only when a very large return in sales is guaranteed would they do it and even then caution would probably prevent it. Little new developments have come from industry on its own.

The IH low-cost raingauge is a good example of Institute-led development. No company thought of it or spent the money developing it. IH did. Now it is available, many companies are marketing it. British Industry does not generally respond dynamically or take risks. ODA should, therefore, seriously reconsider its attitude to funding instrument development in areas which are applicable to developing countries. We have, at IH, several such ideas worth consideration which even IH, in today's financial climate, will not be able to develop without ODA funding. We will submit proposals later this year.

CONSTRUCTION OF CONVENTIONAL AWS





LOW-COST AUTOMATIC WEATHER STATION

Institute of Hydrology. Design Application No. 1047602

NOTES ON REGISTRATION OF DESIGN

Mr J A Cowie
Research Marketing
Natural Environment Research Council
Polaris House
North Star Avenue
Swindon
SN2 1EU

31 July 1987

Dear Mr Cowie

We spoke recently concerning patenting some instrument designs. Enclosed are notes describing them. All three are designs which I originated myself so I would prefer them to be under my name.

The reason I feel that this is a wise precaution, as I explained on the telephone, is that the design of a low cost raingauge, now under licensed production, is being adopted by many automatic weather station (AWS) manufacturers. This has happened very quickly. It may only be a matter of time before a copy appears somewhere. In addition, there are two new innovative designs of AWS which should be patented. If the raingauge is anything to judge by, at least one of the AWS (item 3 below) could have some impact on the market.

Instruments for patenting

1. A low-cost vacuum-formed, raingauge
2. An AWS for cold regions
3. A new-style AWS for conventional situations

Low-cost raingauge

The concept of developing a series of low-cost instruments evolved while working overseas in various third world countries. However, low cost designs also appeal to users in technically advanced countries. The idea was developed initially around the measurement of rainfall, probably the most commonly measured hydrometeorological variable. The majority of electronic automatic raingauges use the "tipping bucket" method, a pivoted, double-sided, container see-sawing back and forth as the collected rain is passed into it.

The majority are made of metal (stainless steel or copper) figure 1, although a few have been made of fibreglass, but with metal "buckets". Metal is expensive, expensive to work, is stolen in many third world countries and is heavy to transport. While early designs of the present gauge (Paper 1) were made in fibreglass, this had a tendency to chip

easily and was later replaced by a vacuum-formed plastic construction, the whole gauge being made in this way, including the bucket. Additionally, the profile was changed to the funnel-shape seen in Paper 2 and photograph 1a/1b. This improves its aerodynamic performance, by minimising the effects of wind flow. Such a design is tough but very cheap, while sacrificing nothing in precision. That is why it is gaining acceptance. We are not aware of any other gauge made using vacuum-formed plastic or which is aerodynamically shaped.

2. Cold Regions Automatic Weather Station (CRAWS)

In 1965 IH developed one of the first AWS capable of remote operation (Papers 3 and 4). This was licensed for production in the 1970s. Since then many other AWS have appeared on the market, many just recently. All bear a close resemblance to that illustrated in Papers 3 and 4. At a recent instrument exhibition, part of WMO's conference at Shinfield Park, many manufacturers were exhibiting similar AWS designs. It was at this exhibition that the proliferation of the low-cost raingauge also became apparent.

These types of AWS are all conventional in design. The first innovative departure was the development of an AWS that would operate in cold regions (CRAWS) where rime ice formation and blowing snow makes conventional AWS unusable.

CRAWS was developed over the period 1977-1987. It is described in Paper 5. It has also been described in several other papers. One station is in use in Antarctica and two in the Cairngorm mountains. It is a somewhat specialised instrument but it is entirely innovative in the way it keeps itself ice and snow free. It is also the forerunner, in many ways, of item 3. While it may or may not be used in large numbers in the future, it would be a useful safeguard to patent the concepts of this very compact, sealed, AWS keeping itself ice free not by the use of heat as all others do but much more economically, in power terms, by pneumatic shock induction, flexing and the use of hydrophobic, soft, constructional materials.

3. Low-cost, compact AWS

All current, conventional, AWS comprise a mast with cross arms from which are deployed individual sensors (Papers 3 and 4). Those normally included are for measuring windspeed, wind direction, solar radiation, net radiation, albedo, temperature, humidity and rainfall; those for meteorology, as opposed to hydrology, also include barometric pressure. In addition to the AWS illustrated in the papers, figure 2 illustrates a selection of those on exhibition at the recent WMO conference. Their likeness is apparent. They are ungainly, large, heavy and expensive. All known AWS are to this general design.

