NITUB

COMMON LABORATORY EQUIPMENT

INSTRUCTION MANUAL

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Preface

Significant amounts of Scientific equipments are continuously provided to laboratories of Public/Private Universities ,Colleges and Research organizations located different areas of Bangladesh where there is little or no access to repair and maintenance services from manufacture's or suppliers. In Bangladesh you will get a lot of people or institutions who can repair TV, Refrigerator, Computers, Air conditioners, etc. But it will be difficult to find a single institutions or person to repair any laboratory equipment. No laboratory work, be it research, quality control, medical testing, industrial development, etc. can succeed without proper functioning of equipment. It is clear that the lack of functioning scientific equipment is a key obstacle to successful research in developing countries, like Bangladesh.

NITUB (Network of Instrument Technical Personnel and User Scientists of Bangladesh) has been delivering training and organizing workshop for several years on common laboratory equipment for technical personnel, common medical equipment for medical personnel and commonly used laboratory equipment for university college teachers on the use, maintenance, trouble-shooting and repairing of wide range of laboratory equipment.

The primary mission of NITUB is to create a skilled manpower in Bangladesh to assure proper use, maintenance and trouble-shooting of scientific equipment so that scientific activities do not suffer due to non-functioning of equipments.

It is also felt necessary that during the training program each trainee will be supplied an Instruction Manual for common laboratory equipment prepared by NITUB so that they can use it on their research or educational institutions too. We hope that this Manual would be useful as bench-top guidelines for individual equipment users. It is also hope that the trained up person will communicate the training to their colleagues or juniors. The manual has been prepared to suit the laboratory technical personnel and user scientists with the aim to make the texts practically useful for understanding how the equipment works and for performing some trouble-shooting.

Finally, I would like to thank Mr. Faruk Ahmed, Instrument Engineer, NITUB for his continuous help in preparing the Manuscript of this Instruction Manual.

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pH meter

pH meter

A pH meter is an electronic device used for measuring the pH (acidity or alkalinity) of a liquid. Special probes are sometimes used to measure the pH of semi-solid substances. A typical pH meter consists of a special measuring probe (a glass electrode & a Reference electrode) connected to an electronic meter that measures and displays the pH reading.

Fig. 1. pH Meter

The probe

The probe is an essential part of a pH meter, it is a rod like structure usually made up of glass. At the bottom of the probe there is a bulb, the bulb is a sensitive part of a probe that contains the sensor which is highly porous . Never touch the bulb by hand and clean it with the help of an absorbent tissue paper with very soft hands, being careful not to rub the tissue against the glass bulb in order to avoid creating static charge . To measure the pH of a solution, the probe is dipped into the solution. The probe is fitted in an arm known as the probe arm.

The Scale

The pH meter has a graduated scale from 0 -14. pH 7.00 is taken as a neutral point. From 7.00 if you go below it defines that the solution under test is acidic. When the pointer shows pH 1.00 or pH 2.00 then the solution is said to be highly acidic and if you go up, the solution will be treated as alkaline. If the meter reads pH 13.00 or 14.00 then the solution is said to be highly alkaline.

Theory of pH Measurement

It is obserbed that pH is a unit of measurements which defines the degree of acidity or alkalinity of a solution. It is usually measured on a scale of 0 to 14. The pH value quantifies the degree of hydrogen ion activity of an acid or a base.

The internationally accepted symbol, pH, is derived from "p", the mathematicaal symbol of the negative logarithm and "H", the chemical symbol for Hydrogen. The pH value is the negative logarithm of Hydrogen ion activity as shown in the mathematical relationship $pH = -\log[H^+]$.

The pH value of a solution is directly related to the ratio of the hydrogen ion $[H^+]$ and the hydroxyl ion $[OH^-]$ concentrations. If the concentration of H^+ is greater than OH^-, the solution is acidic and has a pH value of less than 7. Conversely, if the concentration of OH^- is greater than H^+ the solution is basic, with a pH value greater then 7. If the concentrations of H^+ and OH^- are equal the solution is neutral with a pH value of 7.

It can, therefore, be seen that pH is a measurement of both acidity and alkalinity, even though by definition it is a selective measurement of hydrogen ion activity. The logarithmic relationship between hydrogen ion concentration and the pH unit means that a change of one pH unit represents a ten-fold change in hydrogen ion concentration.

Electrode construction

The construction of glass indicator electrodes and reference electrodes can be made in various ways. A typical glass electrode and a typical calomel reference electrode are shown in Fig. 2.

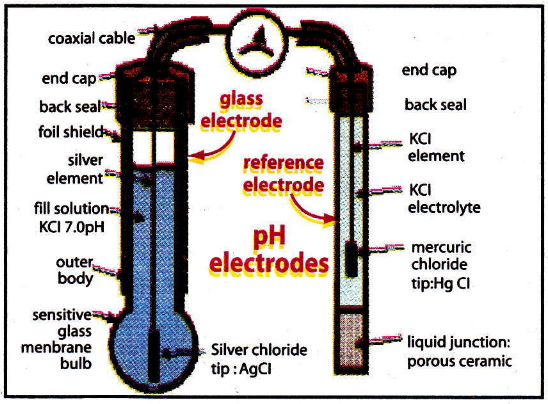


Fig. 2. pH electrode

pH is measured using a setup with two electrodes: the indicator electrode and the reference electrode.

The calomel reference electrode consists of a glass tube with a potassium chloride (KCl) electrolyte which is in intimate contact with a mercuric chloride solution at the end of a Kcl element. It is a fragile construction, joined by a liquid junction tip made of porous ceramic or similar material.

The glass electrode consists of a sturdy glass tube with a thin glass bulb welded to it. Inside of this glass electrode is a known solution of potassium chloride (KCl) buffered at a pH of 7.0. A silver electrode with a silver chloride tip makes contact with the inside solution. To minimize electronic interference, the probe is shielded by a foil shield, often found inside the glass electrode.

Most modern pH meters also have a thermistor temperature probe which allows for automatic temperature correction, since pH varies somewhat with temperature.

Combined electrodes

Since it is easier to handle one electrode instead of two, combined electrodes (single stem) are very popular. The indicating glass electrode and the reference electrode are simply built into a single physical entity. This helps to ensure that the two electrodes have the same temperature during operation.

The pH meter

A pH meter measures the potential difference (in mV) between the electrodes and converts it to a display of pH. In order to obtain a correct measurement, the input amplifier and the converting circuit must meet certain requirements. The principal construction of a pH meter can be seen in the simplified diagram below.

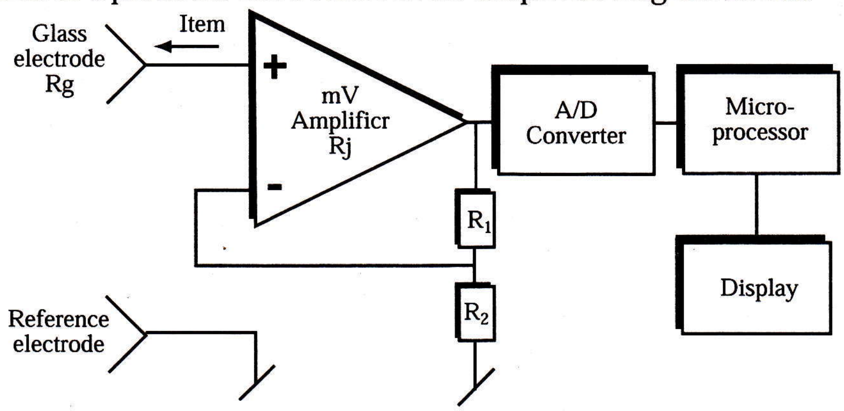


Fig. 3. Simplified pH meter diagram.

The potential difference between the reference electrode and the glass electrode is amplified in the mV amplifier before the A/D converter feeds the signal to the microprocessor for result calculation. Present pH meters contain microprocessor that make the necessary corrections for temperature and calibration .

Checking the meter

If problems occur, e.g. during calibration, it is recommeded that you check the meter without electrodes in order to separate the two possible problem areas. Electrode simulators exist but are not readily available and are often rather expensive. A less expensive yet still effective checking can be made using only simple items and is described below.

1. First of all, check the pH meter in the mV range. Connect the high impedance input (for the glass electrode) to the low input (for the reference electrode).
2. The pH meter should now display only a few mV, ideally almost 0.0mV. Now connect a normal 1.5 V dry cell to the same electrode inputs. The meter should, depending on the state of the dry cell, display a reading in the vicinity of 1.5 V.
3. Switch the pH meter to pH mode and connect the high and low impedance inputs to each other again. The red banana bushing must be used for Radiometer Analytical pH meters.
4. Adjust the termperature to 25°C and (if adjustable) the sensitivity to 100% (59 mV/pH). Most meters will now display a value between pH 5.5 and 8.0. If the meter has a buffer adjustment (standardising) dial, turning this dial should alter

the display value.

5. Connect the 1.5 V dry cell again. The display should go off range. As 60 mV is approximately 1 pH, the 1.5 V will correspond to 25 pH.

The above checks indicate that the pH meter is operating correctly and that the display and microprocessor. However, any misalignment will need to internal calibration. The input circuitry of the input amplifier may also be faulty, i.e. low input impedance and high terminal current. This can be checked if a high ohmic resistor is available. Perform the check in the following way:

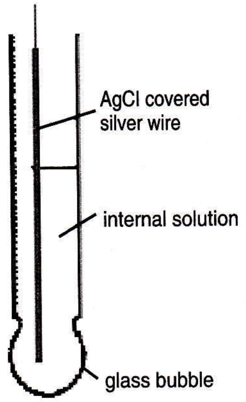
1. Short-circuit the high and low impedance imputs as above (mV range). Note the reading on the display.
2. Now repeat this action but use a resistance of 1 GΩ (1000 MΩ). Note the reading on the display. the difference should not be more than approx. 1 mV.
3. Connect the 1.5 V dry cell again and note the reading on the display.
4. Connect the dry cell through the 1 GΩ resistor and note the display reading. The difference should not be more than a few mV.

