

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

DIVISION of FISHERIES and OCEANOGRAPHY

Report No. 47

PORTABLE TEMPERATURE - CHLORINITY BRIDGE

**(S - T METER)
INSTRUCTION MANUAL**

By D. R. Lockwood

**Marine Laboratory
Cronulla, Sydney
1970**

Reprinted 1974

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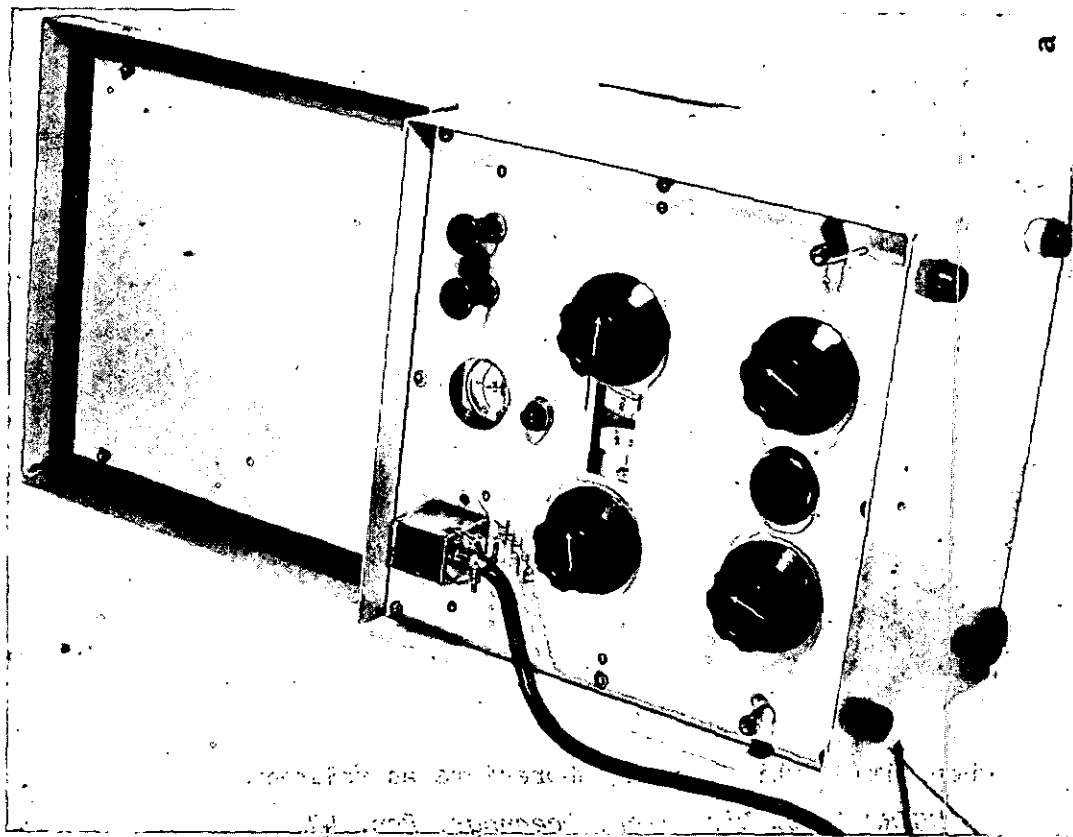
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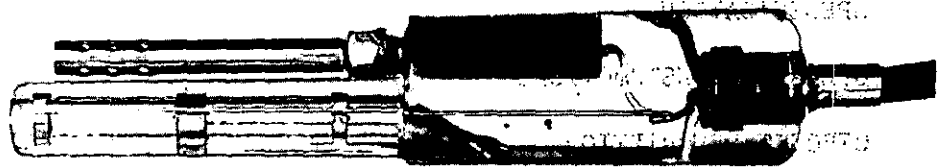
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When citing this report, abbreviate as follows:

CSIRO Aust. Div. Fish. Oceanogr. Rep. 47



a



b

Fig. 1.- (a) S-T meter; (b) measuring head.

1. SPECIFICATION

1.1 General

The S-T meter (Fig. 1) was originally known as a "Portable Temperature-Chlorinity Bridge", and was described by B.V. Hamon in *J. scient. Instrum.*, 33, 1956, 329-33. Originally designed for estuarine field work, it has also proved useful in the laboratory when large numbers of samples have to be analysed quickly in programs where the highest accuracy is not required.

The instrument consists of a self-contained battery-operated a.c. bridge, with a moulded plastic measuring head connected to the instrument by a shielded microphone cable. The principle of the chlorinity measurement is that, at a given temperature, the conductivity of seawater is a function of the chlorinity. The conductivity is sensed with a platinized platinum conductivity cell in the measuring head, which also contains a glass-sealed bead thermistor to compensate for variation of conductivity with temperature. For the measurement of temperature, the conductivity cell is replaced by a fixed resistor, and the variation with temperature of the compensation arm of the bridge is used as a measure of temperature.

The following description and procedures apply specifically to the instruments made some years ago (1960) by R.A. Ratcliffe, Eastwood N.S.W. The Division has recently (1969) bought new instruments made by Auto-Lab Industries Pty Ltd., Chatswood, N.S.W. The main differences are:

- (i) Scales are in salinity, not chlorinity.
- (ii) Ranges are slightly extended, so dilution (Section 2-8) should hardly ever be necessary.
- (iii) Transistors are used instead of valves.
- (iv) There is no dial lamp.
- (v) The case is more thoroughly sealed against moisture ingress.
- (vi) It is necessary to open the instrument and replace a plug-in circuit card when changing from one measuring head to another.

The Auto-Lab instruments are accompanied by their own instruction books and circuit diagrams, but some of the matters dealt with in this report might be found useful and relevant when using, checking, or servicing the Auto-Lab instruments.

Specification S-T meter

1.2 Ranges

The bridge configuration is controlled by two selector switches, one of which selects temperature or chlorinity functions, and the other selects chlorinity range. The following ranges are normally provided:

Temperature:	0-30°C,	scale subdivided to 0.2 degC
Chlorinity:	0-16 ‰,	" " " 0.2 ‰
	16-20 ‰,	" " " 0.05 ‰

1.3 Cable and measuring head

The length of cable fitted depends on the application. For laboratory use it is usually 2 m, and for field use may be up to a maximum of 100 m. The longer cables are usually marked at 1 m intervals. Several interchangeable heads with different cable lengths can be provided, although due to difficulties in balancing the reactive impedances of the cable, the accuracy might suffer slightly with this arrangement (see Section 5.3).

1.4 Accuracy

The following values are maximum errors due to scale marking and initial adjustment, when no corrections are applied. Better accuracy can be obtained if the instrument is calibrated (see Section 5), and corrections applied.

Temperature:	± 0.2 degC
Chlorinity	
(temperature range 5-25°C):	16-20 ‰, range ± 0.05 ‰
	0-16 ‰, range ± 0.1 ‰

On the 16-20 ‰ range, the change in reading with temperature in the range 10-25°C does not exceed 0.02 ‰ when tested with water of chlorinity 19.5 ‰.