Recently I began the design of a new-style AWS departing radically from the conventional designs illustrated. The new design draws on both the techniques of vacuum-forming, developed for the construction of the raingauge, and the concept of a very compact, completely sealed, unified construction developed for CRAWS. This results in a much cheaper and easily transported instrument. It also looks visually as if it belongs to the 1990s, the other designs clearly owing much to early instrument concepts.

So far only one prototype exists, it has not yet been written up as a paper, nor will it be licensed for production until it has been well field tested. However, no serious problems are expected. It could possibly have as big an impact on the market as the raingauge and it is important, therefore, to patent the design. Since nothing has yet been written on the topic, it is illustrated here by means of two figures. The first is the GA Engineering drawing used in its construction (figure 3), photographs 2, 3 and 4. It is clear from these that the design gets rid of all the cross arms and individual sensors, all sensors now being combined into one, small, vacuum-formed, disc-shaped, narrow-profiled, housing. Sensors for solar radiation, albedo, temperature and humidity are housed in cavities above and below the disc, windspeed and wind direction are conventional cups and vane rather than the drag anemometer of CRAWs but these are incorporated in the one single disc housing. A modified drag force wind sensor might later be developed to replace the cups and vane. The result is great economy in construction costs and a much neater, light-weight, design.

If you need more information on any of these instruments, please let me know.

Yours sincerely

Ian C Strangeways

ENCs

ICS/vw

Mr J A Cowie
Research Marketing
NERC
Polaris House
North Star Avenue
Swindon, Wilts
SN2 1EU

Dear Mr Cowie

In my letter of 31 July concerning the patenting of some instrument designs, I was unable to supply good photographs of the third item, a low cost automatic weather station. I said I would supply pictures when they were available and these are now enclosed.

Please let me know how things are progressing. I am intentionally holding back any publicising of this particular development, until its patenability is established.

Yours sincerely

Ian C Strangeways

ENC.

ICS/vw

John Orchard & Co

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TELEX 24532 (for JOHNOPAT)
CABLES JOHNOPAT LONDON WC1

31 DEC 1987

our ref OJO/HB

your ref

Dr. I. Strangeways,
Institute of Hydrology,
Maclean Building,
Crowmarsh Gifford,
Wallingford,
Oxon, OX10 8BB.

DIRECTOR		December 30 1987	JEP B.A.
ACTION			
A	INF		
C	COMMENT		
T	DISCUS		
I	DRAW REPLY		
O			
N			
REPLY			

Low-Cost Automatic Weather-Station Proposed new Design Application

Dear Dr. Strangeways,

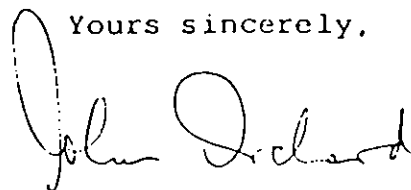
Thank you for your letter of November 10 1987, sending further photographs of the weather-station, for the preparation of a new Design Registration Application.

Enclosed are approval copies of drawings that have been prepared for the application.

Please advise us by return of post whether they properly depict this weather-station in the form that you will be marketing. If amendments are necessary, please indicate them in red ink on a copy of those drawings, and return them to us as soon as possible.

As our Mr. Senhenn advised you on December 11 1987, the application drawings should show the weather-station in the format in which it will be marketed. From his conversation with you that day, we understand that the top-side sensor should be shown above one of the bottom-side sensors.

Yours sincerely,


O.J. ORCHARD

Encs:

c.c. Mr. J. Cowie, NERC

John Orchard & Co

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CHARTERED PATENT AGENTS

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TELEX 24532 (for JOHNPAT)
CABLES JOHNPAT LONDON WC1

our ref OJO/JC

your ref

April 19 1988

J. Cowie, Esq.
Natural Environment Research Council
Polaris House
North Star Avenue
Swindon SN2 1EU

Copy

Low-Cost Automatic Weather-Station
UK Design Application No. 1047602

Dear Mr. Cowie

In accordance with Dr. Strangeways' instructions of January 4 1988, we filed a Design Application and the filing details are set out below:

APPLICANTS: Natural Environment Research Council

APPLICATION NO: 1,047,602

DATE OF FILING: JANUARY 8 1988

ENCLOSURES: Copy of Form Designs No. 2 and copy of drawings as filed, filing receipt and debit note.

We shall write to you again as soon as there is anything to report.

Yours sincerely

O.J. ORCHARD

Enc.
cc to Dr. I. Strangeways with copies.

