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AN ELECTRICAL PROBE FOR THE SENSING
OF WATER LEVELS IN STILLING WELLS

BY

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1966

institute of coastal
oceanography and tides

NATURAL ENVIRONMENT RESEARCH COUNCIL

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At the Tidal Institute the procedure adopted for maintaining a constant and precise relationship between elevations recorded by a tide gauge and the established datum has been through the use of a sounding probe with an electrical indication of contact between probe and water surface. The principles behind this practice can be listed as follows :-

(1) The relatively calm conditions within the well make it possible to determine the elevation of the water surface to an accuracy at least one order higher than is possible outside the well. With an efficient probe instrument well-levels can be readily obtained with an accuracy of the order of $\pm$ 0·005 ft. If such ideal conditions for measurement exist, then it seems obvious that we should take advantage of them.

(2) Procedures which aim to set a tide gauge height with reference to a level determination of the water outside the well seem to us to attempt too much and consequently fail to check upon the gauge pen height and the condition of the well/orifice adequately for the following reasons :-

(a) unless an elaborate system for sounding outside levels is devised this cannot be achieved with any precision so that the working datum of the gauge is necessarily uncertain and tends to be inconstant.

(b) even where an elaborate system for sounding is available it is difficult to match the response function of the device with that of the well so that the above objection still holds. There may also be other reasons why the levels of water inside and outside the well do not coincide at any one instant in time.

(c) modern well design, where the provision of orifice cleaning is arranged, reduces concern over the operation of the well and therefore allows greater concentration on level determinations inside the well.

(d) in older installations serious deterioration in orifice condition is apparent on records in the form of flats particularly at low water and also at high water. Less serious conditions will not affect mean sea level considerations provided the datum link is maintained by an adequate system of interior well soundings. Procedures based upon external determinations destroy this link.

At the Tidal Institute we have been using internal probes over a very long period, certainly in excess of thirty years. In this time, we have formed a clear idea of what type of instrument we require and what its specifications should be. In recent weeks we have found it necessary to construct a new probe which has caused us to collect our thoughts upon this matter and the present note is being put to the Working Party in the hope that the requirements which we have found best suited to these needs might be of more general interest.

The probe is simply a device which is designed to give a clear visual signal at the precise instant when a sounding tape makes contact with the water surface and in so doing makes it possible to evaluate the elevation of the surface with an accuracy better than 0·01 ft. In fact a continuity meter is connected between a surveyor's tape and earth, continuity being established when the tape makes contact with the water. In order to provide an effecient instrument designed to give long service with a minimum of effort, some careful thought must be given to the design of the probe. The instrument described here and to be demonstrated to members of the Working Party was designed by Mr. R.H. Jones and myself and constructed by the former.

Comments upon the design of the probe.

I.   The dimensions of the probe point (that part which makes contact with the water surface) is critical.   A fine needle is unsatisfactory since the signal given by its first contact with the water is not clear enough.   Since the electrical resistance between tape and water decreases as more and more of the needle becomes immersed, the effect is to receive a weak signal which gradually increases giving a slow response of the instrument to water contact.   The danger of systematically over-estimating the depth of the water surface is present in such a system.   A more substantial probe can retain a drop of water at its extremity and so can cause an under-estimation of depth of surface when wet.   Alternatively such a probe on being raised can easily lift the miniscus by 0·01 ft. which again runs the risk of under-estimation.   Tests have shown that an ideal probe point takes the form of a $^1/_{16}$ diameter silver-steel rod with a blunt V-point.

II.   The probe is provided with a gauge to facilitate the setting of its point and to ensure that its length remains constant.

III. The weight of the barrel should be substantial in order to give a sensitive control over tape movements and to counteract the tendency of a rolled tape to display kinks in use.   The presence of any such kinks would cause an over-estimation of depth.   The barrel in this instrument is lead-filled and weighs $1·6$ lbs.

IV.   A very essential component of the probe mechanism is a clamp through which the tape runs as it is lowered into the well.   At the instant of contact the clamp can be used to secure the tape in the reading position. The clamp also incorporates the fiducial mark (with a parallax guide) against which the tape can be read.   The accuracy of a sounding check is to a great extent determined by the ease with which it is possible to read the height of the pen shown on the tide gauge chart as nearly as possible at the same instant at which contact is made.   The procedure in this case is to clamp the tape at the instant of contact at the same time as the gauge is being read.   The tape is firmly secured and a tape reading can then be taken carefully and unhurriedly after the gauge height has been noted.

V.   The design of the circuit, which is reproduced in an accompanying diagram, is arranged to ensure long battery life, tolerance to voltage drop as the battery is used, but most important, a rapid and as near as possible a full-scale deflection of the meter pointer at the first contact of the probe point.