1.5 Batteries

The instrument is powered by two dry batteries:

h.t.	45 V	- Eveready No. 482 or equivalent type;
l.t.	1.5 V	- Eveready No. 742 " " " " " "

Battery life is from a few months to a year in normal service, depending on the amount of use and the storage temperature.

1.6 Mechanical

Construction:

Brass case with aluminium front panel; splash-proof: a screw-down hinged lid with a carrying handle protects the front panel during transport.

Dimensions of instrument case:

Width - $10\frac{1}{2}$ in.
Depth - 12 in.
Height - 9 in.

The measuring head and cable assembly are treated separately. Heads with long cables should be stored on reels.

2. OPERATING INSTRUCTIONS

2.1 Chlorinity and salinity of sea-water

The total salt content of sea-water is frequently expressed as salinity. Salinity is defined as the total amount of solid material in grammes contained in one kilogramme of sea-water when all carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all organic matter oxidized.

Because of the convenience of chlorine analysis by titration with silver nitrate using potassium dichromate as indicator, the salt content of sea-water is frequently expressed as chlorinity. Chlorinity is defined approximately as the total amount of chlorine, bromine, and iodine in grammes contained in one kilogramme of sea-water when the bromine and iodine have been replaced by chlorine. Since this definition depends upon the accepted values of the atomic weights which have changed since this definition was established by an international commission, chlorinity is established in exact oceanographical work by comparison with a standard "normal sea-water", prepared by several agencies.

Salinity is related to chlorinity by the formula:

$$\text{Salinity} = 0.03 + 1.805 \times \text{Chlorinity}$$

Salinity is tabulated in Section 7.4 at chlorinity intervals of 0.01‰ over the chlorinity range 17.5 to 21.5‰.

2.2 Controls

The following controls are provided:

- (i) Power switch
- (ii) Panel light switch
- (iii) Temperature-chlorinity selector switch
- (iv) Chlorinity range switch
- (v) Temperature dial, 0-30°C, subdivided to 0.2 degC
- (vi) Chlorinity dial with two ranges: 0-16‰, subdivided to 0.2‰
16-20‰, " " 0.05‰

2.3 Instructions for setting up

Connect the measuring head to the meter by plugging in at the top left-hand corner of the control panel. This connector must be kept clean and dry at all times. The pins may be smeared with vaseline or silicone grease to retard corrosion. If wet, the connector should be sprayed with a commercial dewatering agent such as CRC 2.26.

Operating instructions S-T meter

Immerse the head in dilute hydrochloric acid for two minutes, raising and lowering the head continuously. It is thought that this helps to keep the electrodes clean and to reduce the effects of polarization, and experience has shown that it does tend to reduce the drift of the chlorinity zero correction. 0.1 N acid is suggested - this has the advantage of having a conductivity of the same order of magnitude as sea-water, which reduces the effect of contamination of the samples with the acid. The acid may be re-used a number of times.

Rinse the cell several times with clean sea-water and, without allowing the electrodes to dry, immerse the head in any convenient sample of sea-water, contained in a suitable vessel. If a cylindrical container of diameter 1.5 in. is used, a sample of approximately 100 ml is required. From this point to the end of the series of measurements, the electrodes must not be allowed to dry. If by accident they become dry, they should be rinsed with acid again before further measurements are made.

With the electrodes now clean and the head immersed in sea-water, turn on the bridge. The right-hand switch operates a panel light to illuminate the potentiometer dials and meter; it is not normally used in the laboratory. Set the lower left-hand knob to "chlorinity" and the lower right-hand knob to the appropriate chlorinity range (16-20‰ for marine waters). Rotate the chlorinity dial until the meter reads zero. Stir the sample by repeatedly raising and lowering the head, adjusting the chlorinity dial until a steady reading is obtained. If the head has not been used for some time, a soaking period of about 10 min is generally required. The first few readings should be regarded with suspicion until the operator is confident that the head is well soaked. If a steady reading cannot be obtained, the cell might need cleaning or replatinizing (see Section 5.2). Batteries might need replacement.

Drain this sample and rinse the beaker a couple of times with sea-water of approximately the same chlorinity as the sea-water to be used for the standardization. This rinse may conveniently be with standard sea-water slightly polluted as a result of previous standardizations, and kept for this purpose. Drain again, and fill with sea-water of known salinity - the standard or substandard. Stir, and adjust the chlorinity dial until the meter reads zero. Read the chlorinity dial. The known chlorinity of the sample and the S-T meter reading should be recorded in the appropriate places on the analysis log sheet (Section 2.7); the difference between these values is the "correction" to be applied to all subsequent measurements. Record the meter and head numbers on the log sheet.

The temperature of the sample should be measured by turning the lower left-hand switch to "temperature" and rotating the temperature dial until the meter reads zero. Read the temperature and record it on the log sheet. The instrument is now standardized and ready for measurement of unknown samples.

2.4 Measurement of unknown samples in the laboratory

After standardization of the instrument the samples can be measured consecutively. No rinsing is required between samples if the observed chlorinity values are reasonably close, but the beaker should be rinsed with sea-water of chlorinity approximately equal to that of the standard before repeating the standardization check.

Individual samples should be stirred by moving the measuring head up and down until a steady reading is obtained. For maximum accuracy, samples and standard should be stored in the laboratory until they have reached temperature equilibrium (within say, 1 degC).

A check on the standardization should be carried out after the first ten or so samples; if this agrees with the previous reading of the standard, checks can be made at the rate of one per twenty samples for the remainder of the series of measurements.

After a series of measurements has been finished, it might be convenient to leave the head immersed in the last sample until next required. If this is not possible, wash the head in fresh (preferably distilled) water before allowing it to dry. This prevents the formation of salt crystals on the electrodes, which damages the platinization. After drying, the head generally needs cleaning with hydrochloric acid before it will give consistent readings.

2.5 Field use

The procedure is similar to that given above (Section 2.4), except that the readings are recorded by station number and depth, rather than by sample number. The depth is generally measured by markings on the head cable.

The frequency of standardization will depend on the accuracy required and the degree of cell pollution experienced. Various schemes have been used, ranging from standardization before and after each station, to once daily standardization.

The cell should be kept wet with clean sea-water for the entire duration of a cruise or field trip. If this is not practicable, the cell should be washed with fresh water after use and acid rinsed before use (see above, Section 2.4).

Operating instructions S-T meter

2.6 Cell contamination

At intervals, particularly when used in water contaminated with sewage or where there are dense plankton populations, the electrodes may become fouled. This is indicated by a large chlorinity correction, and a tendency for the meter to drift. If the usual acid rinse fails to correct the situation, replatinization is indicated (Section 5.2). It should not normally be attempted in the field. **NO ATTEMPT SHOULD BE MADE TO CLEAN THE ELECTRODES MECHANICALLY UNLESS THEY ARE TO BE REPLATINIZED.**

2.7 Log sheets (refer to Appendix 7.1)

The log sheets for the analytical results include spaces for the standardization results and the meter readings for all samples. The meter correction must be applied to all readings. The operator's name and the date should be noted on each sheet.

2.8 Measurement of high salinity samples

The upper range of the S-T meter covers values of chlorinity from 16-20‰ (salinity 29-36‰). This range is adequate for most marine samples. Samples of greater salt content can be diluted with a known quantity of distilled water and the S-T meter used to measure the relative volumes of undiluted sea-water and distilled water, and their densities at the temperature of measurement, must be applied to convert to the chlorinity (or salinity) of the original sample.