FEE: ITEM
1 OR 2

(Rule 12)

REGISTERED DESIGNS ACT 1949

Application for Registration of Design

NOTES

- (a) Insert the name and address of each applicant. Names of individuals should be indicated in full and the surname or family name should be underlined. The names of all partners in a firm must be given in full. Bodies corporate should be designated by their present corporate name and the country of incorporation and, where appropriate, the state of incorporation within that country should be inserted where provided. Full corporate details, eg. "a corporation organised and existing under the laws of the State of Delaware, United States of America," nationality, and former names, eg "formerly [known as] ABC Ltd," are *not* required and should *not* be given.
- (b) Delete words which do not apply. For textile articles see definition given in Rule 2 of the Designs Rules 1984. If "other article", state the article to which the design is to be applied as shown in the representations.
- (c) Delete one or both paragraphs, if inapplicable.
- (d)
- (e) If the applicant has appointed an agent to act on his behalf, the agent's name and address should be indicated at (e) and (f).
- (f) An address for service in the United Kingdom to which documents may be sent must be inserted.
- (g) Attention is directed to Rules 10 and 11 of the Designs Rules 1984.

Application is made for registration of the accompanying design in the name of (a)

NATURAL ENVIRONMENT RESEARCH COUNCIL

Country United Kingdom State

Address POLARIS HOUSE, NORTH STAR AVENUE, SWINDON, SN2 1EU

who claim(s) to be the proprietor(s) thereof.

The design is to be applied to (b) ~~a textile article or wallpaper or similar wall covering or lace or other article~~.

AN AUTOMATIC WEATHER STATION

(c) The design has been previously registered for one or more other articles under No.

(d) The design consists of the design previously registered under No.

modifications or variations not sufficient to alter the character or substantially to affect the identity thereof.