The ph meter seems to be ok.

pH Combined electrode-Construction

Most often used pH electrodes are glass electrodes. Typical model is made of

glass tube ended with small glass bubble. Inside of the electrode is usually filled with buffered solution of chlorides in which silver wire covered with silver chloride if immersed. pH of internal solution varies - for example it can be 1.0 (0.1M HCl) or 7.0 (different buffers used by different producers).



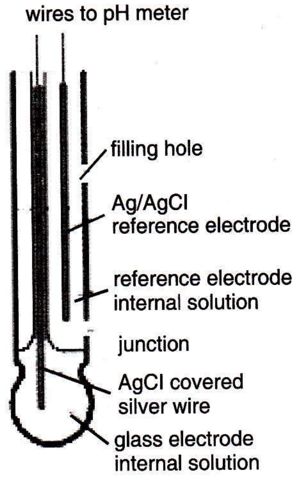


Fig. 4. glass pH electrode Fig. 5. pH combination electrode

Active part of the electrode is the glass bubble. While tube has strong and thick walls, bubble is made to be as thin as possible. Surface of the glass is protonated by both internal and external solution till equilibrium is achieved. Both sides of the glass are charged by the adsorbed protons, this charge is responsible for potential difference. This potential in turn is described by the Nernst equation and is directly proportional to the pH difference between solutions on both sides of the glass.

The majority of pH electrodes available commercially are combination electrodes that have both glass H+ ion sensitive electrode and additional reference electrode conveniently placed in one housing. For some specific applications separate pH electrodes and reference electrodes are still used - they allow higher precision needed sometimes for research purposes. In most cases combination electrodes are precise enough and much more convenient to use.

Construction of combination electrode is in large part defined by the processes that must take place when measuring pH. We need to measure difference of potentials between sides of glass in the glass electrode. To do so we need a closed circuit.

Circuit is closed through the solutions - internal and external - and the pH meter.

However, for correct and stable results of measurements reference electrode must be isolated from the solution so that they will not crosscontaminate - and it is not an easy task to connect and isolate two solutions at the same time.

Connection is made through a small hole in the electrode body. This hole is blocked by porous membrane, or ceramic (asbestous in older models) wick. Internal solution flows very slowly through the junction, thus such electrodes are called flowing electrodes. To slow down the leaking, the gel electrodes internal solution is gelled.

Single &Double junction electrode

In classical combined pH electrode reference electrode is separated from the external solution by the junction through which the electrolyte leaks. Lost electrolyte must be periodically refilled through the filling hole, which makes these elctrodes inconvenient to use, especially in field. Methods of slowing down the leak - like gelling of the electrolyte - have a side effect of shortening the lifetime of the electrode, as it is more prone to the changes in electrolyte composition due to contamination and diffusional leak of the ions. Contaminated gel can not be replaced, thus lifetime of gel electrode is rarely longer then several months.

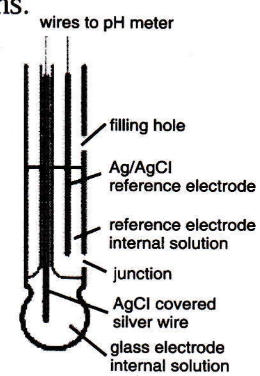


Fig. 6. single junction pH electrode

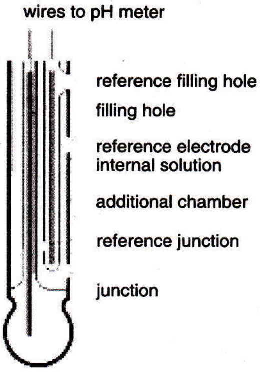


Fig. 7. double juntion pH electrode

To prolong lifetime of such electrodes double junction is sometimes used. In double junction electrodes additional chamber is introduced between reference electrode and external solution. Additional chamber works as a buffer, slowing down the changes in the composition of the reference electrode electrolyte. Double junction electrodes can work longer, but they are more difficult to make, thus more expensive.

Note, that single or double junction refers only to the way reference electrode is made. While you will often see combination electrodes described as pH double junction, external reference electrode can be made double junction as well.

Solid State Electrode

Commercially available solid state pH electrodes are mainly built around Ion Selective Field Effect Transistors (ISFET).

The basic principle of the ISFET working is the control of the current flowing between two semiconductor elements (drain and souce) by electrostatic field, generated by the protonated oxide gate. Protonation of the gate is in a way identical to the process taking place in glass pH electrode, just the methodology used to measure protonation degree is different. Instead of measuring potential difference on two sides of the glass, we measure the current flowing through the transistor. The lower the pH, the more solution is protonated and charged, which changes its electric field - changing in turn current flowing through the transistor. This current is a signal that can be measured to check the pH value.

ISFET electrodes can be very small when compared to the bulky glass bubble of the standard glass electrode. They are also much more sturdy, so they can be easily used in places where fragile glass electrodes will not survive. However, ISFET electrode can't be used with standard pH meters (unless it is connected through special interface) and the pH measurements are generally less precise when compared to glass electrode.

Flowing vs gel electrode

In flowing electrodes internal solution of KCl slowly flows to the outside through the junction - small hole with porous membrane, or ceramic.

As the internal solution is lost from the flowing electrodes it must be refilled so that its level is always above the level of the external (measured) solution. This way internal solution should never get contaminated. However, refilling of the combination electrodes adds to their maintenance cost and makes them difficult to use in portable pH meters.

To overcome problems with filling internal solution is sometimes overcome by intruducing gel electrode. While this helps slow down leak, it doesn't prevent diffusional ion exchange through junction - thus internal solution gets contaminated by the ions diffusing from the external sources, at the same time loosing its own ions. As the composition of internal solution changes and can't be restored by refilling, gel electrodes have in general shorter life time, although they are easier to use and maintain.

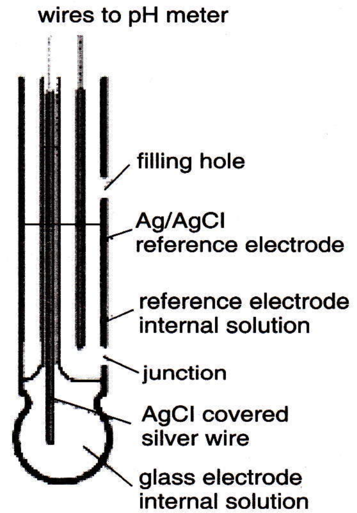


Fig. 8. Combination pH electrode

Other method of prolonging the lifetime of the electrode is the use of double junctions.

Speed of the flow is one of the important electrode parameters. It can't be too fast nor to slow. Flow can be too fast in case of broken membrane or lost (loose) wick, it can be too slow if the membrane/wick was clogged by some chemical precipitate. For example AgCl if the electrode was used to measure pH of solution containing Ag^{+} ions. See electrode cleaning to learn how to unclog electrode.

Choosing pH Electrode

There are many types of pH glass electrodes. In some specific applications you should be very carefull when selecting one, but in most cases the selection is easy. Look for other users working in similar environment and ask them about their experience with different types with different electrodes. Then this way you should be able to find the best offer pretty fast. For selecting electrodes few hints are given below.

If you are working with aqueous solutions containing at least 5% water and your solutions doesn't contain any substances reacting with silver, look for general purpose electrodes.

If you work with solutions containing organic material, proteins, TRIS buffers, heavy metals, or with very low ionic strength solutions, look for calomel electrode. Listed substances can react with silver and clog the junction.

Instead of using calomel electrode you may look for double junction electrode, as it will have similar properties.

If you are working with solutions that can clog normal electrode junction (like oils, foods or paints) look for teflon junction electrode. Junction in these electrodes is made of porous teflon, making it resistant to impurities.

Don't forget to check electrode pH range - some electrodes can't work in high pH, and electrode temperature range - especially if you are going to measure pH in solutions above 60°C.

In most cases manufacturers sites contain a wealth of information about available pH electrode models and their applications.

pH Electrode Maintenance

- Handle electrode with care. It is fragile!
- Keep electrode always immersed. Use the solution recommended by manufacturer or neutral solution of KCl (3M-4M).
- Remember to always keep internal level of filling solution above the level of measured solution.
- Fill electrode (the flowing type) with correct filling solution (as recommended by manufacturer - usually KCl solution, 3M to saturated) show that it cannot be dry internally.
- If the electrode is not used for a long period of time, you may store it dry to prevent aging (aging takes place only when the electrode is wet). Don't try it with gel electrodes - these have to be stored in concentrated solution of KCl only.
- If dried incidentally, or after storing - soak in a solution for at least 24 hours before using.
- If you are using the electrode in solution containing substances able to clog the junction or stick to the glass bubble, clean the electrode as soon as possible after use.
- Don't put electrode in solutions that can dissolve glass - hydrofluroic acid (or acidified fluroide solution), concentrated alkalies.
- Don't put electrode into dehydrating solution such as ethanol, sulfuric acid, etc.

pH Electrode Storing

Electrodes with liquid electrolytes (not gel types) may be stored either wet or dry. A wet stored electrode allows an immediate use and a short response time, which is not true for dry stored ones. Unfortunately, the wet stored electrode is aging faster, because the process of aging (changing of the structure in the membrane) proceeds also in the case of non-use. Keeping electrodes wet should preferably be made in KCl solution (3M-4M). Most electrodes have a protective cap that can be filled with storage solution before placing.

To store pH electrode dry you must first remove internal solution, rinse the electrode in DI/RO water, and let it dry.

Note that you can't store dry combination electrodes and gel electrodes. In fact electrodes that can be stored dry are getting more and more rare.

If electrode is stored wet, don't forget to cover fill hole to prohibit evaporation of reference fill solution.

Gel type electrodes can be stored only wet, soaked in the KCl solution (3M-4M). Never store them in DI/RO water.

Check your electrode owners manual for details, as these may depend on the electrode make.

Electrode Calibration

Before measuring pH you have to calibrate (standardize) **electrode**. To calibrate the electrode you need at least two solutions of known pH. Most commonly used commercially available calibration buffers have pH of 4.01, 7.00 and 10.00.

Details of the calibration procedure depend on the pH meter model. First step is usually related to temperature correction. Some models will measure temperature by itself, others need external temperature probe, or you will have to enter temperature measured by others means using dials or buttons. Note that this setting changes only slope of the calibration curve and doesn't take into account fact, that buffer pH changes with temperature.