A suggested procedure is described below, and a table of the correction factor for common values of temperature and salinity is given.

Required:

Distilled water.

10 ml pipette, A grade, ± 0.02 ml.

(The pipette is most important, and should be of the highest quality.)

100 ml stoppered graduated flask, A class, ± 0.06 ml.

Procedure:

1. After the sample of sea-water has been placed in the S-T meter beaker and its chlorinity found to lie above the range of the instrument, the sample should be returned to its stoppered bottle whilst the volumetric glassware and distilled water are made ready.

Operating instructions
S-T meter

2. The graduated flask should be either completely dry or rinsed with a small quantity of the high-chlorinity sample. If the flask has been previously washed and rinsed with distilled water, it is most important that it should be rinsed and drained twice with the sample before being used.
3. The pipette should be either completely dry or rinsed with distilled water: it can be used immediately after rinsing with distilled water.
4. Using the pipette, deliver 10 ml distilled water into the flask allowing the pipette to drain for the time stated on its calibration certificate. The distilled water should be within 1 degC of the temperature of the sample. This can conveniently be arranged by storing the samples and distilled water together.
5. Fill the flask exactly to its mark by the addition of the high-chlorinity sea-water. Stopper the flask and mix the diluted sample thoroughly by repeated inversions of the flask.
6. Rinse the S-T meter beaker and electrode assembly with a little of the diluted sample, drain the beaker, and refill with diluted sample. Measure the chlorinity in the usual way and record its value in the usual column on the log sheet, but place an asterisk by the value. At the foot of the log sheet place an asterisk and the words "90 ml sample diluted with 10 ml distilled water". The chlorinity of the diluted sample should be corrected in the normal way, and converted to salinity.
7. Measure the temperature of the sample by turning the lower left-hand switch of the S-T meter to "temperature" and rotating the temperature dial until the meter reads zero; read the temperature and record its value in the "remarks" column of the log sheet.
8. If the diluted sample is to be kept, discard the undiluted sample left in its original stoppered bottle, rinse the bottle with a little diluted sea-water remaining in the graduated flask, and drain the S-T meter beaker and flask into the stoppered sample bottle for retention.
9. Before placing the next sample of sea-water in the S-T meter beaker, rinse with new sample since its chlorinity may be markedly different from the traces of diluted sample remaining in the beaker.
10. Before the graduated flask can be used for the dilution of another sample it must be rinsed with that sample; no other rinsing is required.

Operating instructions
S-T meter

11. The salinity of the diluted sample is multiplied by a factor (Table 1) to give the salinity of the original sample.

For values of temperature and salinity lying outside the tabulated values, the factor can be calculated from the expression:

$$\text{Conversion factor} = \frac{10\rho_t}{10\rho_t - \rho_{\text{dist.}}}$$

where ρ_t = density of salt water of salinity equal to the diluted sample at the temperature of measurement; and $\rho_{\text{dist.}}$ = density of distilled water at the same temperature.

Example: After dilution, a sample has a chlorinity of 19.54‰ (corrected), temperature of measurement 21.4°C; calculate the salinity of the original sample.

The first step is to convert chlorinity to salinity by use of the table in Section 7.4 of the expression $\text{Sal.} = 0.03 + 1.805 \times \text{Chl.}$ (Section 2.1). For this example, the salinity is found to be 35.30‰ and from Table 1, the raising factor is 1.10790.

Original salinity = 35.30 × 1.10790

= 39.11‰

Effect of dilution on accuracy of measurement: Laboratory tests have indicated that the above method does not affect the accuracy of final salinity measurement by more than ± 0.02‰, so that the results of analyses made by this method are compatible with those made with the S-T meter in the normal manner. Extreme care is necessary in the dilution of the original sample.

TABLE 1

TABLE OF RAISING FACTOR

Salinity ‰	Temperature °C					
	15	17	19	21	23	25
31	1.10825	1.10826	1.10827	1.10828	1.10829	1.10830
32	816	817	818	819	820	821
33	807	808	809	811	812	813
34	798	799	801	802	803	804
35	789	790	792	793	794	795
36	780	781	783	784	785	786
37	771	772	774	775	776	777

3. CIRCUIT DESCRIPTION

(Refer to circuit diagram Section 6.3)

3.1 General

The instrument consists of an a.c. resistance bridge supplied by a 3 kHz oscillator. Three bridge configurations are provided by the selector switches S1 and S2. S1 selects temperature or salinity measurement, and S2 selects either of two chlorinity scales. Separate balancing potentiometers are used for the temperature and salinity bridges. The bridge output is transformer-coupled to an amplifying stage and detected by a phase-sensitive detector. Subminiature vacuum tubes, type DL68, are used throughout.

3.2 Oscillator (V4)

This is a conventional tuned-plate oscillator. Bias is provided by the grid-leak/capacitor combination R18/C10. The bypassed resistor R17, in series with the positive power supply lead, provides some amplitude stabilization, and may be altered if necessary to adjust the level of the output to the measuring bridge to its normal value of 0.5 V rms. An additional centre-tapped output is provided to drive the grids of the phase-sensitive detector.

3.3 Detector amplifier (V1)

This is a tetrode amplifier with a tuned transformer-coupled input. Bias is provided by the resistor R12, which is in series with the negative lead of the high tension battery.

3.4 Phase-sensitive detector (V2, V3)

This is a balanced pair of triodes, biased beyond cut-off by a voltage from the bypassed resistors R12 and R13, which are in series with the negative lead of the high tension battery. A polarizing voltage of about 4 V peak is applied in opposite phase to each grid, causing a series of negative pulses at the plates. To the extent that exact balance exists, no deflection of the meter occurs. When an a.c. signal from V1 with a phase of 0° or 180° is applied to the centre tap of the polarizing voltage winding, the effect is to increase the size of the pulses on one side, and to decrease those on the other side, causing the meter to deflect. The operation of this circuit is improved if the valves V2 and V3 are selected as a balanced pair. Final balancing can be achieved by trimming R15 or R16.

Circuit description S-T meter

3.5 Measuring bridges

3.5.1 Salinity

R8 (the series combination of R8A and RV8) is chosen so that the series combination of the thermistor and R8 has a variation with temperature closely matching that of sea-water. The fixed resistor R8A is installed so that correct compensation is obtained with RV8 at about half setting. Changes in the slope of the compensation error curve, due to slight variations of the thermistor resistance may be corrected during recalibration by adjusting RV8. It is generally necessary to change R8A if a new thermistor is fitted.

R6A is chosen after adjustment of R8 to obtain the desired sensitivity on the 0-16‰ chlorinity range, with RV6 at half setting. Small changes in cell constant, and adjustments of RV8 will cause calibration errors, which may be removed by adjusting RV6. This adjustment is valid for both chlorinity ranges, as the relationship between ranges is set by R3, R4, and RV2, all of which are stable precision resistors. As better accuracy is usually required in the 16-20‰ range, RV6 is used to make the final zero adjustment on this range, after R3 and R4 have been fixed.