with

(e) Name of agent, if any: JOHN ORCHARD & CO

(f) Address for service in the United Kingdom: Staple Inn Buildings North,

High Holborn, London, WC1V 7PZ

(g) Signature

John Orchard & Co

Dated this

8th day of January

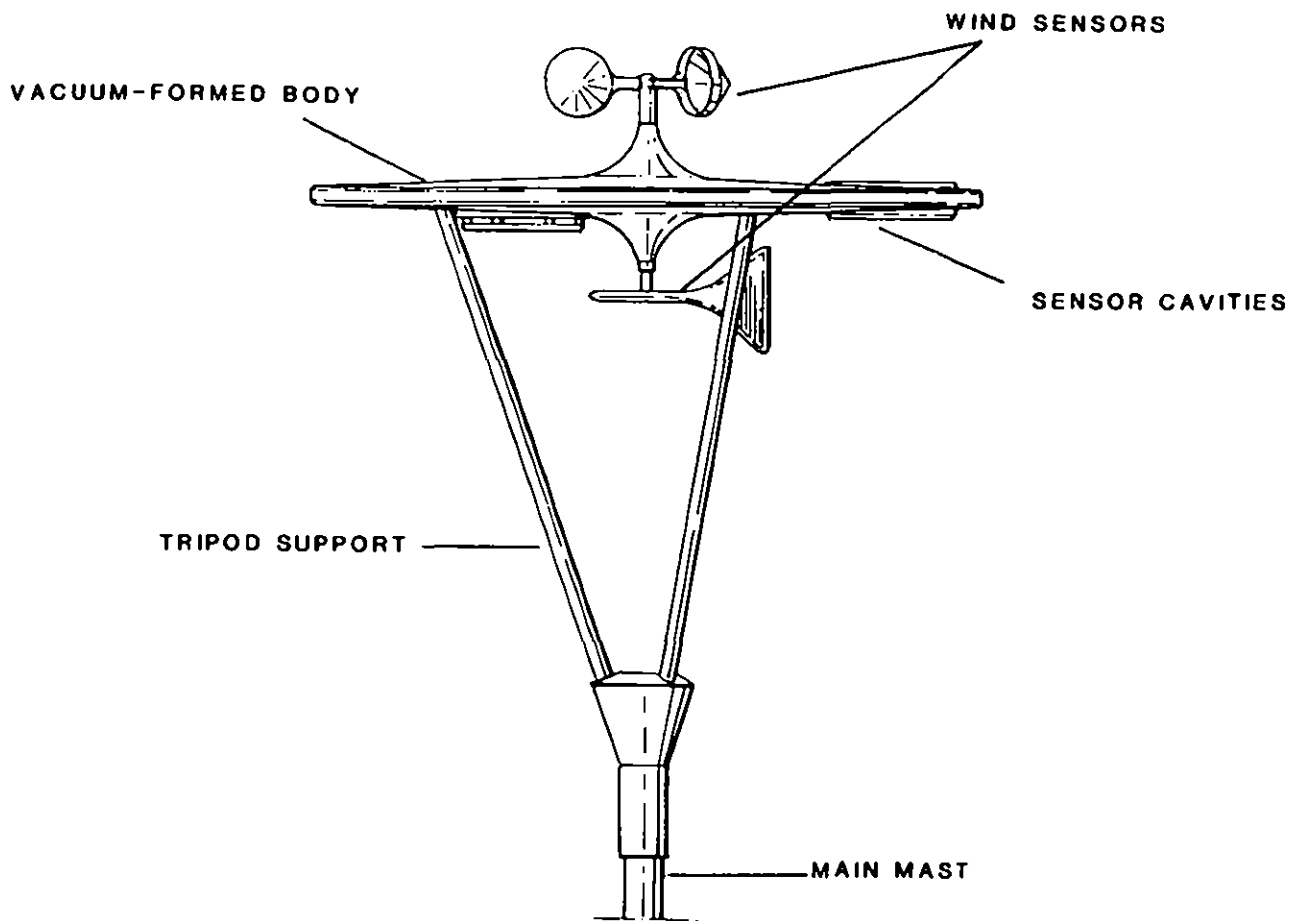
19 88

Please note Three identical representations or specimens of the design should accompany this Form, and except in the case of an application in respect of a textile article, wallpaper (or similar wall covering), or lace, each representation or specimen should carry a statement of the features of the design for which novelty is claimed. If words, letters or numerals appear in the design the Registrar will normally require a disclaimer of any right to their exclusive use to appear on each representation or specimen.