In this context it has been ascertained that a typical resistance between earth and the water surface in a conventional tide gauge well is between $2K\Omega$ and $3K\Omega$.   On this basis an adjustment is provided in the form of a fixed $3K\Omega$ resistor which can be put in circuit via a push button switch.   On occasion this switch may be depressed whereupon the meter needle will give a reading which can be adjusted to a full scale deflection through the potentiometer knob.   The ammeter used is a 500μ A meter with an internal resistance of 75Ω .   This determines I_M for full scale deflection.   The total resistance of the circuit is $7·2 K\Omega$, the shunt current I_S, 750μ A and the total current of the circuit I_T, $1·25$ m A.   A small and readily obtainable 9 volt battery is used and although its characteristics cannot be readily obtained, it is estimated that its life is greater than 20 hours of continuous contact of probe with the water surface.   With this sensitivity it is our experience that a sounding accuracy of the order of $\pm$ ·005 ft. can be obtained with ease and also that it is possible with experience to discriminate between a true water contact and contact with floating debris in the well.

VI. The reading obtained from this instrument does not give the distance between the fiducial mark and the water surface for two reasons (a) the tape graduations are referred to the outer extremity of a pull ring which has been removed to facilitate the fitting of the probe barrel and point (b) the graduations do not take into account the length of the barrel and probe point.

In practice this gives no inconvenience. In order to convert a sounding to a tidal elevation referred to tide gauge zero it is necessary to subtract the sounding from a constant value which depends upon the height of the instrument in its operating position. Items (a) and (b) can be incorporated in this constant. At Birkenhead, this has been achieved as follows :-

i) The tide gauge is mounted upon a metal-framed table which straddles the well. The probe is mounted beside the gauge flush with the table edge.

ii) It has been ascertained that the table surface is truly level.

iii) Fixed to a framework around the well top and at floor level is a brass plate, the level of which has been determined by O.S. (say ODN+X ft.).

iv) By moving the probe along the table surface it can be brought to rest immediately above the brass plate whereupon a "sounding" is made down to the brass plate and the tape reading noted as Y ft.

v) Tide gauge zero is defined as Z ft. below ODN   the constant to be used with the probe is X+Y+Z see diagram.

VII. Costs.

The costs of component parts :-

One 50 ft. steel tape in case graduated in feet, tenths and hundreths.

£4   14s.   9d.

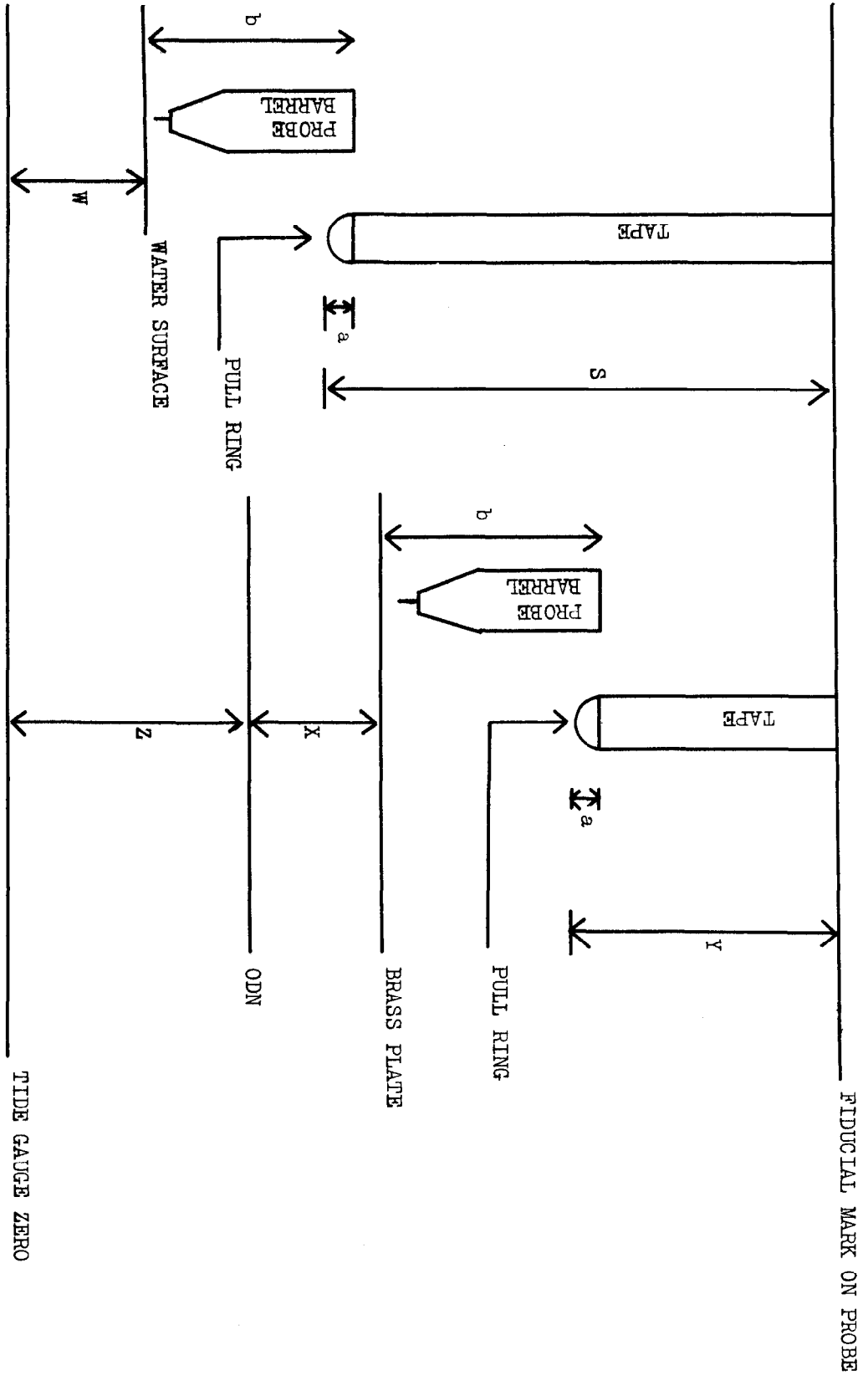One ammeter (range 0-500 μ A - internal resistance 75 Ω)