Reactive unbalance of the bridge, caused mainly by the capacity of the cable, can cause small errors due to imperfect working of the phase-sensitive detector. This effect is reduced on the 16-20‰ range by C1. The balance can only be correct at one chlorinity value, as the requirement for reactive balance is that the ratio of the capacitances across the cell and the compensation arm of the bridge be in inverse proportion to the resistance ratio, which is a function of chlorinity. The chlorinity at which reactive balance occurs will be a function of the length of the cable. In practice, where an instrument is used with several heads with different cable lengths, C1 is selected for balance with the most commonly used head, near to the most commonly measured value of chlorinity.

3.5.2 Temperature

If R8 is correctly set, the variation with temperature of the compensation arm of the bridge is very closely that of sea-water. Hence the variation of scale setting with temperature is closely repeatable from instrument to instrument, and is fixed by the ratio of the resistances of R1 and RV1. For maximum bridge sensitivity, R2 is chosen to be approximately equal to $R1 + RV1$, with RV1 at half setting. Zero adjustment is determined by R7. After adjustment of R8, R7A is chosen to correctly align the temperature scale, with RV7 at half setting. During recalibration, zero adjustments may be made with RV7.

C2 reduces reactive unbalance, and remarks similar to those made concerning C1 apply to this.

4. MAINTENANCE

4.1 General

a) Clean off dust, salt particles, and moisture, inside and outside the case.

b) If moisture is present inside the case, spray with a de-watering agent, such as CRC 2.26. Allow compound and moisture to drain off and clean off excess compound with absorbent cloth or tissue. Examine case seals and repair if necessary, before proceeding further.

c) Inspect thoroughly for signs of corrosion, damaged components, and for dry or fatigued joints. Correct where found.

d) Switch on and check for general operation. Test battery voltages and replace if necessary (make sure that the lamp is on while checking the 1.5 V battery). If the instrument is not working, find and repair the faults by the usual methods. After repair, recheck battery voltages with the instrument switched on.

e) Look for signs of erratic operation due to dirty potentiometers, valve sockets or head connector. Clean or replace where applicable.

4.2 Oscillator

a) Check frequency: 3 kHz, $\pm 20\%$.

b) Check output level to bridge: 1.5 V p-p, $\pm 20\%$.

c) Check distortion: less than 2% (not readily apparent on oscilloscope).

Adjustment is not normally required after initial setting-up, so that performance outside these limits generally indicates faulty components.

4.3 Amplifier

a) With the head shielded from air currents or in water, adjust the temperature dial to give a meter deflection of about half scale. Adjust the trimming capacitor C4 to give maximum output at V1 anode. Measure directly at V1 anode when making this adjustment.

b) Check that the signal at V1 anode is not clipping at either extreme of the null meter reading, indicating malfunction of the valve or bias network. Note that the output near the balance setting will normally be distorted, as the harmonics of the oscillator are not in general nulled because of reactive unbalance in the bridge.

Maintenance
S-T meter

4.4 Detector

a) Adjust the temperature dial to balance. Short-circuit the bridge side of the detector transformer and observe the null meter reading. If this is greater than one third of a minor division, remove any existing shunts from R15 and R16 and shunt either one (depending on the direction of the meter deflection) to reduce this to as near zero as can be obtained, using a single shunt resistor.

b) If the value of the shunt resistor obtained is less than 1 M ohm, examine the circuit waveforms for possible malfunction. If the circuit appears to be operating normally, remove the shunt and balance the valves by replacing one or both until the meter deflection is less than one minor division and repeat the balancing procedure.

5. CALIBRATION

5.1 General

The least stable part of the instrument is the conductivity cell, because of the fragility of the platinization and its susceptibility to fouling. Because of this, when the chlorinity correction becomes unacceptably large it is often sufficient simply to replatinize the cell. When maximum accuracy is sought, particularly in field measurements, the temperature compensation correction curve should be measured about every six months. When this is done it is convenient to reduce both the temperature and the chlorinity corrections to zero. Calibration procedures, including those for the alignment of new heads, are given below.

5.2 Platinization

a) Check the polarization. Acid rinse the cell and soak it in a sample of clean sea-water for at least 15 min. Measure the polarization capacity expressed as capacity in parallel with the cell at a frequency of 500 Hz, using the "polarization bridge" described in Appendix 7.2. If the capacity is greater than 0.025 μF , replatinization is necessary.

b) Strip and clean the cell by filling it with conc. HCl (10 N), and applying a voltage of about 3 V for 5 min, reversing the polarity every 10 sec. If the fouling is particularly bad, it may be necessary to first clean the cell mechanically with detergent and a stiff bristle brush. After stripping, rinse the cell with distilled water.

c) Fill the cell with platinizing solution prepared as follows:

Weigh 3 g of hydrochloroplatinic acid hexahydrate ($\text{H}_2\text{PtCl}_6 \cdot 6\text{H}_2\text{O}$, "platinic chloride" of commerce) into a porcelain crucible.

Add 20 ml of conc. HCl and take to dryness. Repeat once.

To the dry residue add 25 mg of lead acetate ($\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3\text{H}_2\text{O}$) and dissolve in 100 ml of 0.0025 N HCl. Filter through Whatman No.1 paper into a clean dry bottle.

d) Apply a voltage of about 5 V for 5 min, reversing the polarity every 10 sec. Rinse the cell and recheck the polarization. Soak the cell for several hours before attempting any measurements, as there appears to be an initial aging process.

NOTE: The platinizing solution can be kept and used repeatedly. A convenient method of retaining the stripping and platinizing solutions is to clamp the cell vertically in a retort stand, closing the lower end with a small rubber bung or with a rubber cap.

Calibration
S-T meter

5.3 Reactive balance

This need only be adjusted during major overhauls or when the best obtainable accuracy is required, when a head with a different cable length from that with which the reactive balance was originally adjusted is used.

a) Immerse the cell in a sample of sea-water of roughly the chlorinity and temperature expected to be most commonly measured.

b) Disconnect C1, replacing it with an adjustable capacitance box. Connect an oscilloscope to monitor the waveform at the anode of V1.

c) Adjust the temperature dial and the capacitance box to reduce the signal at V1 as nearly as possible to zero (there will always be a small residual, due mainly to harmonics of the oscillator).

Install the nearest standard value of C1 to the capacitance indicated on the box.

d) Determine C2 similarly, using the chlorinity dial and the 16-20‰ range.