To The Registrar

Designs Registry, The Patent Office

LOW COST AUTOMATIC WEATHER STATION



SIDE VIEW

LOW COST AUTOMATIC WEATHER STATION

TEMPERATURE SENSOR CAVITY

HUMIDITY SENSOR CAVITY

ALBEDO/NET SENSOR CAVITY

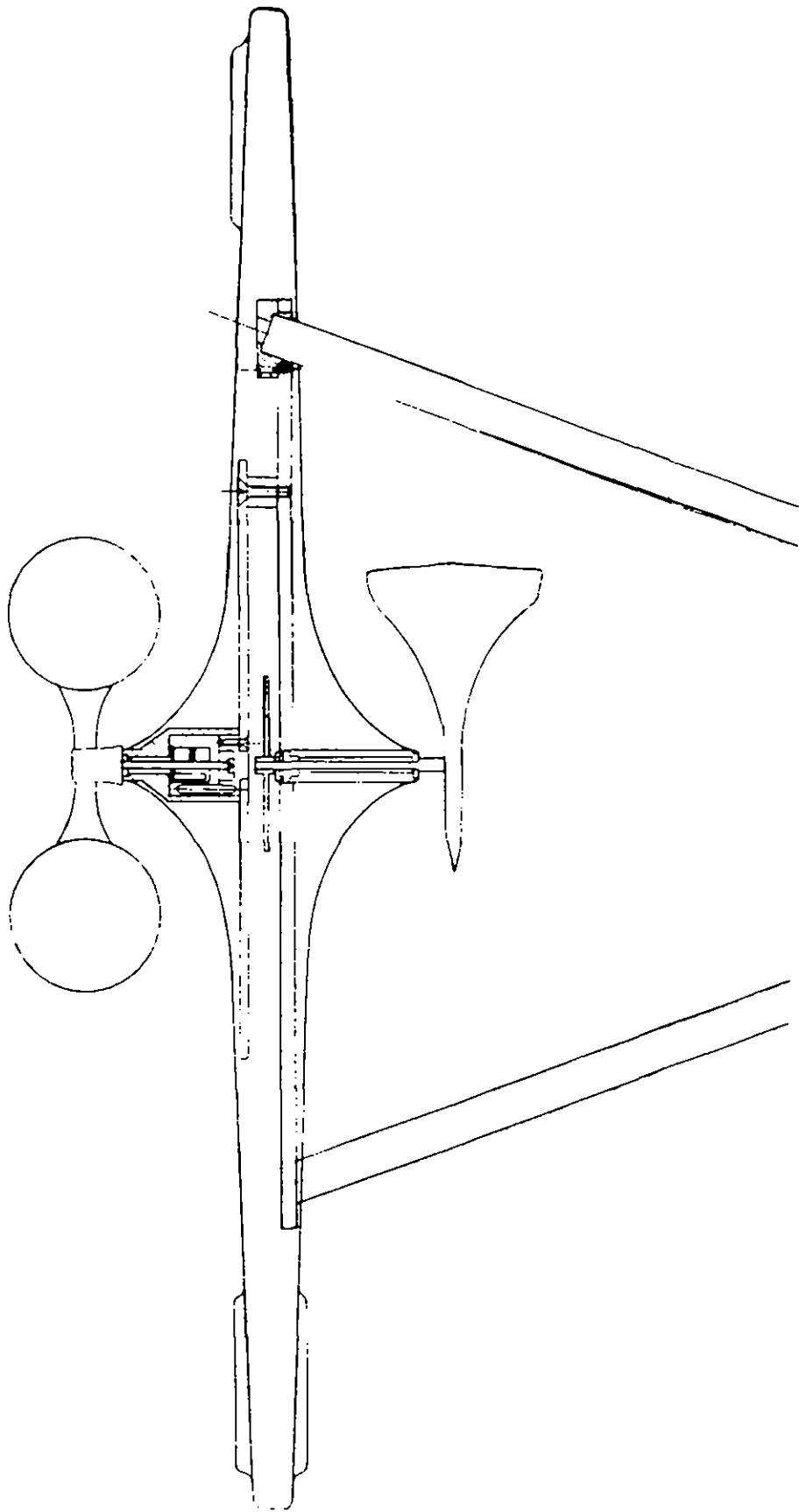
WIND DIRECTION SENSOR

UNDERSIDE

ANEMOMETER

SOLAR SENSOR CAVITY

TOPSIDE



GENERAL ASSEMBLY OF LOW COST AWS

PAPERS ON THE TOPIC OF LOW COST INSTRUMENTS



SECRETARY-GENERAL: A. C. WIIN-NIELSEN
DEPUTY SECRETARY-GENERAL: R. SCHNEIDER

WMO BULLETIN

JANUARY 1980 VOL. XXIX No. 1

A SIMPLE HYDROLOGICAL INSTRUMENT SYSTEM

By I. C. STRANGEWAYS, M. TURNER and W. S. INSELL*

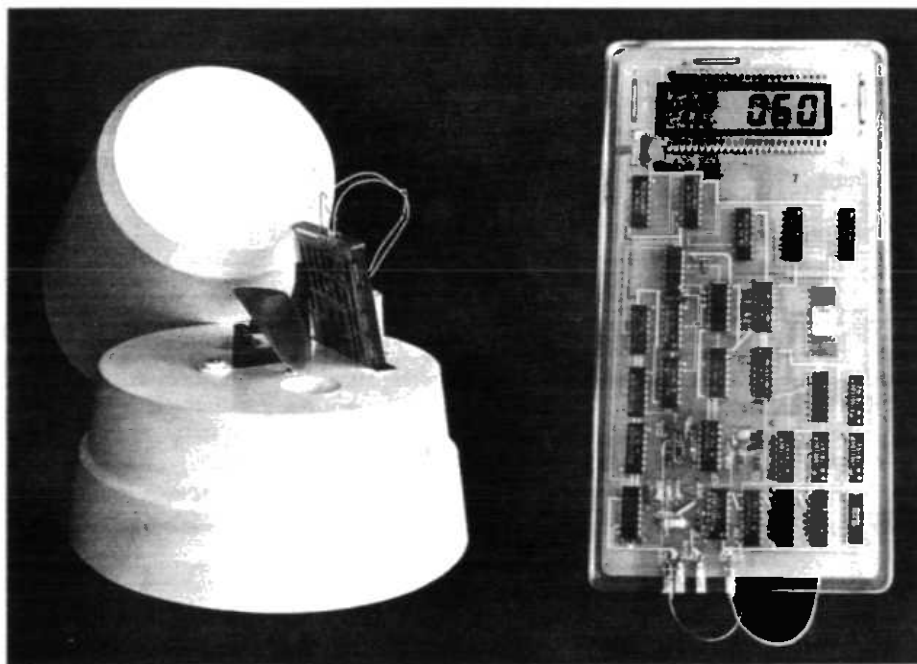
The concept

* Institute of Hydrology, Wallingford (United Kingdom).

The concept of the simple instrument system for hydrology evolved from the quest for instrumentation which developing countries could afford to buy and would find convenient to use. Most electronic hydrological instruments are expensive, and maintenance can be a problem in remote localities where suitable expertise is unavailable.

"Simple" in this context refers to the instrument's operation and servicing. Certainly not to its technology. Such a system must be simple to maintain, simple to use and inexpensive. It might seem that these demands are contradictory, but they need not be.

Since rainfall is probably the most important single measurement in hydrology, the first instrument to be developed in this series was a rain gauge. Runoff, generally accepted as being next in importance, was the second variable to be considered.