Next step is to put the electrode into pH 7.00 buffer. Rinse the electrode with distilled water from a wash bottle into an empty beaker before immersing it into new solution. You should do it every time when electrode is moved from one solution to other to minimise contamination. Check if the working part of the electrode is completely immersed in the buffer. Take care not to hit the bottom of the beaker with the electrode. Wait for the reading to stabilize (it takes few seconds usually, up to a minute sometimes).

Modern pH meter models working in calibration mode often recognize the buffer automatically and take necessary action by themselves. In case of older pH meters you will probably have to turn one of calibration knobs so that the pH meter shows 7.00.

Sometimes pH readings will oscillate. If the oscillations are small try to find out the best position of the knob so that 7.00 is a mean displayed value. If the oscillations are large and erratic, they may be caused by faulty junction (check all), faulty cable (check them), faulty electrode (try other electrode) or faulty pH meter. Sometimes also static electricity can be a reason of erratic readings- consider changing clothes, grounding yourself or shielding pH meter, cables and electrode. If you are using magnetic stirrer check if switching it off doesn't stop oscillations.

Next steps will depend on the solution you want to measure pH of. If you plan to measure pH in acidic solutions, use pH=4.01 buffer. If you plan to measure high pH use pH=10.00 buffer. If you want to be able to measure pH in the wider range, you may want to proceed with three point calibration and you will need both buffers. Remember that high pH buffers tend to absorb atmospheric CO_2 thus they should be used as fresh as possible - don't leave the bottle open and do the calibration immediately after filling the beaker with the buffer.

Rinse the electrode and move it to the second buffer. Once again pH meter will either act on itself, or you will have to use a knob (probably different from the one used in the previous step). Repeat the action for the third buffer if needed (using third knob - if present).

After that you are ready to take measurements.

Please remember, that above outline is very general. Different pH meters may require slightly different operating procedures. You should go through your manual to be sure how to proceed and how to maintain the electrode.

Electrode Cleaning

Cleaning of the electrode (note that in case of gel electrodes replacing of the reference solution is usually impossible):

General

- Soak in 0.1M HCl for half an hour.
- Drain and refill the reference solution.
- Soak the electrode in filling solution for one hour.

Inorganic

- Soak in 0.1M tetrasodium EDTA solution for 15 minutes.
- Drain and refill the reference solution.
- Soak the electrode in filling solution for one hour.

Protein

- Soak in 1% pepsin / 0.1M HCl for 15 minutes.
- Drain and refill the reference solution.
- Soak the electrode in filling solution for one hour.

Grease and Oil

- o Rinse with detergent or ethanol solution.
- o Drain and refill the reference solution.
- o Soak the electrode in filling solution for one hour. Electrode response may be enhanced by substituting a mixture of 1:1 pH 4 buffer and filling solution for the soaking solution.

Cleaning of the clogged junction:

Pollution by sulfides

- o Use a solution of 8% thiocarbamide in 1 mol/L HCl.
- o Keep the electrode in the above solution till junction's color turns pale.

Pollution by silver chloride

- o Use concentrated ammonia solution.
- o Keep the electrode in the above solution for about 12 hours.
- o Rinse and put into pH 4 buffer for at least 1 hour.

Other contamination have to be removed by cleaning with distilled water, alcohol or mixtures of acids. If nothing else helps you may consider to use of ultrasonic cleaner as last resort.

Electrode Rejuvenating

Note: following procedures are a last resort. They may work, they may not. You may try with them before throwing electrode away.

First of all - clean the electrode as described in electrode cleaning section, then:

- Soak the electrode for 4-8 hours in 1M HCl solution.
- Rinse it and move to pH 7 buffer for an hour.
- Give it a try.

If the electrode is still not working:

- Fill the electrode with filling solution.
- Move to the fume hood!
- Place the electrode in the 10% nitric acid solution on a hotplate. Heat to boiling, and keep it in the solution for 10 minutes.
- Place 50 mL of filling solution in a second clean beaker. Heat, although boiling is not necessary.
- While the electrode is still hot, transfer it to the beaker of heated filling solution. Set aside to cool.

When the electrode has cooled, test the electrode as described in the testing electrode parameters section. This rejuvenating procedure is particularly effective with gel filled combination electrodes. Do not be concerned if a small amount of the gel protrudes through the reference frit during the boiling in nitric acid step. This is both acceptable and useful.

If this procedure does not result in a pH electrode that responds quickly and has a slope of 55 - 61 mV/pH unit, the electrode is unrecoverable and should be thrown away.

Some manufacturers suggest the electrode may be reactivated by treating with a diluted solution of hydrofluoric acid followed by subsequent conditioning in electrolyte. Before considering the procedure, take into account that hydrofluoric acid is extremely dangerous! Safer (but still dangerous) approach can be to use some slightly acidic solution containing fluorides, like 20% ammonium hidrofloride, NH_4HF_2. Put glass bulb part of the electrode in the solution for 15 seconds in a bath of 1 M hydrochloric acid. Rinse the electrode well and soak for 24 hours in a pH buffer with pH < 7.

Standard calibration buffers

substance(s)	concentration	pH
hydrochloric acid HC	1 0.1000M	1.094
potassium trihydrogen oxalate KH_3C4O_8	1 0.1000M	1.679
potassium hydrogen phthalate KHC_8H4O_4	0.05000m	4.005
potassium hydrogen tartrate	saturated in 25°C	3.557
disodium hydrogen phosphate Na_2HPO_4 potassium dihydrogen phosphate KH_2PO_4	0.02500m 0.02500m	6.865
disodium hydrogen phosphate Na_2HPO_4 potassium dihydrogen phosphate KH_2PO_4	0.008695m 0.03043m	7.413
disodium tetraborate Na_2B4O_7	0.02500m	9.180
sodium hydrogen carbonate $NaHCO_3$ sodium carbonate Na_2CO_3	0.02500m 0.02500m	10.012
calcium hydroxide $Ca(OH)_2$	saturated in 25°C	12.45

Calibration of buffers

In general you will probably use commercially available calibration buffers, sold either as ready solutions or as tablets to dissolve in deionized water. However, it may be interesting to look at the table of standard solutions that can be used for the electrode calibration. pH given is for 25°C:

m stands for molality, M for molarity.

Please note that high pH buffers are less stable, as they tend to absorb atmospheric CO_2 which lowers their pH. During calibration you should open the bottle only to pour the buffer to the beaker. Never left the bottle open.

It is also important to remember that pH of buffer solutions change with temperature. pH of potassium hydrogen phthalate solution rises to 4.16 at 80°C. Many pH meters doesn't take these changes into account automatically, even if they allow automatic temperature compensation during measurements.

Temperature Correction for pH sensitive glass

The resistance of glass electrodes partially depends on the temperature. The lower the temperature, the higher the resistance. It takes longer time for the reading to stabilize if the resistance is higher. In addition, the response time will suffer to a greater degree at temperatures below 10°C.

Since the resistance of the pH electrode is in the range of 200 Mohm, the current across the membrane is in the pico Ampere range. Large current can disturb the calibration of the electrode for many hours. For these reasons high humidity environments, short circuits and static discharge are detrimental to a stable pH reading.

The pH electrode's life also depends on the temperature, the electrode life is drastically reduced.

Typical Electrode Life

Ambient Temperature	1-3 years
90°C	Less than 4 months
120°C	Less than 1 month

High concentrations of sodium ions interface with readings in alkaline solutions; the pH at which interference starts to be significant depends upon the composition of the glass. This interference is the alkaline error and causes the pH to be underestimated. Hannas glass formulations have the indicated characteristics.

Alkaline Error **Sodium Ion Correction for Glass at 20-25°C**		
Concentration	**pH**	**Error**
0.1 Mol L^{-1} Na^{+}	13.00	0.10
	13.50	0.14
	14.00	0.20
1.0 Mol L^{-1} Na^{+}	12.50	0.10
	13.00	0.18
	13.50	0.29
	14.00	0.40

Symptoms	Problem	Solutin
Trouble-shooting Guide		
The meter is slow in responding and gives faulty readings	The electrode is not working or the reference junction is closed	Leave the electrode in a storage solution after cleaning the jouction. If problem persists, replace the electrode
The meter does not accept the 2nd buffer solution for calibration	Out of order pH electrode	Follow the cleaning procedure. If this doesn't work replace the electrode
The reading drifts	Defective pH electrode	Replace the electrode
Display shows:	Out of range pH scale	a) Recalibrate b) Make sure the pH sample is in the specified range c) Check the electrolyte level and the general state of the pH electrode
Display shows:	Out of range temperature scale	Make sure the temperature is in the 0^{0}C to 100^{0}C range and the temperature probe is plugged in
Display shows:	Out of range mV scale	Electrode not connected
Display shows: "WRONG 2" and "WRONG"	Erroneous buffer solution used for offset calibration	Make sure the buffer setting is correct and the solution is fresh. Replace the buffer if necessary
	Defective electrode	Replace the electrode
Display shows: "WRONG 2" and "WRONG"	Erroneous buffer solution used for slope calibration	Make sure the buffer setting is correct and the solution is fresh. Replace the buffer if necessary
	Defective electrode	Replace the electrode
The meter does not work with the temperature probe	Out of order temperature probe	Replace the probe
The meter fails to calibrate or gives faulty reading	Out of order pH electrode	Replace the electrode

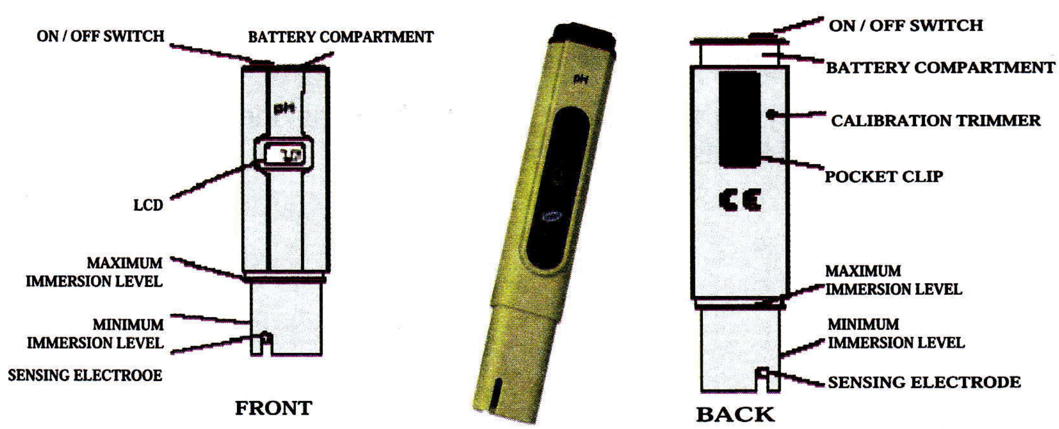
pH Values at Various Temperatures

Temperature has an effect on pH. The calibration buffer solutions are affected by temperature change to a lesser degree than normal solutions. During calibration the meter will automatically calibrate to the pH vale corresponding to the measured or set temperature.

