PROJECT REPORT

ON

GROUNDWATER EXPLORATION

Under guidance of

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B Tech, 8th semester

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CERTIFICATE

This is to certify that the thesis entitled, "STUDY OF GROUNDWATER EXPLORATION"submitted by Mr Priti Ranjan Sahoo in partial fulfillments for the requirements for the award of Bachelor of Technology Degree in Civil Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

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An assemblage of this nature could never have been attempted without reference to and inspiration from the works of others whose details are mentioned in reference section. I acknowledge my indebtedness to all of them. Last but not the least to all of my friends who were patiently extended all sorts of help for accomplishing this undertaking.

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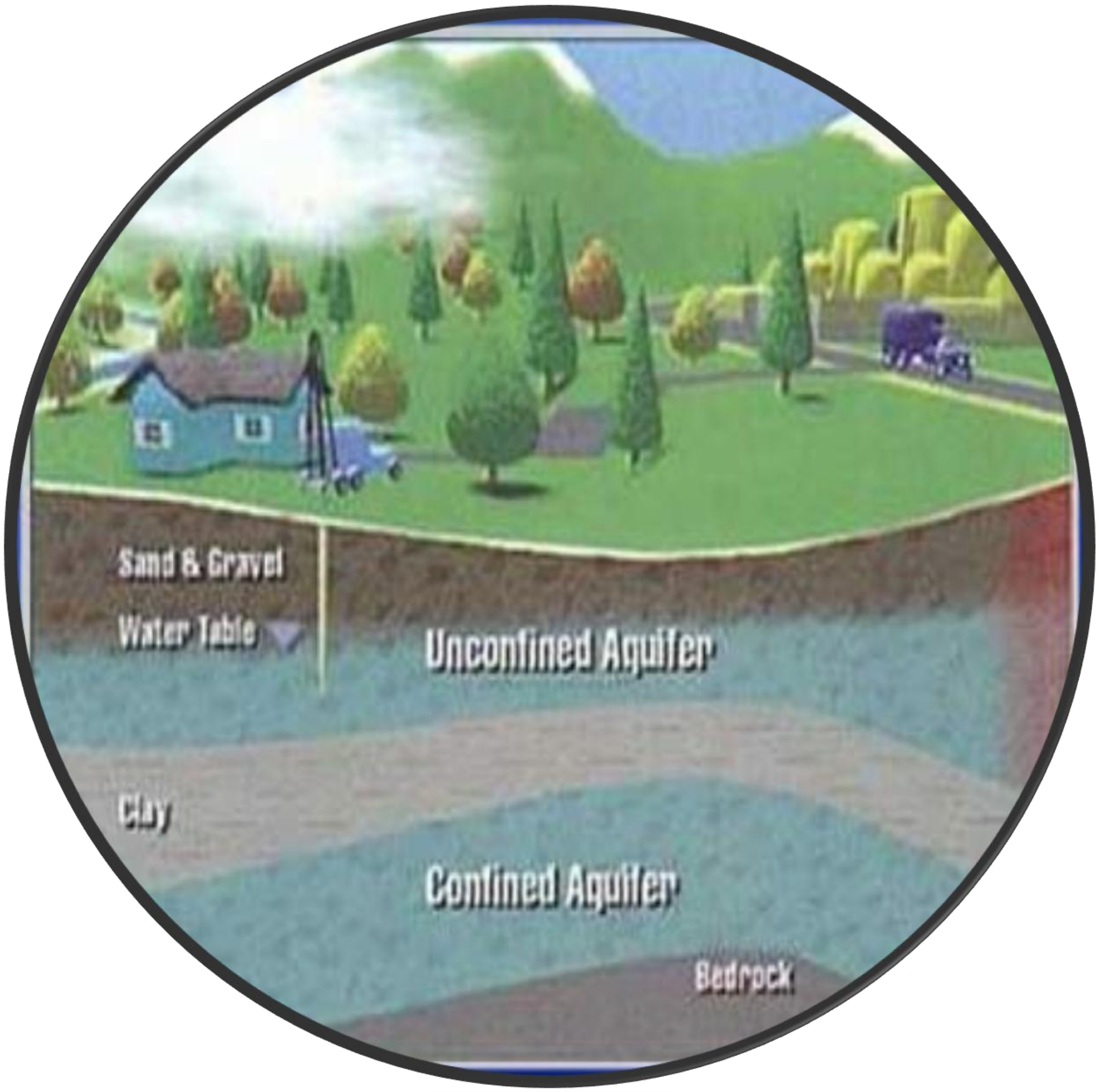
Groundwater