The complete rain gauge (*left*), and a close-up view of the electronic module with display (*right*)

The rain gauge

The rain gauge can be considered in two parts: the sensor and the electronic module. The sensor is a tipping bucket which is undoubtedly the best and certainly the simplest method for sensing rain electrically. Drop-counting, weighing or syphoning are more complex and less reliable. To avoid the high labour costs involved in machining metals, moulded plastics were used for the funnel, base and bucket mechanism. Early prototype rain gauges made of expanded polyurethane were considered to be insufficiently rugged for long-term use, although acceptable results were obtained when an outer skin of polyester resin was applied. Fibreglass is now used, since it is tougher and no more expensive. Rain gauges have been made of fibreglass before, but they have tended to be of complex shape: the present design is simple, consisting of only two parts, the top funnel and a base on to which fits the bucket. The bucket, and the stand on which it pivots, are moulded of epoxy resin which is simple to mould and does not require special machinery. The moulds are made of silicon rubber. A magnet, moulded in the upper arm of the bucket, activates a reed

switch moulded in the upper arm of the bucket support. These four items constitute the complete gauge.

The electronic module

The module uses the latest microelectronic chips, but the circuit is no more complex than is absolutely essential. Each tip of the bucket (representing 0.5 mm of rainfall) closes a contact, these are counted and stored in a solid-state memory. Eighty-six daily totals (of up to 999 tips per day) can be stored in the current design, although memories of much greater capacity will certainly become available during the next few years. During manufacture the time interval can be adjusted (to as low as one second if required) to suit different applications, making the module a general purpose event recorder. The contents of the memory are read manually by activating a reed switch with a magnet. A liquid crystal display indicates the day-number and the number of tips for that day. Each day is displayed in sequence.

Costs are kept low, and at the same time reliability is increased by:

- Minimizing the number of plugs or sockets (only four are required);
- Not using manually operated switches (only three reed switches are used);
- Not using a case (by encapsulating the electronics board).

The costs of plugs (especially multi-way), and their wiring is high, and they are also a source of failure. Inter-connecting plugs between the memory and a separate display unit are avoided by including the liquid crystal display on the electronic memory board. The board is completely encapsulated in polyester resin, thereby preventing corrosion (a serious problem in equatorial areas) and dampness. This eliminates the need for casing, costs are reduced and reliability increased. Encapsulation does, of course, prohibit repair of the circuit should it fail, but the reliability of the microelectronic chips themselves is very high. Furthermore, the cost of a replacement module is probably comparable with the cost of repair.

The prototype gauges are powered by four AA-size alkaline batteries encapsulated in silicon rubber. This power pack, which lasts for the full 86 days, fits into a slot in the rain-gauge base alongside the electronic module. Later models will use rechargeable batteries and tests are being carried out on the use of solar energy.

Progress so far

In January 1979 the first gauge was installed in the equatorial climate of Java. In March, another gauge was installed in the Highlands of Scotland to assess its performance in a sub-arctic climate. Two were recently sent to Brazil and three to the Libyan Sahara where they will experience temperatures up to 50°C and intense solar radiation. The remaining gauges will be tested in Kenya and the United Kingdom. More gauges are currently being made for normal use and further testing.

Although the original concept was of an instrument of radiosonde standard, what has evolved during development is a system somewhere between the sonde and the more expensive conventional instrument. It would appear that the simple instrument may be as accurate and reliable as the latter, and at only a fraction of the cost.

Future developments

Other hydrological variables, such as river level, will require the electronic module to be more complex since a bridge, an amplifier and an analogue-to-digital converter will be necessary. Redesigned modules are therefore planned to include these facilities, but only those components required for the particular application will be used on any one board. A river-level sensor is currently being designed and later developments will cater for all the common hydrological variables.

Acknowledgements

The authors wish to acknowledge the co-operation of FAO, the Meteorological Department of the Libyan Arab Jamahiriya, the Institut Pertanian Bogor (Indonesia) and the Cairngorm Rangers (Scotland) in testing the prototype gauges.

We are also grateful to the United Kingdom Overseas Development Administration for funding the project.

Low cost hydrological data collection

IAN STRANGWAYS

*Institute of Hydrology, Wallingford
Oxfordshire OX10 8BB, UK*

ABSTRACT Many hydrological instruments are expensive and this often limits the amount of data which can be collected. Not only are they expensive but they can also be difficult to maintain locally. Returning instruments to their country of origin for repair causes delays, is often difficult and introduces further expense. The Institute of Hydrology is, therefore, carrying out a long-term programme, funded by ODA, to develop a series of low cost, simple to maintain, instruments for a range of hydrological variables. A rain gauge and a water level sensor have so far been produced, with low cost loggers. Currently under development is an instrument for measuring water depth in village wells, an operator visiting the wells to take manual readings. The system has to be interference-proof and must not involve the removal of the well covers. This instrument will be described, to illustrate the approach used in developing all of the sensors in this series of low cost instruments.