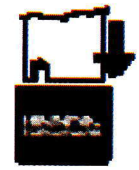
TEMP		pH VALUES				
oC	oF	4.01	6.86	7.01	9.18	10.01
0	5	4.01	6.98	7.13	9.46	10.32
5	41	4.00	6.95	7.10	9.38	10.24
10	50	4.00	6.92	7.07	9.33	10.18
15	59	4.00	6.90	7.04	9.27	10.12
20	68	4.00	6.88	7.03	9.22	10.06
25	77	4.01	6.86	7.01	9.18	10.01
30	86	4.02	6.85	7.00	9.14	9.96
35	95	4.03	6.84	6.99	9.10	9.92
40	104	4.04	6.84	6.98	9.07	9.88
45	113	4.04	6.83	6.98	9.04	9.85
50	122	4.06	6.83	6.98	9.01	9.82
55	131	4.07	6.84	6.98	8.99	9.79
60	140	4.09	6.84	6.98	8.97	9.77
65	149	4.11	6.85	6.99	8.95	9.76
70	158	4.12	6.85	6.99	8.93	9.75

For instance, if the buffer temperature is 25°C, the display will show pH 4.01 or 7.01 or 10.01. If the buffer temperature is 20°C, it will show pH 4.00/7.03/10.06 or at 50°C, the display will show pH 4.06/6.98/9.82.

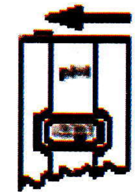
Pocket-Sized pH Meter



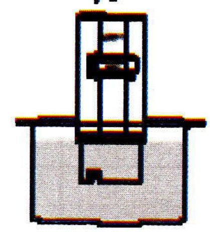
OPERATION



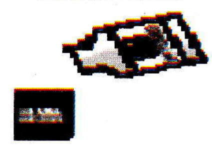
- o Remove the protective cap. Do not be alarmed if white crystals appear around the cap. This is normal with pH electrodes and they dissolve when rinsed with water.
- o Turn the meter on sliding the switch on the top.



- o Immerse into solution up to the max immersion level.



- o Stir gently and wait until the display stabilizes.

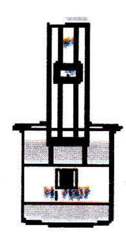


- o After use, rinse the electrode with water to minimize contamination and store it with a few drops of storage (HI70300) or pH 7 (HI 7007) solution in the protective cap.

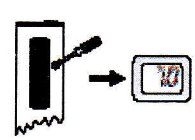
DO NOT USE DISTILLED OR DEIONIZED WATER FOR STORAGE PURPOSES.

- o Large fluctuations in readings could be due to lack of calibration, dry electrode or rundown batteries.

CALIBRATION



- o Immerse the tester up to the maximum immersion level in pH 7 buffer (HI 7007)
- o Allow the reading to stabilize and using a small screwdriver adjust the calibration trimmer to read 7.0.



Calibration is now complete.

ALWAYS USE FRESH BUFFERS FOR CALIBRATION.

BATTERY REPLACEMENT

When the meter cannot be switched on or the display fades, pull out the battery compartment and replace all three 1.5V batteries, while paying attention to their polarity.

Batteries should only be replaced in a safe area using the battery type specified in this instruction manual.

Centrifuge

What is Centrifuge?

A centrifuge is a piece of equipment that puts a substance in rotation around a fixed axis in order for the centrifugal force to separate a fluid from a fluid or from a solid substance. Generally, a motor drives the rotary motion of the sample. There are many different kind of centrifuge, and some are used often for very specialized purposes.

Fig. 9. Centrifuge

Theory:

Protocols for centrifugation typically specify the amount of acceleration to be applied to the sample, rather than specifying a rotational speed such as revolutions per minute. The acceleration is often quoted in multiples of gram (g), the acceleration due to gravity at the Earth's surface. This distinction is important because two rotors with different diameter running at the same rotational speed will subject samples to different accelerations.

The centrifugal force can be calculated by assigning the rotation radius and speed in the following equation:

Centrifuge force RCF(x g) = 11.18 x (speed N (rpm) ^2/1000) x Rotation radius (cm).

History:

English military engineer Benjamin Robins (1707-1751) invented a whirling arm apparatus to determine drag, and Antomin Prandl invited the first centrifuge in order to separate cream from milk to make churning butter in much easier.

Installation and Power Supply:

- The centrifuge should be placed on a flat concrete floor.
- Avoid places where vibration is transmitted from other locations or an inclined place.
- Do not install the centrifuge in places where it may be exposed to direct sunlight or high temperature. Also avoid places where the ambient temperature is extremely high (40°C or above) or extremely low (10°C or below).
- Do not install the centrifuge in a place with high humidity or in dusty places.

- The power supply voltage must be the same as that indicated on the nameplate of the centrifuge and the voltage vibration must be within the range as specified.
- To prevent a chance of electric shock, connect the ground wire of the power cord to the ground terminal. Do not use water pipes for grounding or any gas pipe/ telephone wire/ Lighting rod ground wire etc.

Operation:

Before the centrifuge is put into initial operation one should go through the instruction manual thoroughly which is normally supplied with the instruments and he/she should proceed step by step as per the instructions.

Cautions in operation:

Do not open the door while the rotor is rotating.

- Always operate the centrifuge at a speed below the maximum allowable speed.
- Always mount four buckets in position.
- Always place tube racks in bucket.
- Balance the loads (Sample, Bucket, Tube rack, cushion, etc) before operation.
- Do not apply force to rotate sensitive "SPEED", "TEMP." and "TIME" knobs.
- Do not use buckets and tube racks of a size other than specified or those of other manufactures.
- Do not centrifuge the Flammable or Bio-hazardous liquid.
- If the centrifuge is to be moved to another location, remove the rotor from the motor shaft before transportation.
- Do not modify the centrifuge or the rotor, not use parts other than those specified.

Different Types and Uses:

- Simple centrifuges are used in biology and biochemistry for isolating and separating bio-compounds on the basis of molecular weight. These are rotate at a slower rate than an ultracentrifuge, and have a larger rotors, and be optimized for holding large quantities of material at intermediate acceleration.
- Some centrifuges are used for drying (hand-washed) clothes-usually with a water outlet.
- Other centrifuge, the first being the Zippe-type, are used to separate isotopes, and these kinds of centrifuges are in use in nuclear power and nuclear weapons programs.

- The ultracentrifuge is a centrifuge optimized for spinning a rotor at very high speed, capable of generating high acceleration as high as (1,000,000G 9,800km/s^2). There are two kinds of ultracentrifuges, the analytical and preparative ultracentrifuge. Both classes of instruments find important uses in molecular biology and polymer science. Theodor Svedberg invented the ultracentrifuge in 1923, and won the Noble Prize in Chemistry in 1926 for his research on colloids and proteins using the ultracentrifuge. The kinds of information that can be obtained from an analytical ultracentrifuges include the speed of macromolecules, the conformational changes in macromolecules, subunit stoichiometry of macromolecules, approx. molecular weights, and equilibrium constants for self associating systems. The ultracentrifuge is used in biology for pilleting of fine particulate fractions, such as cellular organelles (mitochondria, microsomes, ribosome) and viruses. They can also be used for gradient separation.
- In soil mechanics, centrifuge utilize centrifugal acceleration to match soil stresses in a scale model to those found in reality.
- Large industrial centrifuge are commonly used in water and wastewater treatment to dry sludge.
- Gas centrifuge are used to enrich uranium. The heavier isotopes of uranium (Uranium-238) in the uranium hexafluoride gas to concentrate at the walls of the centrifuge as it spins, while the desired uranium-238 isotopes are extracted and concentrated with a scoop selectivity placed inside the centrifuge. It takes many thousands of centrifuges to enrich enough uranium for use in a nuclear reactor (around 3.5% enrichment), and many thousands more to enrich it to bomb-grade (around 90% enrichment).

Use and Safety:

The load in a laboratory centrifuge must be carefully balanced. Small differences in mass of the load can result in a large force imbalance when the rotor is at high speed. This force imbalance strains the spindle and may result in damage to centrifuge or personal injury.

Centrifuge rotors should never be touched while moving, because a spinning rotor can cause serious injury. Modern centrifuges generally have features that prevent accident contract with a moving rotor. The tremendous rotational kinetic energy of the rotor in an operating centrifuges makes the catastrophic failure of a spinning rotor a serous concern. The stresses of routine use and harsh chemical solutions eventually cause rotors to deteriorate. Proper use of the instrument and rotors within recommended limits and careful maintenance of rotors prevent corrosion and to detect deterioration are necessary to avoid hazard.

Maintenance:

Daily Maintenance

1. **Check the rotor locking bolt is not loosened.**

If the bolt is loosened, retighten it using the accessory Allen wrench.

2. **Check all the buckets mounted on the swinging bucket rotor lift up smoothly.**

   For maintenance, mount buckets on the rotor when it is not in motion and lift up buckets manually. If the movement is not smooth, contact your local dealer for maintenance.

3. **Check that no foreign material or water exists in the chamber.**

   Remove foreign materials or water, if any, before operation.

4. **Check the nut of the trunnion pin is not loosened.**

   If the nut is loosened, tighten it.