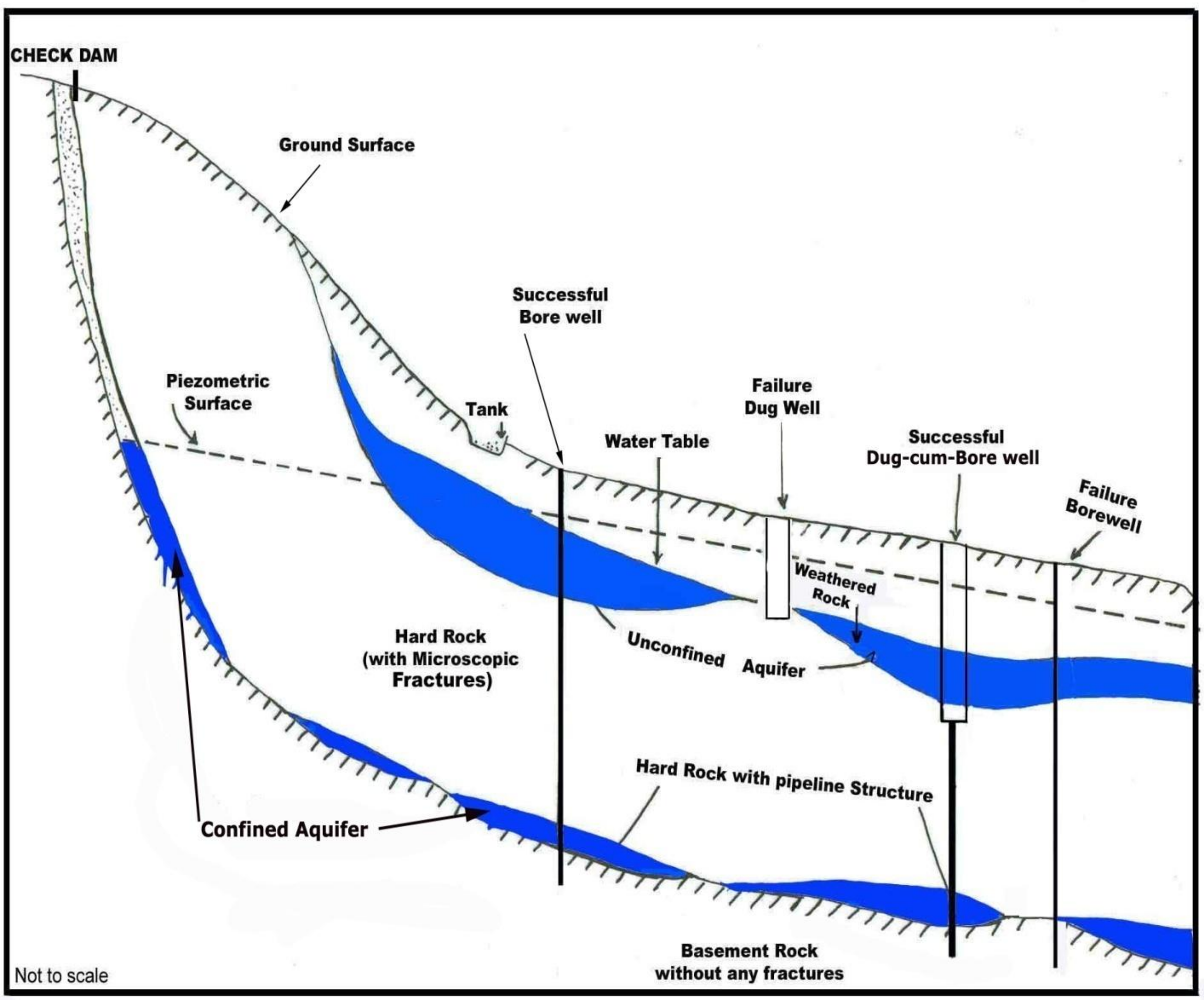
Groundwater is the under ground water that occurs in the saturated zone of variable thickness and depth, below the earth's surface.Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of lithologic formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. Groundwater is recharged from, and eventually flows to, the surface naturally; natural discharge often occurs at springs and seeps, and can form oases or wetlands. Groundwater is also often withdrawn for agricultural, municipal and industrial use by constructing and operating extraction wells. The study of the distribution and movement of groundwater is hydrogeology, also called groundwater hydrology.Image of the entire surface water flow of the Alapaha River near Jennings, Florida going into a sinkhole leading to the Floridan Aquifer groundwater.Typically, groundwater is thought of as liquid water flowing through shallow aquifers, but technically it can also include soil moisture, permafrost (frozen soil), immobile water in very low permeability bedrock, and deep geothermal or oil formation water. Groundwater is hypothesized to provide lubrication that can possibly influence the movement of faults. It is likely that much of the Earth's subsurface contains some water, which may be mixed with other fluids in some instances. Groundwater may not be confined only to the Earth. The formation of some of the landforms observed on Mars may have been influenced by groundwater. There is also evidence that liquid water may also exist in the subsurface of Jupiter's moon Europa.