Collecte des données à bas prix

RESUME Beaucoup d'instruments hydrologiques coûtent cher et ce fait limite souvent la quantité de données qu'on peut collecter. Non seulement ils sont coûteux mais aussi on peut éprouver bien des difficultés quand il s'agit de leur entretien sur place. Quand il faut renvoyer les instruments à leur pays d'origine pour les faire réparer, ceci occasionne des délais, s'avère souvent difficile et amène encore des frais. L'Institut Hydrologique exécute donc un programme à long terme, avec fonds fournis par l'ODA, pour la mise au point d'une série d'instruments peu coûteux et faciles à entretenir pour toute une gamme de variables hydrologiques. Jusqu'ici on a créé un pluviomètre et un détecteur de niveau d'eau avec enregistreurs à bas prix. En cours de mise au point il y a actuellement un instrument pour mesurer la profondeur d'eau dans les puits de village; un opérateur visite les puits pour faire des relevés manuels. Le système doit être résistant à toute intervention non autorisée et ne doit pas nécessiter l'enlèvement des couvertures des puits. On décrit cet instrument pour expliquer la méthode utilisée pour mettre au point tous les détecteurs dans cette série d'instruments à bas prix.

THE COST OF COLLECTING HYDROLOGICAL DATA

The collection of hydrological data, whether it be groundwater, climatological, river level, or other information, is usually an expensive process. The cost of the instrument itself can be high, particularly if it is electronic, as most modern instruments are. The subsequent maintenance is also expensive. It is rare for users to be able to maintain such instruments themselves, due to their complexity, while returning an instrument to the manufacturer for repair is both inconvenient and expensive, particularly if the manufacturer is in another country. It is sometimes necessary to accept this situation, but it can often be avoided and the Institute of Hydrology has been investigating ways in which this can be done.

THE ACCURACY OF DATA

Users of data often have unclear views about accuracy. Firstly, in specifying what they want of an instrument, there is a tendency to ask for a higher accuracy than is needed. This puts costs up. An example of this is the current trend to ask for data loggers with 12 bit accuracy (a discrimination of 1 in 4095) when, in most applications 8 or at most 10 bit accuracy (1 in 255 or in 1023) is more than adequate. One way of reducing costs, therefore, is to design the instrument to have adequate but not unnecessarily high accuracy.

Secondly, there is an attitude which is the reverse of this, in which users take data from sources other than their own without enquiring into their accuracy. If it is quoted to three figures, for example, or if the logger gives it to that discrimination it is automatically assumed that it has that accuracy (1 in 999). It rarely has, especially as sensors and their interface circuits rarely attain it. High discrimination loggers can, therefore, mislead because they are usually more accurate than the sensors measuring the variables. In addition to this, it is also important to ask whether it is meaningful to make a highly precise measurement of a variable which could well differ by several per cent only a short distance away.

LOWERING THE COST OF INSTRUMENTS

By taking a realistic look at what accuracy it is sensible to aim for, and by rethinking design philosophies and manufacturing techniques, several low-cost instruments have been developed at the Institute of Hydrology. The first, a raingauge with a solid state logger capable of storing daily rainfall totals for 86 days, was developed several years ago (Strangeways *et al.*, 1980). The second (Fig.1), developed more recently, is a raingauge with improved aerodynamic properties based on the findings of Rodda (1967); it also has an improved logger. The next in the series is a float-operated water level sensor. While developed for river level measurements, it can also be used to measure groundwater in wells of 20 cm diameter or more. The float rotates a 20-turn potentiometer

which is part of a simple, 4-chip, electronic circuit. This circuit, when "called" by the logger replies with a burst of pulses (from 0 to 1000), the number being proportional to depth. All but the first raingauge, which was fabricated in fibreglass, are based on vacuum-forming for much of their construction, which is low in



FIG.1 Prototype low-cost raingauge designed to have an improved aerodynamic performance. It has a funnel diameter of 254 mm precisely defined by a stainless steel rim.

cost, high in quality, and adaptable. Microelectronic chips are used for the logger, but with economy, providing essential facilities only. Single pole plugs, used sparingly, in place of expensive multi-pin plugs, and reed switches, operated by a magnetic probe in place of vulnerable toggle switches, cut costs and improve reliability. The whole is encapsulated in a vacuum-formed case for long-term protection. Other sensors and loggers are currently being developed. Having outlined the general concept of this low cost system a specific instrument developed for groundwater measurement will be described in more detail.