5. **Check the latch of the door it works perfectly.**

   If not, stop using the centrifuge and contact your local dealer for maintenance

6. **Check the gas-spring holding screws are not lessened or other trouble.**

   If there is any abnormality, stop using the centrifuge and repair the faults.

7. **Check that the grounding wire is correctly connected.**
8. **Check the knobs, digital displays, lamps and switches operate correctly.**

Monthly Maintenance

1. **Clean the rotor.**

   Remove the rotor from the shaft, and clean it with neutral detergent and warm water. Then rinse it with distilled water, and dry it.

2. **Check the rotor, the buckets, etc. for any damage, rust or deformation.**

   If any damage, rust or deformation is found, repair it.

3. **Clean the radiator for the refrigerator located at the bottom left of the centrifuge.**

   Remove any dust accumulated on the radiator using a brush or toothbrush. Dust accumulated adversary affects cooling efficiency.

4. **Check the over speed detect circuit operates normally.**

   Remove the rotor and start rotation for checkout.

Annual Maintenance

1. Maintain carbon brushes of the motor.

Do as per details of the instruction manual.

2. As for the following maintain items do as per instructions.

1. Loosening of motor installation bolt and nuts.
2. Acceleration current of the motor.
3. Calibration of the digital "TEMP." display indication.

Greasing:

No greasing of the motor is required.

The motor uses on non-greasing type bearing. Improper lubrication may result in failure.

Do not apply any lubricant.

Cleaning:

1. If the sample is split, remove the sample and clean the inside of the centrifuge. Dry the inside before you operate the centrifuge.
2. If water has accumulated inside the rotor, place the rotor with its bottom side up and dry it completely.

Dismount rotor and buckets. Wash out any stains with only a small amount of water so that none leaks into bearings through the motor shaft portion.

Remove drain plug and drain water trapped in chamber in a tray placed under centrifuge.

The rubber around the motor shaft scaling is sufficiently tight enough to stop water leakage.

Sterilization:

Ethanol disinfections or gas sterilization is recommended.

Do not heat rotor and the buckets above 100°C

Troubleshooting:

Problem	Checkpoint	Action taken
1. The "STOP" key lamp does not light even if the "POWER" switch is pulled up.	Check the knife switch of the power supply.	Turn the knife switch on.
	Is the power applied to the knife switch?	Inspect the power supply.
	Is the power supply voltage correct? (Note 1)	Use a power supply in the correct voltage range.
2. The power is turned off immediately even if the "POWER" switch is pulled up.	Is the power supply too high? (Note 1)	Use a power supply in the correct voltage range.
3. Door does not open even through pedal is depressed	Is the "POWER" switch turned on?	Pull up the "POWER" switch to turn the power on.
	Is the <READY> lamp lit or flashing?	Wait until the rotor is completely stopped.
	Remove front cover and check if pedal wire is loose.	If wire is loose, contact your local dealer for inspection.
4. The motor does not rotate	Is the "POWER" switch turned on?	Pull up the "POWER" switch to turn the power on.
	Is the timer set to "0"?	Set the timer by turning the "TIME" knob clockwise.
	Is the <READY> lamp lit?	Go back to problem 1. & 2., and check the power supply.
	Is the alarm <OPEN> lit? (Note 3)	Press on the front edge of the door and lock the door.
	Is the alarm <IMBAL> flashing?	Check the distribution of buckets and tubes,
	Is the alarm <SPEED> flashing?	Check the set rpm,
	Is the alarm <ERROR> flashing?	Check the Alarm indicatiors.
5. The speed does not reach the set value even if the "SPEED" knob is turned.	Is the power supply voltage to low?	Use a power supply in the correct voltage range.
	Is the alarm <IMBAL> flashing?	Check the distribution of buckets and tubes.
6. Excessive vibration	Are buckets and tubes correctly distributed? (Note 3)	Distribute buckets and tubes correctly.
	Do not buckets swing smoothly?	Contact your local dealer.
	Are 4 adjusters fixed to the floor?	Keep the centrifuge in horizontal position by using the adjusters.
	Is adjuster lock nut tight? (Note 4)	Tighten lock nut if it is loose.

Laboratory Ovens

Laboratory ovens consist of four basic components:

Introduction:

Fig. 10. Laboratory ovens

- Heater element
- Temperature regulator
- ON/OFF switch (may be part of the temperature regulator)
- Thermometer

An additional component on some ovens is a fan.

There are two types of temperature regulator. It may be a simple voltage regulator with a heat sensitive leaf switch or it may be a thermostat linked to a capillary heater to a neon light. The thermometer is housed in the top of the oven.

Calibration:

Most ovens have a calibrated scale around the temperature regulator knob which shows the scale is usually adjusted so that it is correct for one particular temperature (stated in the handbook). If the oven is commonly operated at a different temperature the range setting of the thermostat, can be adjusted to give correct scale reading for the required temperature:

- Heat the oven to the required temperature as indicated by the thermometer.

Depending on the type of oven either:

- Carefully remove the control knob. Use a small screwdriver to adjust the range screw. Replace the knob and check the setting- repeat until correct.

or

- Rotate the calibration knob to give the temperature reading of the thermometer. Adjust the range screw until the neon light goes off.

Fault Finding:

There are three potential areas in which faults can occur:

- The power supply
- The heater element
- The temperature regulator

If a fault occurs disconnect the oven from the mains then adopt the following procedure:

Symptom: Oven does not heat

- Power supply

  Check:

- Power supply is available from the mains socket.
- Fuse in the plug.
- Live, neutral and earth wires leading into the oven.
- Continuity across the on/off switch
- Heater element

  Check:

- Continuity
- Temperature Regulator

  Check:

- Thermostat switch close when oven is turned fully on.

Symptom: Oven heats but cannot be controlled

- This can be caused by the contacts of the thermostat welding together. With the oven hot (but disconnected) turn the control knob to minimum and check for an open circuit between the thermostat contacts.

Symptom: Oven can be controlled but the temperature gradually increases.

- This suggests a leak in the hydraulic system of the thermostat. Replace the thermostat.

Symptom: Oven can be controlled but the temperature fluctuates (>30C).

- Fault in the capillary heater and electrical short to earth.
- Thermostat switch control is reached above its maximum tolerance. Replace the thermostat.

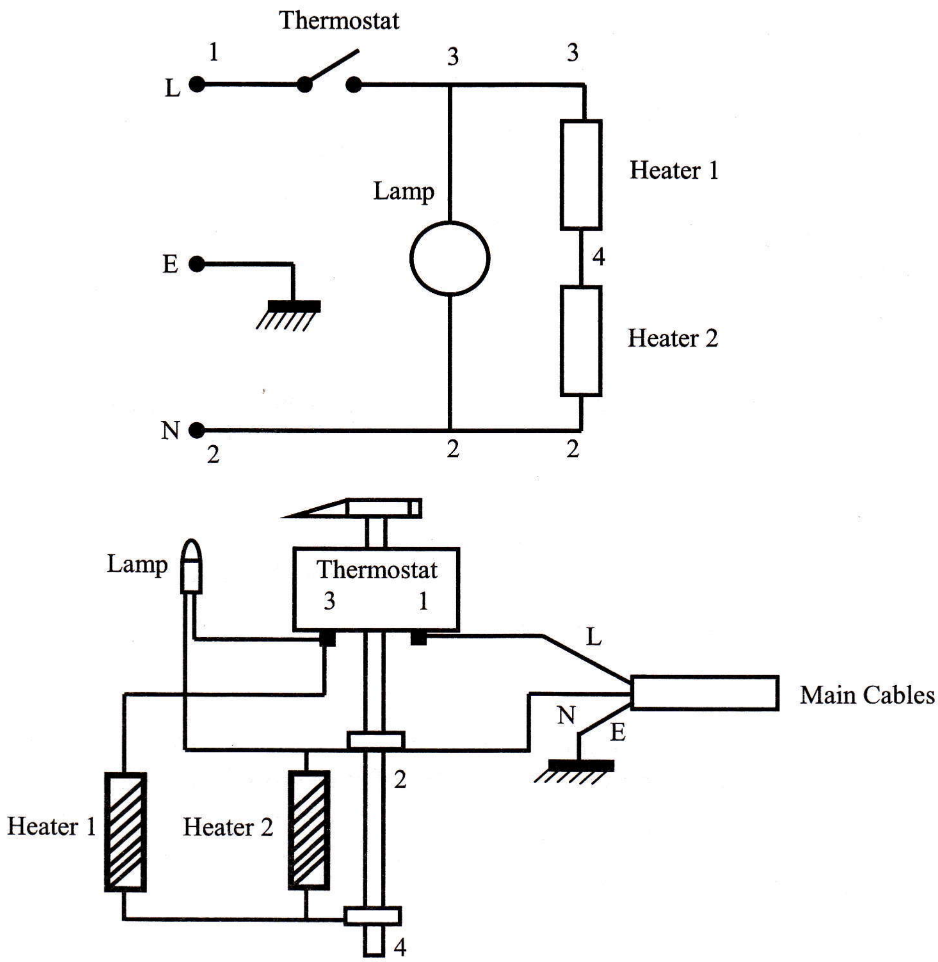


Fig. 11. Wiring Diagram for a Simple Oven

MAGNETIC STIRRER

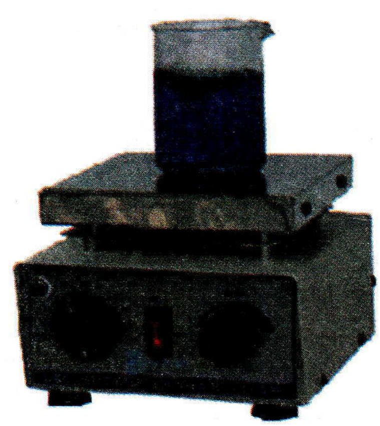


Fig. 12. A magnetic stirrer

A magnetic stirrer or magnetic mixer is a laboratory device that employs a rotating magnetic field to cause a stir bar (also called "flea") immersed in a liquid to spin very quickly, thus stirring it. The rotating field may be created either by a rotating magnet or a set of stationary electromagnets, placed beneath the vessel with the liquid. Magnetic stirrers often include a hot plate or some other means for heating the liquid.