5.4 Calibration (temperature compensation and zero adjustment)

a) After checking the polarization and while the head is soaking, cool about 2 l of clean sea-water, chlorinity about 19.5‰, to 0°-2°C. It is often convenient to do this overnight.

b) Transfer about 500 ml of the cooled water to a 2 l conical flask connected to the sample container as shown in diagram 6.1. Fill the sample container by raising the conical flask and using the stopcock to admit the required amount of water to the container. Allow at least 5 min for temperature equilibrium to be attained, draining the sample back into the flask and refilling several times as the sample is warmed in the process of cooling the head.

c) Carefully balance the temperature and chlorinity dials of the S-T meter and record the settings. Slowly lift the head in and out of the sample several times until a repeatable chlorinity reading is obtained. This procedure avoids errors due to bubbles and to lower temperature water being trapped in the cell or around the thermistor and should be used throughout the calibration.

d) Drain the sample back into the flask and raise its temperature 2-3 degC by immersing the flask in hot water. Experience will indicate how hot to have the water and how long to immerse the flask. As a guide, the heating bath should be at a temperature of about 30°C at first, increasing to about 60°C at the end of the calibration. The immersion time for the flask will be about a minute.

e) Using the procedures of the preceding two paragraphs, take a series of readings covering the whole of the temperature range of the meter. Plot these as a graph of chlorinity vs. temperature. The plot should be a smooth curve with a shape similar to those shown on diagram 6.2. If the deviations from the smooth curve exceed 0.01‰, insufficient care was taken, and the whole series should be repeated.

f) Adjust R8 if necessary, by means of RV8. Diagram 6.2 indicates the direction of the adjustment. Repeat the process until satisfactory compensation is obtained. When this has been done, use the remainder of the cold water to cool the head and the sample container to room temperature.

g) Fill the sample container with water of accurately known chlorinity (standard or recently measured substandard), having first rinsed the container twice with water of similar chlorinity. Set the chlorinity dial to the chlorinity of the sample and adjust RV6 until the meter reads zero. Note the temperature of the sample.

h) Remove the head from the sample container and measure the temperature of the sample with an accurate thermometer. Apply the thermometer correction to obtain the true water temperature and, replacing the head in the container, set the temperature dial to the true water temperature and zero the meter using RV7. Remove the head again and check the temperature of the sample. Repeat the procedure if necessary.

i) Seal the adjusting screws of the trimming resistors with wax. Using the readings from the last obtained temperature compensation run, prepare a graph of the temperature compensation correction as a function of sample temperature, setting the correction to zero at the sample temperature at which RV6 was adjusted.

5.5 Head standardization

This procedure is used when a new head is constructed, and is generally necessary when a thermistor is replaced in an existing head, as the required values of R6, 7, 8 are generally outside the range of adjustment provided by the trimming resistors. While it is possible to carry out this procedure using resistance boxes in place of the three head resistors, better results will be obtained using the test jig described in Appendix 7.3. In the following description, it is assumed that the test jig is being used.

a) Remove the existing connector, if any, from the cable and connect the two conductors and the screen to the appropriate terminals on the test jig. Carry out the full procedure given above in Section 5.2, and in Section 5.4 up to and including para. h. Begin with a trial setting of R8 of about 80 ohms, and with R6 and R7 set to give approximately correct readings of chlorinity and temperature.

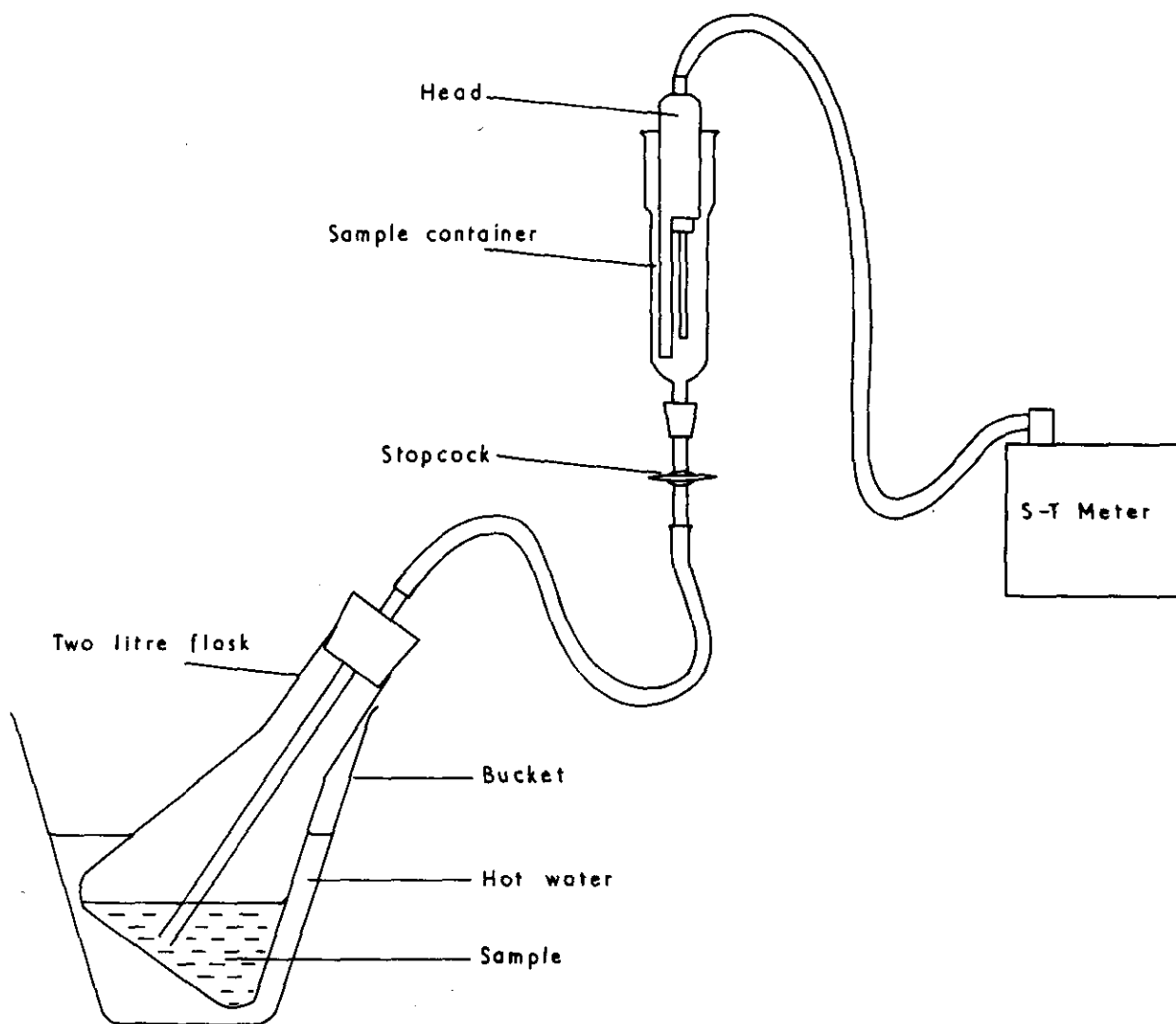
**Calibration
S-T meter**

b) Measure the resultant settings of the variable resistors on the test jig to ± 0.5 ohms. Subtract from these values half the resistance of the variable resistors RV6, 7, 8. The remainders are the required values of the fixed resistors R6A, 7A, 8A.

c) Procure the required resistors and make up the new connector assembly. Repeat the calibration of Section 5.4 to obtain the exact settings of the variable resistors and the compensation correction graph.