Groundwater



Aquifer

An aquifer is a layer of relatively porous substrate that contains and transmits groundwater. When water can flow directly between the surface and the saturated zone of an aquifer, the aquifer is unconfined. The deeper parts of unconfined aquifers are usually more saturated since gravity causes water to flow downward.The upper level of this saturated layer of an unconfined aquifer is called the water table or phreatic surface. Below the water table, where generally all pore spaces are saturated with water is the phreatic zone.Substrate with relatively low porosity that permits limited transmission of groundwater is known as an aquitard. An aquiclude is a substrate with porosity that is so low it is virtually impermeable to groundwater.A confined aquifer is an aquifer that is overlain by a relatively impermeable layer of rock or substrate such as an aquiclude or aquitard. If a confined aquifer follows a downward grade from its recharge zone, groundwater can become pressurized as it flows. This can create artesian wells that flow freely without the need of a pump and rise to a higher elevation than the static water table at the above, unconfined, aquifer.The characteristics of aquifers vary with the geology and structure of the substrate and topography in which they occur. Generally, the more productive aquifers occur in sedimentary geologic formations. By comparison, weathered and fractured crystalline rocks yield relatively smaller quantities of groundwater in many environments. Unconsolidated to poorly cemented alluvial materials that have accumulated as valley-filling sediments in major river valleys and geologically subsiding structural basins are included among the most productive sources of groundwater.The high specific heat capacity of water and the insulating effect of soil and rock can mitigate the effects of climate and maintain groundwater at a relatively steady temperature. In some places where groundwater temperatures are maintained by this effect at about 50°F/10°C, groundwater can be used for controlling the temperature inside structures at the surface. For example, during hot weather relatively cool groundwater can be pumped through radiators in a home and then returned to the ground in another well. During cold seasons, because it is relatively warm, the water can be used in the same way as a source of heat for heat pumps that is much more efficient than using air. The relatively constant temperature of groundwater can also be used for heat pumps.