£1   7s.   6d.

Miscellaneous electrical items   £0   10s.   0d.

Wooden Case, brass, labour   Not costed.

DIAGRAM TO EXPLAIN PROBE CONSTANT

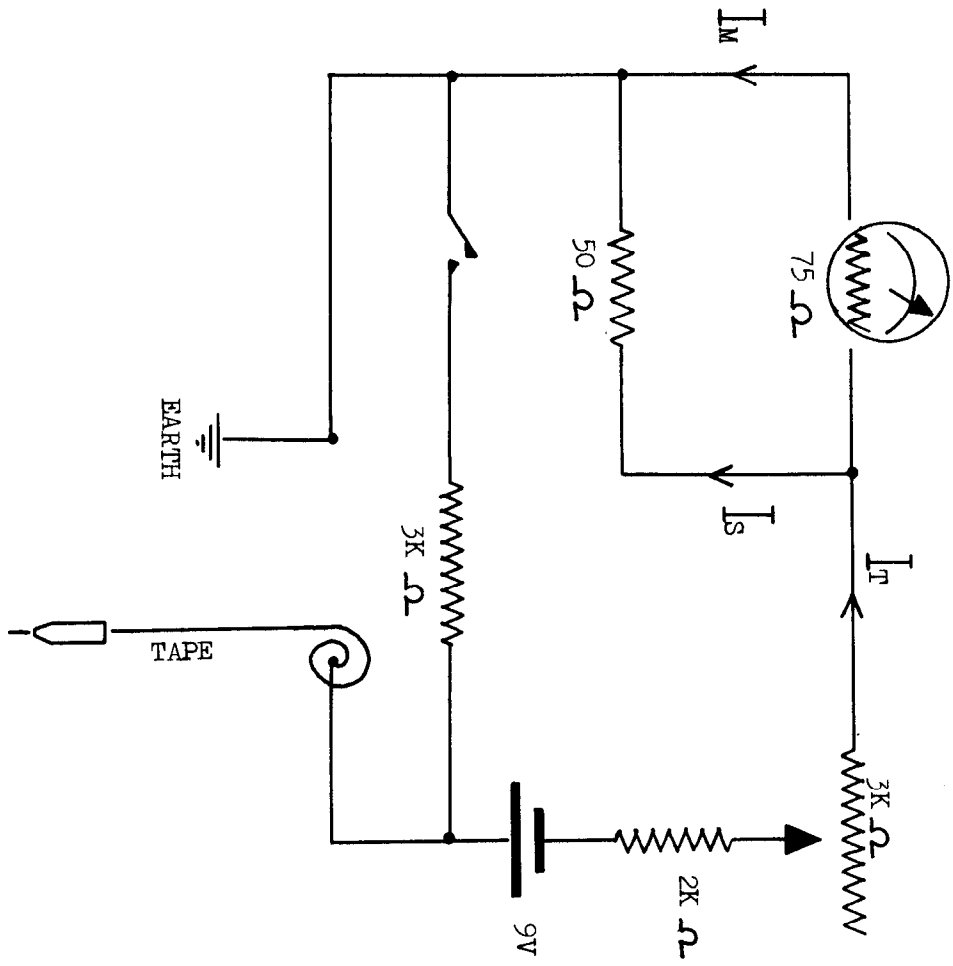Height of fiducial mark above tide gauge zero = X + Y + Z - a + b