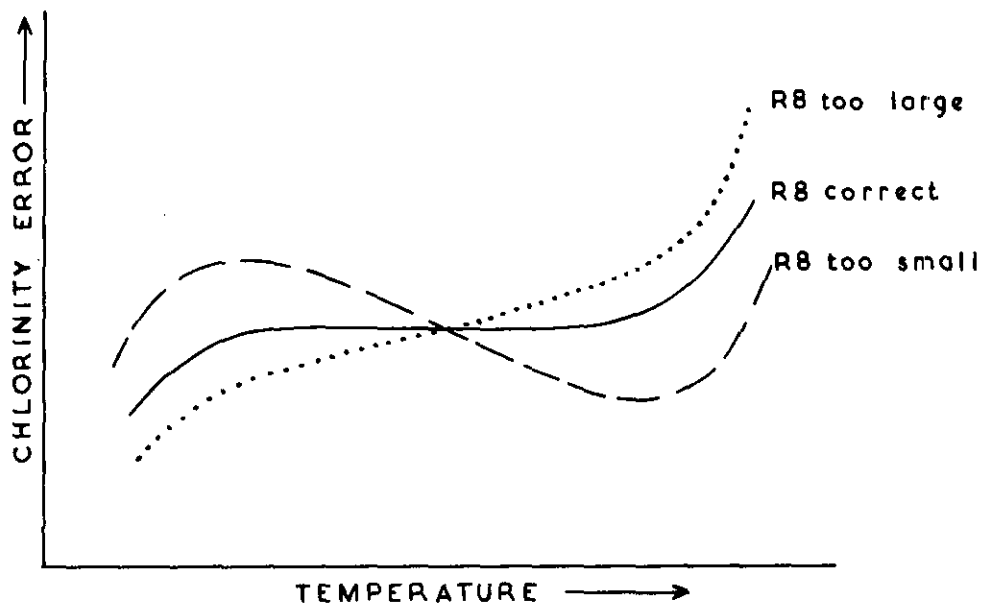
d) Note the values of R6A, 7A, 8A in the maintenance record of the instrument.

6.1 Arrangements for determination of temperature compensation error curves



Diagrams
S-T meter

6.2 Typical temperature compensation error curves.



6.3 Circuit diagram

PARTS LIST

R1	Resistor w/w 250 Ω	±5%
R2	" " 350 Ω	±5%
R3	" precision w/w 520 Ω	approx., adj. on test
R4	" " 480 Ω	" " "
R5	" w/w 50 Ω	±10%
R6A R7A R8A	" precision w/w, adj. on test	
R9	" w/w 300 Ω	±10%
R10	" 75 kΩ metox F23	±5%
R11	" 100 kΩ	" " "
R12	" 1.5 kΩ	" " "
R13	" 2.0 kΩ	" " "
R14	" 1 MΩ	" " "
R15 R16	" 100 kΩ	see maintenance Section 4.4
R17	" 5 kΩ metox F23	±5%
R18	" 500 kΩ metox F23	±5%
R19	" 100 Ω	
RV1	Potentiometer precision Painton type CV25	250 Ω
RV2	" " " " "	50 Ω
RV6 RV7 RV8	Trimming potentiometer Beckman 79P	10 Ω
C1	Capacitor polyester 0.006 μF,	see calibration Section 5.3
C2	" " 0.003 μF,	" " "
C3	Deleted	
C4	Capacitor air trimmer 40 pF	
C5 C6	" polyester 0.1 μF	400 V
C7	" electrolytic 100 μF	6 V
C8	" polystyrene 0.025 μF	
C9 C10	" polyester 0.1 μF	400 V
V1 V2 V3 V4	Valve subminiature DL68	
M1	Meter sealed Master Instr. SHSRS 18	50-0-50 μA
S1 S2	Selector switch Oak type H 4 pole,	2 positions
T1	Transformer ferrite core D36/22 turns as shown	B&S SSC/EN
T2	Transformer ferrite core D36/22 turns as shown	PRI 26 B&S SSC/EN, SEC 42 B&S EN