Magnetic stirrers are often used in chemistry and biology. They are preferred over gear-driven motorized stirrers because they are quieter, more efficient, and have no moving external parts to break or wear out (other than the simple bar magnet itself). Due to its small size, a stirring bar is more easily cleaned and sterilized than other stirring devices. They do not require lubricants which could contaminate the reaction vessel and the product. They can be used inside hermetically closed vessels or systems, without the need for complicated rotary seals.

On the other hand, the limited size of the bar means that magnetic stirrers can only be used for relatively small (under 4 liters) experiments. They also have difficulty dealing with viscous liquids or thick suspensions.

- Components Required: U-Shaped Magnet, Bar Magnet, Hot Plate, Electronic Controller, Motor, Box (Made of Mild Steel),Cable, Switch etc.
- Construction :An U-shaped magnet is placed at the motor tip and the motor is located at the centre. The hot plate is placed in the centre at the top of the box. Two electronic controllers one for hot plate and another for motor are connected properly. A bar magnet is placed inside a beaker which contains a solution to be stirred and the beaker is placed at the top of the hot plate.
- When the motor will rotate along with the magnet, the bar magnet in the solution will also rotate according to the magnetic rule i.e. similar pole repel each other and dissimilar pole attract each other.
- USE : The magnetic stirrer produces from gentle to vigorous stirring acting suitable for :
- Rapid preparation of solution
- Titration and Agitation during eletrochemical tests.

Probable Areas of faults

Disalignment of magnetic motor, Regulator, Cable, and socket may be faulty.

Remedies

1. Check Motor, Regulator, Cable & Socket etc. Repair or Replace.
2. Align magnet if necessary.

ELECTRICAL STIRRER

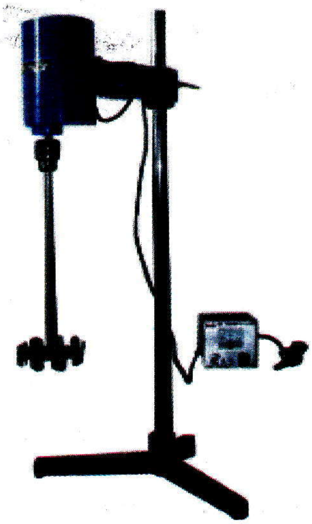


Fig. 13. An electrical stirrer

An electrical stirrer is a common laboratory instrument which is used for stirring, mixing, homogenizing and dispersing of liquids.

The components required for the construction of an electrical stirrer is a motor, stand with a heavy base, clamp, round shaped steel rod, electrical controller, cable, switch etc.

An electrical motor is hanged by a clamp on a steel rod and the steel rod is fixed with a stand which has a heavy base. The motor is connected with an electrical controller so that the speed can be regulated. A shaft with four wings is connected to the tip of the motor which stirrers the solution kept in a beaker. Sometimes a Timer is also provided which stops the motor after a desired time.

The motor is supplied with a voltage range of 220/240V, 50 Hz and has a max, speed 1600 rpm and maximum output 30W.

Probable Areas of faults:	Motor, Regulator, cable and socket
Remedies:	Check Motor, Regulator, Cable or electrical connector etc. Repair or Replace

Thermostatic Water Bath

A thermostatic water bath is an essential laboratory equipment. The bath is used for routine clinical, bio-medical, industrial research, quality control, reference testing etc.

The components required for the construction of water bath are Aluminum sheet/Aluminum casting, Water Heater, Concentric Rings with center cover, two nozzles for keeping constant level of water, Thermostat etc.

The single/two/four hole bath chamber is made of aluminum and has a heating element bonded to underneath for sufficient heat transfer. The bath is electrically heated and fitted with constant level device. Complete with eight concentric rings and center cover

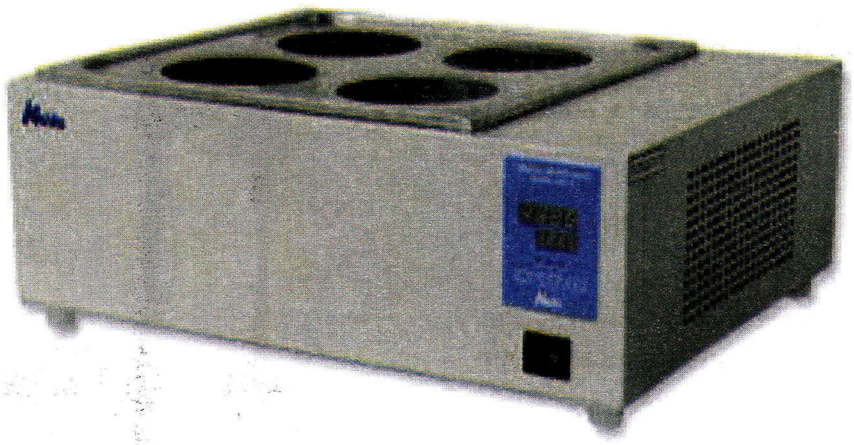


Fig. 14. A Thermostatic Water Bath

The heater is supply with a voltage ranging of 220/240V a.c., 50 Hz.

The uniformity and quality construction of a Water Bath provides constant temperature control over the range of ambient to near 100°C for numerous applications where temperature uniformity and stability are important.

Probable Areas of faults:	Thermostat, Water heater, Electrical connection and Regulator
Remedies:	Check thermostat, Water Heater, Electrical Connection. Repair or Replace.
Caution:	**Take care that water heater should be always immersed under water during the running of water bath. If it goes below the water level it will burn up or damage.**

The following instruments are widely used for troubleshooting or faults finding of the circuits or instruments.

THE MULTIMETER

It is a general purpose instrument having the necessary circuitry and switching arrangement for measuring ac/dc voltage or ac/dc current or resistance or decibel loss between two points in a circuit.. It is widely used for continuity test. It is simple, compact and portable because the only power it uses is the battery.

Multimeter may be of analog type or digital type. The analog type is of the pointer and scale

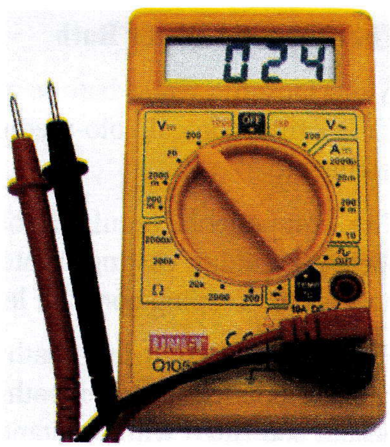


Fig. 15. A multimeter

type. However , digital multimeters are becoming increasingly popular because of their easy readability, numerical display and improved accuracy.

Probable Areas of Faults /Remedies;

Analog multimeter is operated by dry cell batteries. So, there is a chance to damage the batteries. Check the battery and if it is found a low voltage , then change the battery. If in a Digital Multimeter shows some faults then electronic circuit is the main cause . So check it.

OSCILLOSCOPE

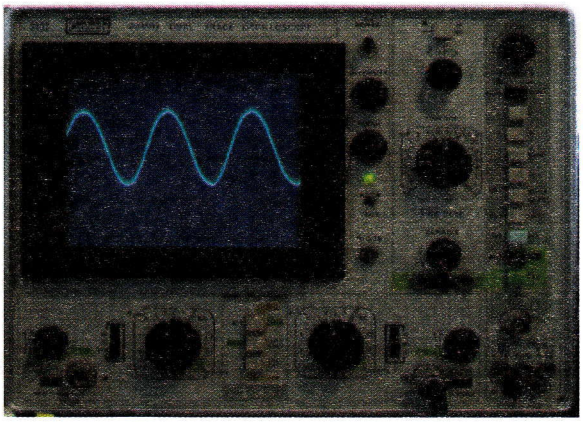


Fig. 16. An Oscilloscope

It is generally referred to as Cathode Ray Oscilloscope or Scope (CRO). The oscilloscope provides a two dimensional visual display of the signal waveshape on a screen thereby allowing an electronic engineer to 'see' the signal in various parts of the circuit. It, in fact gives the electronic engineer an eye to see what is happening inside the circuit itself. It is only by seeing the signal waveform that he can correct errors, understand mistakes in circuit design, and thus , make suitable adjustment. The dual channel oscilloscope displays the magnitude and frequency variations of electronic signals. It can provide a graph of the strength of one or two signals over time, or allow comparison of one waveform to another.

An oscilloscope consists of the following major subsystems :

1. Cathode Ray Tube (CRT)
2. Vertical amplifier : It amplifies the signal waveform to be viewed.
3. Horizontal amplifiers : It is fed with sawtooth voltage which is then applied to the X - Plates.
4. Sweep generator : produces sawtooth voltage waveform used for horizontal deflection of the electron beam.
5. Trigger Circuit : produces trigger pulses to start horizontal sweep.
6. High and Low voltage power supply.

OPERATION OF AN OSCILLOSCOPE

The different Controls/Knobs permit the adjustment of

1. **Intensity** : for correct brightness of the trace on the screen
2. **Focus** : for sharp focus of the trace
3. **Horizontal Centering** : for moving the pattern right and left on the screen.
4. **Vertical Centering** :for moving the pattern up and down on the screen.
5. **Horizontal Gain (also time/div. time /cm)** : for adjusting pattern width.
6. **Vertical Gain (also volt/div. or volt/cm)** : for adjusting pattern height.
7. **Sweep Frequency** : for selecting number of cycles in the pattern.
8. **Sync Voltage Amplitude** : for locking the pattern.

The different Switches permit selection of

1. Sweep type
2. Sweep range
3. Sync type

An oscilloscope operate upto 60 MHz can allow viewing of signals within a time span of a few nanoseconds and can provide a number of waveform displays simultaneously on the screen. It also has the ability to hold the displays for short or long time (of many hours) so that the original signal may be compared with one coming on later.

Note : Do not set any Knob at its extreme position. Set the Knob at middle position and the move left or right direction.

APPLICATIONS OF AN OSCILLOSCOPE

No other instrument in electronic field is as versatile as an oscilloscope. In fact, a modern oscilloscope is the most useful single piece of electronic equipment that not only removes guesswork from technical troubleshooting but makes it possible to determine the trouble quickly. Some of its uses are as follows.