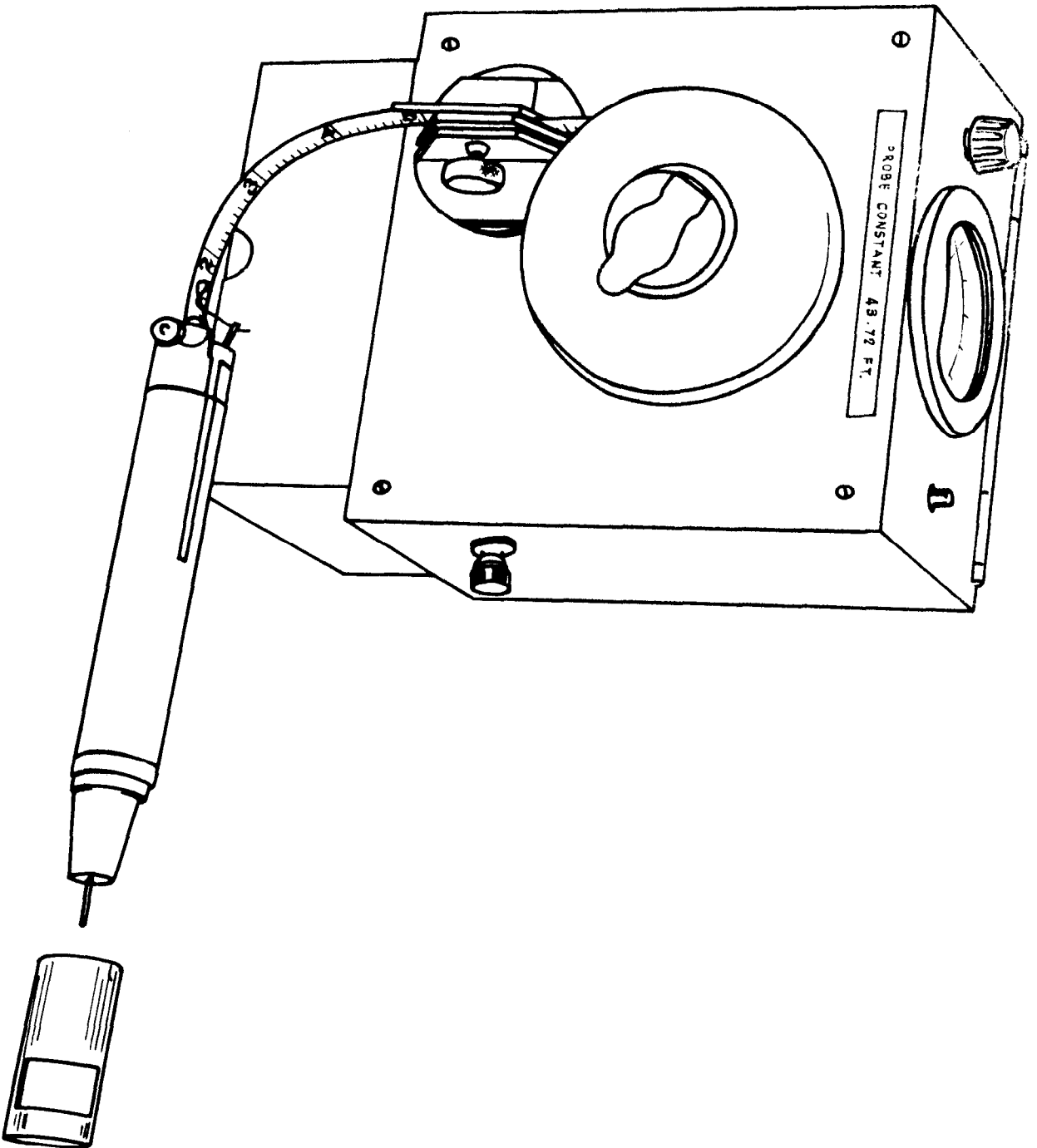For any sounding(S), height of water surface (W) above tide gauge zero is given by

$$W = (X + Y + Z - a + b) - (S - a + b)$$

$$= (X + Y + Z) - S$$

i.e. The constant from which tape readings should be subtracted is simply X + Y + Z

ELECTRICAL CIRCUIT OF PROBE

EARTH

TAPE

I_M

I_S

I_T

50 Ω

75 Ω

3K Ω

3K Ω

2K Ω

9V

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