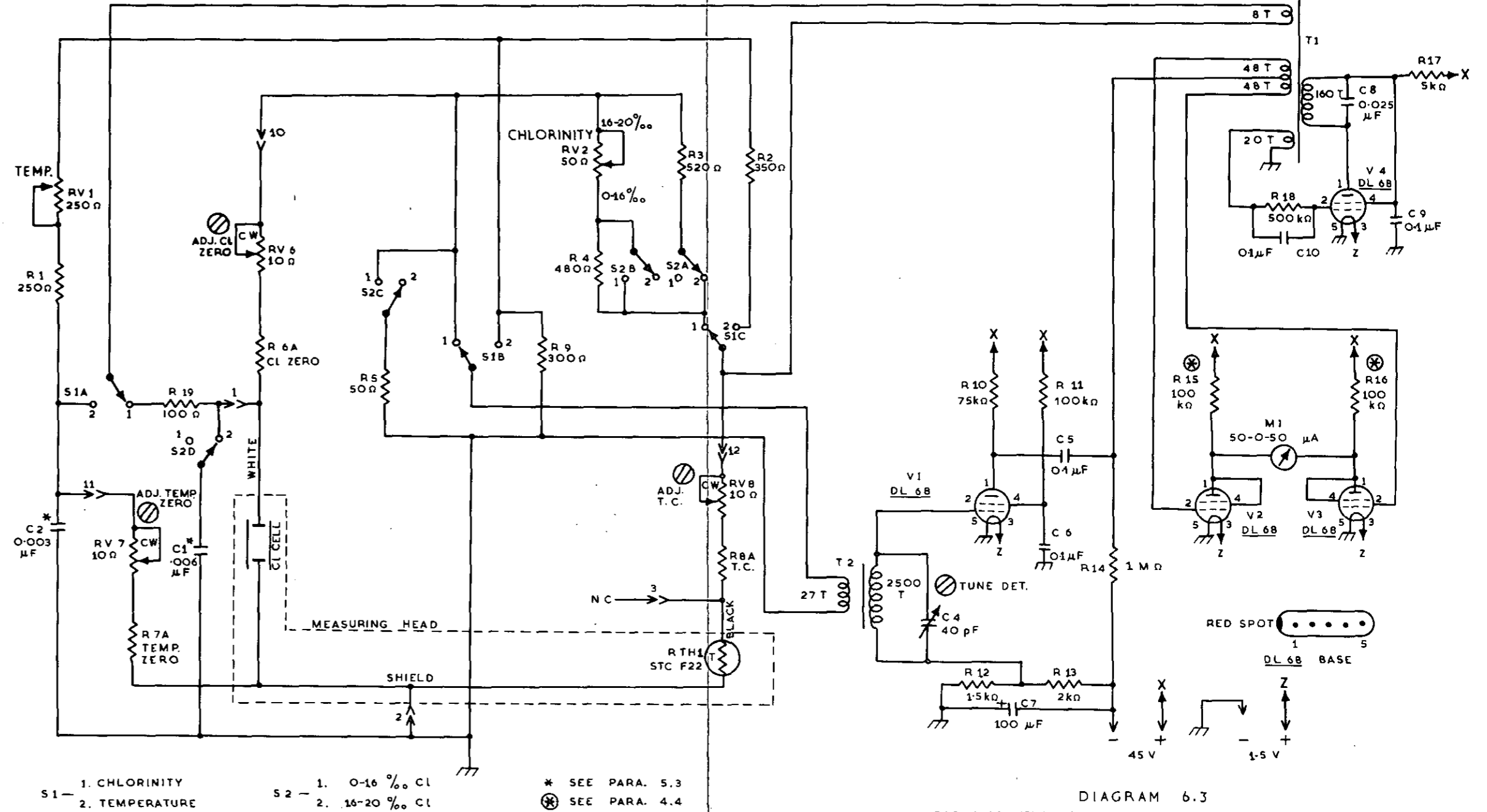


DIAGRAM 6.3
PORTABLE TEMPERATURE-CHLORINITY BRIDGE MK. II
CIRCUIT SCHEMATIC

7.1 Log sheet

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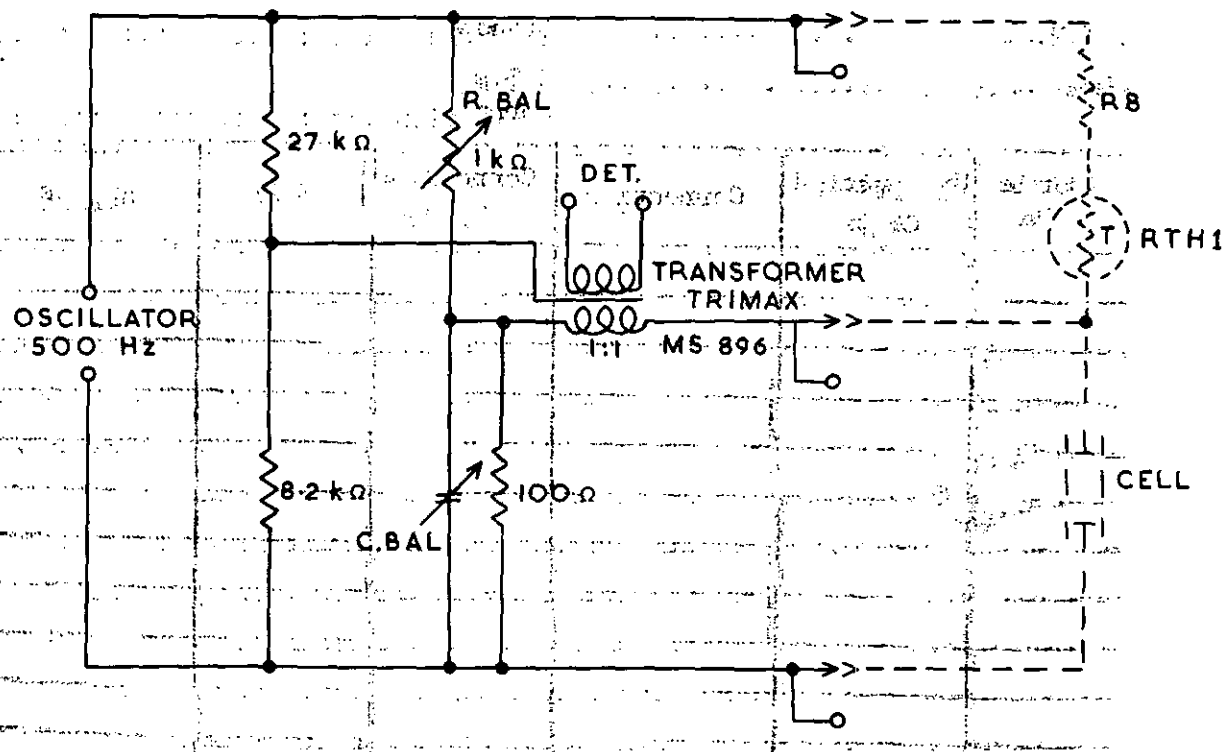
SALINITY