1. Measurement of ac/dc voltages
2. Finding B/H curves for hysteresis loop.
3. For engine pressure analysis
4. Study of stress, strain, torque, accelerations etc.
5. Frequency and phase determinations by using Lissajous figures.
6. Radiation pattern of antenna

7. Amplifier gain
8. Modulation percentage
9. Complex waveform as a short-cut for Fourier analysis.
10. Standing waves in transmission lines etc.
11. To give visual display of waveshapes such as sine waves, square waves and their many different combinations.
12. To trace and measure a signal throughout the RF, IF and AF channels of radio and television receivers.
13. It provides the only effective way of adjusting FM receivers, broadband high frequency RF amplifiers and automatic frequency control circuit.
14. To visually show the composite synchronized TV signal.
15. To display the tuned circuits.

The Bode Plotter

The Bode plotter produces a graph of a circuits frequency response and is useful for analyzing filter circuits. The Bode plotter is used to measure a signals voltage gain or phase shift. When the Bode plotter is attached to a circuit, a spectrum analysis is performed.

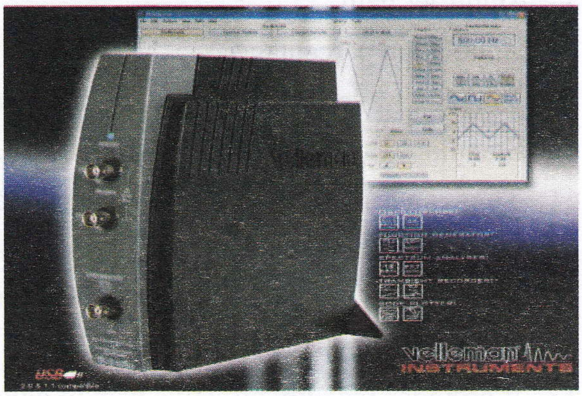


Fig. 17. The Bode Plotter

FUNCTION GENERATOR

The function generator is a voltage source that supplies sine, triangular or square waves. It provides a convenient and realistic way to supply power to a circuit. The waveform can be changed and its frequency, amplitude, duty cycle and DC offset can be controlled. The function generator frequency range is great enough to produce conventional current as well as audio and radio frequency signals. The function generator has three terminals through which waveforms can be applied to a circuit. The common terminal provides a reference level for the signal.

Fig. 18. A Function Generator

The Q Meter

This instrument is designed to measure some of the electrical properties of coil and capacitance by measuring the Q - value of an R - L- C circuit.

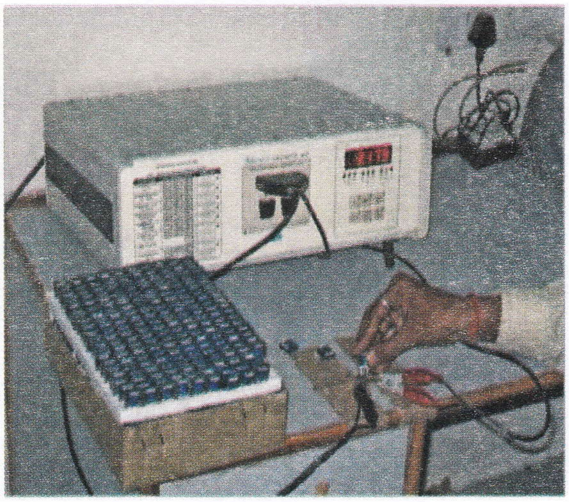


Fig. 19 The Q Meter

Applications

1. Q of a coil.
2. Inductance and capacitance.
3. Distributed capacitance of a coil.
4. Q and p.f. of a dielectric material.
5. Mutual inductance of coupled circuits.
6. Coefficient of coupling.
7. Critical coupling.
8. Reactance and effective resistance of an inductor at operating frequency.
9. bandwidth of a tuned circuits.

The above list does not exhaust the number of its possible applications. It has been very truly said that if ever an RF problem exits a Q - meter can always provide the answer.

MICROSCOPE

A microscope (Greek : micron =small and scopes = aim) is an instrument for viewing objects that are too small to be seen by the naked or unaided eye. The science of investigating small objects using such an instrument is called microscopy, and the term **microscopic** means minute or very small, not easily visible with naked or unaided eye. In other words, requiring microscope to examine.

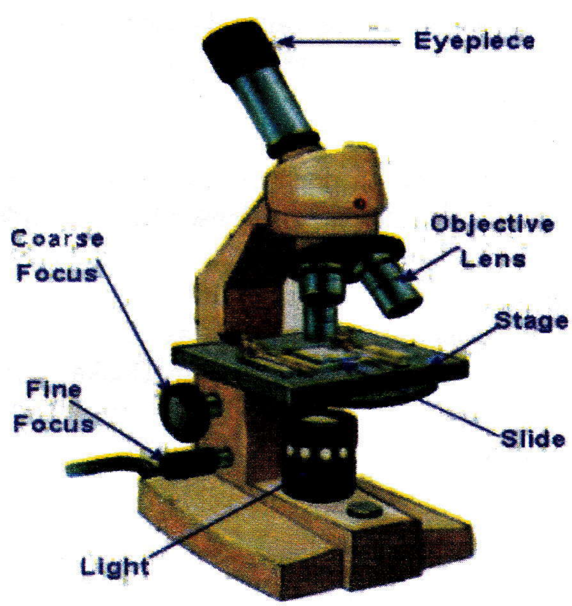


Fig. 20. A Microscope

The most common type of microscope - and the first to be invented is the **optical microscope**. This is an optical instrument containing one or more lenses that produce an enlarged image of an object placed in the focal plane of the lens or lenses.

Compound Optical Microscope

The diagram (Fig. 20) shows a compound microscope in its simplest form - as used by Robert Hooke, for example - the compound microscope would have a single glass lens of short focal length for the objective and another single glass lens for the eye piece or ocular. Modern microscope of this kind are usually more complex, with multiple lens components in both objective and eyepiece assemblies. These multi-component lenses are designed to reduce aberrations. In modern microscopes the mirror is replaced by a lamp unit providing stable, controllable illumination.

Now a days , Compound Microscope has become much advanced and improved , and there is an attachment of monitor in place of eye-piece and there is also a facility to attach a camera for microphotography of the specimen/samples.

Maintenance of the Microscope

As the microscope consists of a good number of lenses & mirror and it is very sensitive to moisture. If it is kept few days without in operation it will grow fungus and this will blurred the image of the object or specimen. So it is advised to keep the lenses (when not in use) in a desiccator with fully charged Silica gel (Calcium Chloride). Second way to keep your lenses free from fungus , your laboratory should be fully air-conditioned and well curtained (i.e.to free from dust) and be fitted with Dehumidifiers to keep the moisture level as per the specification of the instruments. If the lenses are fully contaminated with fungus - Clean with Xylene or methanol with soft tissue paper slowly and gently. Do not use rough hand or don't be aggressive but be friendly to your instruments. When you need to dislocate the lenses from the microscope ,you need a special type of screw driver/tools. So collect it from the local scientific store. Sometimes the bulb which is used for illumination of the specimen chamber goes out order. The bulb to be collected and replaced as per the specification. These sort of bulbs are available at Stadium Market in Dhaka. Finally, it is advised to cover up your instrument with dust cover after every use.

If you like to create/organise a unit or center for repairing instruments in your department/Laboratory, you will require the following essential tools and accessories ;

- Wire Stripper
- Pliers & Cutter
- Wrench
- Scissors
- Knife
- Screw Driver (Assorted)
- Jewelry Driver Set
- Hexagon Key Set
- Spanner Set
- Hacksaw
- File
- Hammer
- Soldering Iron / Solder
- Wire
- Power Supply Unit
- Switches
- Magnifying Glass
- Bread Board /Project Board
- Multimeter
- Continuity-Cum Logic Tester
- Oscilloscope
- Function Generator etc.
- Special type of tools for dismantling lenses of microscope.

General Fault Finding

Fault finding still tends to be more of an art than a science but there are some general points which you should consider when investigating electrical faults:

▲ Never assume anything. Check all aspects of the equipment.

▲ Work carefully and systematically. Work with a circuit diagram, checking components and connections in a logical sequence. Gradually focus in on a problem area.

▲ Do not believe the description of symptoms given to you by a user. Check the symptoms for yourself.

▲ Only make one change to the system at a time. If you make more than one change then you will not know which has caused any alteration in behavior.

▲ Carry out an initial visual check of the equipment. You should look for obvious problems such as loose connections, obvious short circuits and signs of overheating. remember that a burnet out component is unlikely to be the root cause of the problem. There is probably another fault which has caused too much current to flow.

▲ Always disconnect equipment from the mains before working on it. If you decide to switch the equipment on with the cover removed then be very careful to avoid touching live components.

▲ Remember that most faults are caused by the most common component failures Always check the frequent failure prone components such as semiconductors before reliable components such as resistors, capacitors, etc.

▲ If you cannot find a fault and you decide to call a service engineer then make a careful note of the symptoms and of any changes you have made so that the service engineer does not have to repeat your work.

Soldering

Soldering is essentially a mechanical skill which needs to be practised. It is difficult to describe on paper but here are some tips:

- Cleanliness: Make sure that components are cleaned and free from oxides. Always use a clean soldering iron tip on a damp sponge before every joint.
- Temperature: Make sure that all components in the joint are well heated so that solder can flow freely through the joint.

▼ **Stability:** Hold the work firmly (eg. in a vice) so that the components cannot move whilst you are making the joint. This also gives one hand to hold the iron and one to hold the solder.

- **Insulation:** Be careful not to create unwanted short circuits by bridging terminals with excessive solder or by leaving too much bare wire. Only strip off a minimum amount of insulation and if using stranded wire, twist the strands together.

- **Tin all components:** Coat each component with a small amount of solder before bringing them together to make the joint. This makes it much easier to get solder distributed throughout the joint. Always apply the solder directly to the joint. Do not melt the solder on the iron first.

- **Heat sensitivity:** Some components can be damaged by excessive heat from a soldering iron. This includes most semiconductors, eg. Transistors, Integrated circuits etc. Use a heat sink between the joint and the component body or cool the component with an aerosol freezer spray before making the joint.