VILLAGE WELL INSTRUMENTATION

An instrument requested by the UK Overseas Development Administration (ODA), who are also funding several of the other developments described here, concerns the measurement of the water level in village wells. Such an instrument will have a wide application in many African countries, wherever wells are the source of village water supplies; it will also have a use in research applications. It would be impractical to instrument such wells with the more usual, but more expensive, water level measuring equipment.

Our brief was to develop an easy to use, low in cost, simple to maintain instrument, to measure variations in water level in village wells. Annual level variations (of 2-3 m) and short term level changes (of 10-15 m), due to pumping, were to be measured to a resolution of about 1%. The instrument was to be portable, hand-held and manually read by a local operator and was not to interfere with the normal protection to the well. That is, it should not allow unauthorized access to the interior of the well. At the time of writing, a prototype has been made and tested; later it will be production engineered. It, and the other systems described above, are being, or will be, manufactured commercially under licence.

As Fig.2 shows, the system operates using the well established bubble technique, but simplifies it, requiring only the most economical of components to be left on-site in the well (a small-bore plastic tube between the well's outer casing and the inner pumping tube, terminated in a tube connector at the well-head, capped to protect it against interference). Air is compressed by a bicycle pump into the air reservoir. The air is then allowed to escape, slowly, via an adjustable valve, to the well. As the water in the sensing tube is gradually displaced by the air from the

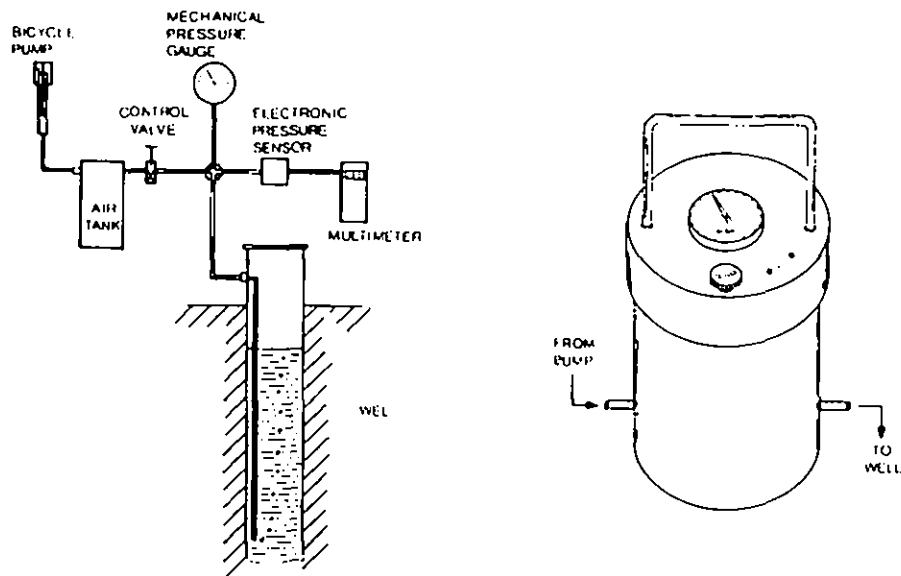


FIG.2 Schematic of village well water depth instrument system.

cylinder, the air pressure in the tube starts to increase. This is displayed on the mechanical pressure gauge. Pressure continues to rise until bubbles start to emerge from the bottom of the sensing tube, at which time the pressure stops rising and stays constant. This pressure is then read from the meter, which can be calibrated directly in depth. If greater accuracy is required, the pressure can be sensed using a low-cost electronic pressure transducer, its output being measured and displayed on a battery-operated, pocket, digital voltmeter. Since the unit is taken by the operator to each site in turn it can service a large network of wells.

Its cost, in production, will be under £200 and the cost of the on-site components should not exceed £25, possibly less. Because of its simplicity the system is unlikely to fail. If it does, the parts are sufficiently cheap to be replaced on a throw-away basis.

CONCLUSION

The views expressed here should not be taken to imply that no place is seen for more complex instruments. There clearly is a place for them in all countries. Indeed the Institute currently operates many such systems worldwide, notably automatic weather stations (Strangeways, 1972). It would also seem probable that satellite telemetry will have an important role to play in the future, especially in undeveloped countries, and this is not simple. Low-cost instrumentation, as described in this paper, is just one option open to users, but an important one.

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