Date Analysis Date Collection
S.T.M. Standard
Head S.T.M.
Correction

Bottle No.	Uncorrected Cl ‰	Correction	Corrected Cl ‰	S ‰	Remarks

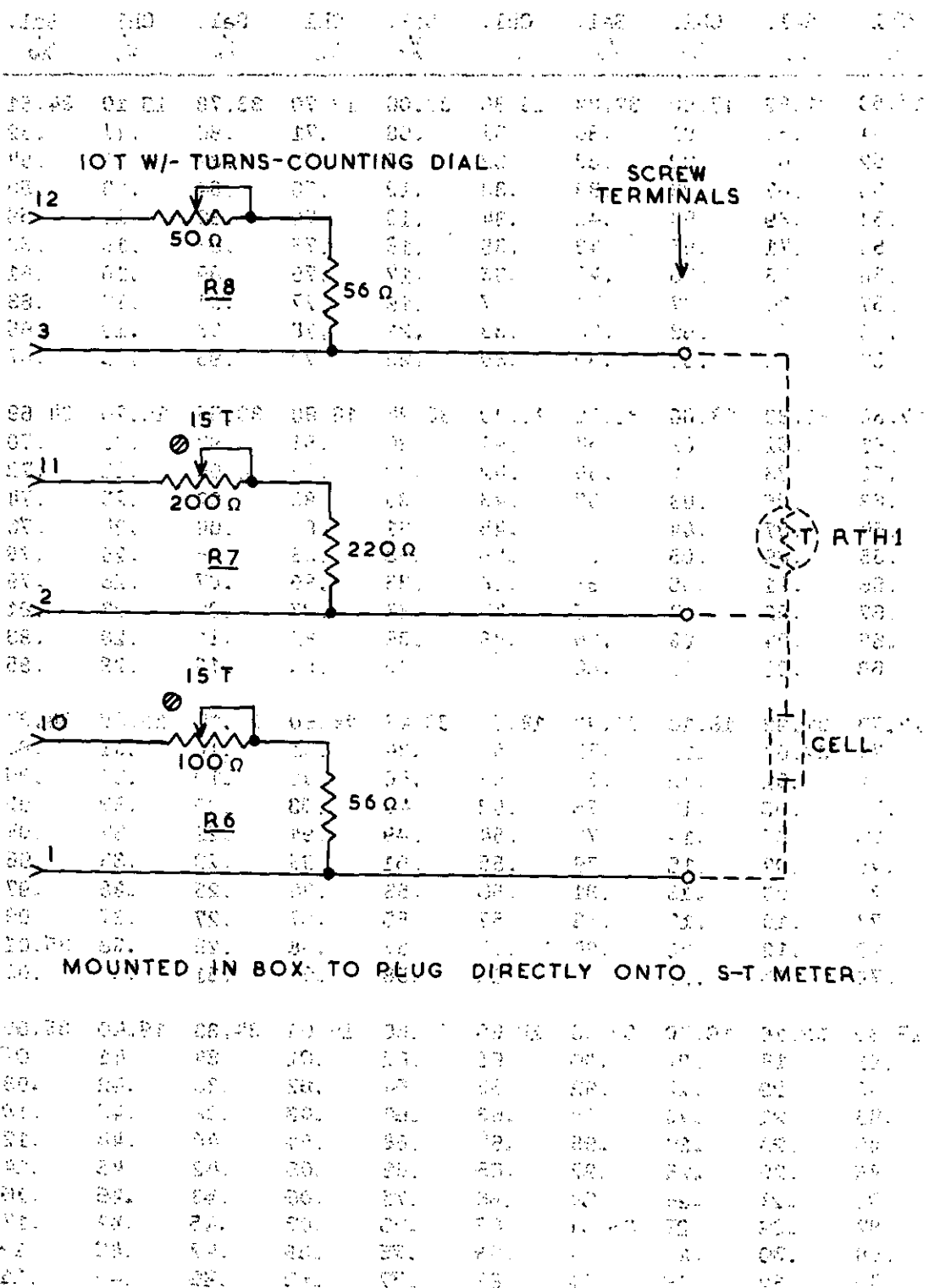
7.2 Polarization bridge

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7.3 Test jig

Initial or substitute wireward: 4-1



Appendices
S-T meter

7.4 Conversion of chlorinity to salinity

Chl. ‰	Sal. ‰	Chl. ‰	Sal. ‰	Chl. ‰	Sal. ‰	Chl. ‰	Sal. ‰	Chl. ‰	Sal. ‰
17.50	31.62	17.90	32.34	18.30	33.06	18.70	33.78	19.10	34.51
.51	.64	.91	.36	.31	.08	.71	.80	.11	.52
.52	.65	.92	.38	.32	.10	.72	.82	.12	.54
.53	.67	.93	.39	.33	.12	.73	.84	.13	.56
.54	.69	.94	.41	.34	.13	.74	.86	.14	.58
.55	.71	.95	.43	.35	.15	.75	.87	.15	.60
.56	.73	.96	.45	.36	.17	.76	.89	.16	.61
.57	.74	.97	.47	.37	.19	.77	.91	.17	.63
.58	.76	.98	.48	.38	.21	.78	.93	.18	.65
.59	.78	.99	.50	.39	.22	.79	.95	.19	.67
17.60	31.80	18.00	32.52	18.40	33.24	18.80	33.96	19.20	34.69
.61	.82	.01	.54	.41	.26	.81	.98	.21	.70
.62	.83	.02	.56	.42	.28	.82	34.00	.22	.72
.63	.85	.03	.57	.43	.30	.83	.02	.23	.74
.64	.87	.04	.59	.44	.31	.84	.04	.24	.76
.65	.89	.05	.61	.45	.33	.85	.05	.25	.78
.66	.91	.06	.63	.46	.35	.86	.07	.26	.79
.67	.92	.07	.65	.47	.37	.87	.09	.27	.81
.68	.94	.08	.66	.48	.39	.88	.11	.28	.83
.69	.96	.09	.68	.49	.40	.89	.13	.29	.85
17.70	31.98	18.10	32.70	18.50	33.42	18.90	34.14	19.30	34.87
.71	32.00	.11	.72	.51	.44	.91	.16	.31	.88
.72	.01	.12	.74	.52	.46	.92	.18	.32	.90
.73	.03	.13	.75	.53	.48	.93	.20	.33	.92
.74	.05	.14	.77	.54	.49	.94	.22	.34	.94
.75	.07	.15	.79	.55	.51	.95	.23	.35	.96
.76	.09	.16	.81	.56	.53	.96	.25	.36	.97
.77	.10	.17	.83	.57	.55	.97	.27	.37	.99
.78	.12	.18	.84	.58	.57	.98	.29	.38	35.01
.79	.14	.19	.86	.59	.58	.99	.31	.39	.03
17.80	32.16	18.20	32.88	18.60	33.60	19.00	34.33	19.40	35.05
.81	.18	.21	.90	.61	.62	.01	.34	.41	.07
.82	.20	.22	.92	.62	.64	.02	.35	.42	.08
.83	.21	.23	.94	.63	.66	.03	.38	.43	.10
.84	.23	.24	.95	.64	.68	.04	.40	.44	.12
.85	.25	.25	.97	.65	.69	.05	.42	.45	.14
.86	.27	.26	.99	.66	.71	.06	.43	.46	.16
.87	.29	.27	33.01	.67	.73	.07	.45	.47	.17
.88	.30	.28	.03	.68	.75	.08	.47	.48	.19
.89	.32	.29	.04	.69	.77	.09	.49	.49	.21

7.4 Conversion of chlorinity to salinity (Cont'd)

Chl. ‰	Sal. ‰	Chl. ‰	Sal. ‰	Chl. ‰	Sal. ‰	Chl. ‰	Sal. ‰	Chl. ‰	Sal. ‰
19.50	35.23	19.90	35.95	20.30	36.67	20.70	37.39	21.10	38.12
.51	.25	.91	.97	.31	.69	.71	.41	.11	.13
.52	.26	.92	.99	.32	.71	.72	.43	.12	.15
.53	.28	.93	36.00	.33	.73	.73	.45	.13	.17
.54	.30	.94	.02	.34	.74	.74	.47	.14	.19
.55	.32	.95	.04	.35	.76	.75	.48	.15	.21
.56	.34	.96	.06	.36	.78	.76	.50	.16	.22
.57	.35	.97	.08	.37	.80	.77	.52	.17	.24
.58	.37	.98	.09	.38	.82	.78	.54	.18	.26
.59	.39	.99	.11	.39	.83	.79	.56	.19	.28
19.60	35.41	20.00	36.13	20.40	36.85	20.80	35.57	21.20	38.30
.61	.43	.01	.15	.41	.87	.81	.59	.21	.31
.62	.44	.02	.17	.42	.89	.82	.61	.22	.33
.63	.46	.03	.18	.43	.91	.83	.63	.23	.35
.64	.48	.04	.20	.44	.92	.84	.65	.24	.37
.65	.50	.05	.22	.45	.94	.85	.66	.25	.39
.66	.52	.06	.24	.46	.96	.86	.68	.26	.40
.67	.53	.07	.26	.47	.98	.87	.70	.27	.42
.68	.55	.08	.27	.48	37.00	.88	.72	.28	.44
.69	.57	.09	.29	.49	.01	.89	.74	.29	.46
19.70	35.59	20.10	36.31	20.50	37.03	20.90	37.75	21.30	38.48
.71	.61	.11	.33	.51	.05	.91	.77	.31	.49
.72	.62	.12	.35	.52	.07	.92	.79	.32	.51
.73	.64	.13	.36	.53	.09	.93	.81	.33	.53
.74	.66	.14	.38	.54	.10	.94	.83	.34	.55
.75	.68	.15	.40	.55	.12	.95	.84	.35	.57
.76	.70	.16	.42	.56	.14	.96	.86	.36	.58
.77	.71	.17	.44	.57	.16	.97	.88	.37	.60
.78	.73	.18	.45	.58	.18	.98	.90	.38	.62
.79	.75	.19	.47	.59	.19	.99	.92	.39	.64
19.80	35.77	20.20	36.49	20.60	37.21	21.00	37.94	21.40	38.66
.81	.79	.21	.51	.61	.23	.01	.95	.41	.68
.82	.81	.22	.53	.62	.25	.02	.97	.42	.69
.83	.82	.23	.55	.63	.27	.03	.99	.43	.71
.84	.84	.24	.56	.64	.29	.04	38.01	.44	.73
.85	.86	.25	.58	.65	.30	.05	.03	.45	.75
.86	.88	.26	.60	.66	.32	.06	.04	.46	.77
.87	.90	.27	.62	.67	.34	.07	.06	.47	.78
.88	.91	.28	.64	.68	.36	.08	.08	.48	.80
.89	.93	.29	.65	.69	.38	.09	.10	.49	.82

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