- **Problems:** Poor (or Dry) joints are usually caused by dirty components, too little solder, too little heat or moving the components whilst the joint is still molten.

Advanced Troubleshooting methods and techniques, Procedures and Practices. (Analog & Digital) Electronic Equipments

Electronic Equipment → Cluster of → Active Components: (Integrated Circuits –IC Chips, transistors, diodes)

+

Passive Components: (Resistors, Capacitors, Inductors, Switches)

- Failure of any component may cause the equipment to fail.
- **Troubleshooting:** Locating the problem/fault/error ***quickly*** and restoring it to normal operation.
- **Cost of Troubleshooting:** Cost of diagnosis/isolation of fault (Variable past-time factor) + Cost of Components (fixed parts).
- Speed is important because loss of time is loss of money and productivity.
- Speed depends on education, training experience and the attitude of the troubleshooter.

+

Availability of proper test equipment, accessories, replacement parts.

⇨ **Typical Problems**

1. Operators Problem ("Cockpit" Problem)
2. Defective Components
3. Mechanical Problems
4. Power Supplies
5. Environmental Problems
6. Noise
7. Timing Problems (Digital Equipment)
8. Software (Computerized Equipment)

▼ **Operators Problem**

▽ Not equipment problem, but encountered when equipment is used improperly.

▽ Does not quite know how to use or interpret the result of application.

▼ **Typical cockpit Problems are also:**

1. Improper interconnection of different units
2. Improper control setting
3. Output results misinterpreted
4. Incorrect data is used
5. Equipment specifications is exceeded

▼ Cockpit Problems are relatively easy to overcome. Operator should read the manual of operation attentively or one who is conversant with the operation should demonstrate.

▼ **Defective Components**

Most Common Faults are: Overloaded, Specifications exceeded, Poor quality substandard components.

❖ Some type of Components fail more often than others. List the order of most common failure :

1. Fuses , Indicator Light
2. Switches , Relays
3. Power Supplies
4. Connectors
5. Transistors , Diodes
6. Capacitors, Resistors, Transformers
7. Integrated Circuits
8. Printed Circuit Boards

▼ **Mechanical Problems**

Devices mechanical in nature having moving parts have higher failure rate. Switches and relays are candidates for failure.

▼ **Power Supply (PS)**

Ac line voltage converted to stable DC voltage for operation of circuits. P.S. problems are relatively easy to locate. Quick check of the voltages reveals the fault.

▼ **Environmental Problems**

Condition of environment is important. Poor ventilation for heat, oil, grease, humidity, vibration, dust, chemicals and salt air affect the way of equipment operation. Proper heat sink, ventilating holes, fans should operate without obstruction.

▼ NOISE

- Random, unwanted signals in the equipment are noise. Source of external or internal signal can cause intermittent the operation, malfunction or total failure. Ac power line surges and spikes, magnetic or electrostatic field, RF interference coming from radio/T.V. transmitters. Internal sources: Capacitive or inductive coupling of adjacent circuits.
- There are some difficult problems to track down. Only knowledgeable and experienced shooter can identify the causes and can take remedial measures.

▼ Software Problem

Digital equipment using computers can develop software problems. Software programmes to operate the equipment and are stored in RAM or ROM . The hardware may be operating properly, but the software defects make it appear as a hardware problem is the cause.

▼ I.C. Problems

ICs are being increasingly used. They are either mounted on a socket or directly soldered on to the P.C.B. IC pins are so close that a tiny piece of wire, metal or solder scrap and stray debris may short the pins. Short or low resistance may be caused by chemicals. Salty air may cause gradual salt built-up for a short and consequential failure.

▼ Troubleshooting Techniques

1. System function technique
2. Signal tracing technique
3. Voltage tracing technique
4. Substituting techniques

▼ System Function Techniques

Used to isolate defect to a particular portion of a complex piece of equipment. Most effective and should be used when-ever possible, Should be tried first.

▼ Signal Tracing Techniques

- Appropriate signal is injected at various point of the ckt. and its transmission traced by an oscilloscope. Thereby a faulty component is easily located

▼ Voltage resistance Techniques

- Most manufacturers ckt. diagrams and data sheets indicate voltages required at certain tests points. By measuring those voltages it is possible to localize a defect.For example a short transistor would show up lesser voltage at the collector.
- Resistance measurement is always done when power is turned off.

▼ Transistor Circuits Troubleshooting

Sometime the transistor are mounted on sockets which may create problems due to poor contact. Transistors fail by being open or short. Transistor being equivalent to two diodes, can be checked by ohmmeter. Backward to forward resistance ratio should be well over 100. A transistor checker is quite handy. It also checks the ß and of the transistor. For a failed transistor if the exact type is not available, an equivalent replacement may be substituted consulting replacement chart.

▼ Troubleshooting IC's

Causes of failure: Excessive voltage, heat, bending of leads etc. By measuring outputs one can tell if the IC is a good one. Hewlett Packard (5011) Troubleshooting kit tests DTL and TTL DIP IC's. Priced at $625, it is handy.

▼ Troubleshooting Intermittent Defects

If an electrical contact opens or shorts intermittently, intermittent defect results.

Reasons: mechanical changes, e.g. vibration, shock, position the equipment, air flow, moisture et.

To locate faults: jar, bang or shake the chassis; defects may appear permanently or disappear. Look for loose piece or metal, minute hair-crack or a break in printed circuit, or dry solder junction. Suspected points may be resoldered.

▼ Procedure for Troubleshooting

- There is no formal or established procedure.
- Actual approach will vary depending upon the equipment, applying a logical and sequential reasoning process.
- Since there is no full-proof step-by-step procedure to follow, one way of looking at it is a cause-and-effect process.

  Notice the effect and attempt to determine what cause it.

▼ **Basic Procedure May Involve for Three Major Steps**

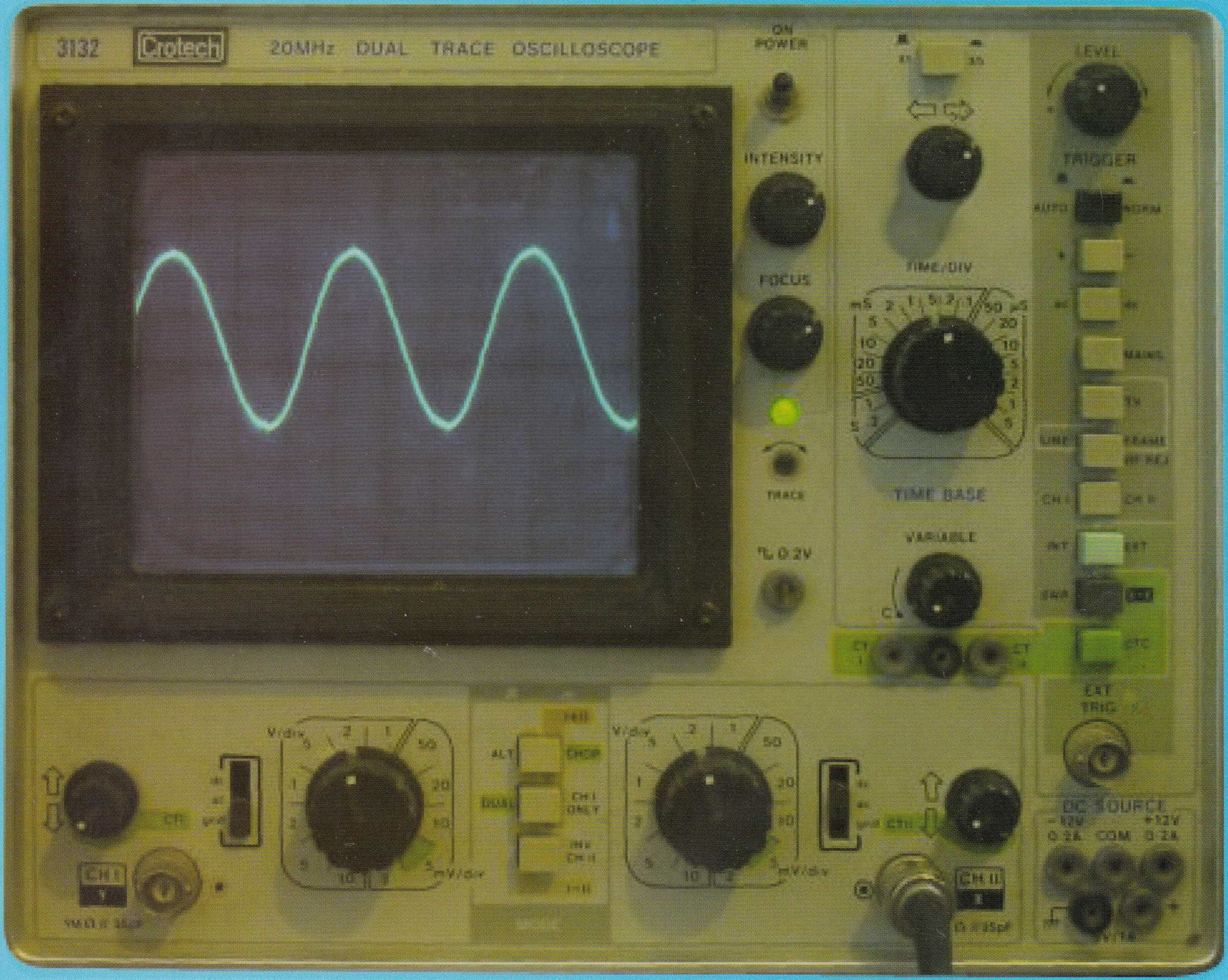
1. Collection and familiarization with data and documentation.
2. Fault isolation.
3. Repair.

▼ **Data/Documentation Collection/Reading**

- Operation/Service manuals, Logic and Schematic Diagrams, Specification, Operational Procedures, Parts Lists.
- Service and Repair Records may provide clue. In some equipment the same things seem to fall over and over.
- Tips for the persons who might have serviced the equipment before.

▼ **Diagnostic checks (Digital/Computerized Equipment)**

A lot of digital equipment, particularly the large digital systems using computers, have special diagnostics tests that can be run to help locate the problem. Some equipments are designed to contain the specific point in a circuit where the equipment failed. Usually in such cases the equipment documentation will spell out in detail what is being tested and how.



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