Groundwater makes up about twenty percent of the world's fresh water supply, which is about 0.61% of the entire world's water, including oceans and permanent ice. Groundwater is naturally replenished by surface water from precipitation, streams, and rivers when this recharge reaches the water table. It is estimated that the volume of groundwater comprises 30.1% of all freshwater resource on earth compared to 0.3% in surface freshwater; the icecaps and glaciers are the only larger sources of fresh water on earth at 68.7%.Groundwater can be a long-term 'reservoir' of the natural water cycle (with residence times from days to millennia), as opposed to short-term water reservoirs like the atmosphere and fresh surface water (which have residence times from minutes to years). The figure shows how deep groundwater (which is quite distant from the surface recharge) can take a very long time to complete its natural cycle. The Great Artesian Basin in central and eastern Australia is one of the largest confined aquifer systems in the world, extending for almost 2 million km^2. By analyzing the trace elements in water sourced from deep underground, hydro geologists have been able to determine that water extracted from these aquifers can be more than 1 million years old. By comparing the age of groundwater obtained from different parts of the Great Artesian Basin, hydro geologists have found it increases in age across the basin. Where water recharges the aquifers along the Eastern Divide, ages are relatively young. As groundwater flows westward across the continent, it increases in age, with the oldest groundwater occurring in the western parts. This means that in order to have travelled almost 1000 km from the source of recharge in 1 million years, the groundwater flowing through the Great Artesian Basin travels at an average rate of about 1 meter per year.

SURFACE INVESTIGATIONS

Although groundwater cannot be seen on the earth's surface,a variety of techniques can provide information concerning its occurrence and under certain conditions even its quality. Surface investigations helps us in finding the information about the type, porosity, water content and compactness of subsurface formation. IT is generally done with the aid of electrical and sismic properties of earth and without any drilling on the surface. The information's supplied by these techniques are partially reliable and involve less expenditure. It provided only indirect indications of groundwater so that underground hydrologic data must be inferred from surface investigations. Correct interpretations requires supplementary data from sub surface investigations to substantiate surface findings. It is mainly achieved by the geophysical method viz, electrical resistivity & seismic refraction method.

ELECTRICAL RESISTIVITY METHOD

The electrical resistivity of a rock formation limits the amount of current passing through the formation when an electric potential is applied. It may be defined as the resistance in ohms between opposite faces of a unit cube of material.

Resistivity: Resistance in ohms (Ω) between opposite faces of a unit cube of the material.

$$\rho = RA/L$$

Unit = ohm –m^2/m = ohm-meter

Resistivity of various type of water:

dTypes of water	**Resistivity in ohm-meter**
Meteoric water (derived from precipitation)	30-1000
Surface water (in districts of sedimentary rocks)	10-100
Ground water (in areas of igneous rocks)	30-150
Sea water	0.20
Groundwater(in areas of sedimentary rock)	More than 1

Both porous and non porous rocks behave as insulators until they are in dry condition. Resistance decreases with increase in pore water. Unconsolidated material has more resistance than compacted material of same composition. Sedimentary rock has better conductance i.e. lesser resistance than igneous rocks. Clay has higher conductivity than sand because of presence of iron cluster on surface of the clay. Based on this knowledge from resistivity survey it is possible to distinguish between major rock group and the water bearing zones.

ELECTRICAL RESISTIVITY OF SOME COMMON MATTER

COMPOSITION	RESISTIVITY(Ohm-m)
Top soil	5-50
Pea and clay	8-50
Clay sand and gravel mixture	9o-250
Saturated sand and gravel	40-100
Moist to dry sand and gravel	100-3000
Mud stone and shale	8-100
Sand stone and lime stone	100-1000
Crystalline rock	200-10000
Quart	100
Calcite	500
Dense granite	1000000
metamorphic rock	100-100000000
Unconsolidated sedimentary rock	10-10000
Gavel and sand with water	100
Fresh water	100
Shale and clay	10
Brine	0.05

Geophysical Method

- Electrical Resistivity Method
- Seismic Refraction Method

Electrical Resistivity Method:

The electrical resistivity of a rock formation limits the amount of current passing through the formation when an electric potential is applied. It may be defined as the resistance in ohms between opposite faces of a unit cube of material.

Resistance in ohms (Ω) between opposite faces of a unit cube of the material.

$$\rho = RA/L$$

Unit = ohm –m^2/m = ohm-meter

1.Electrode arrangement:

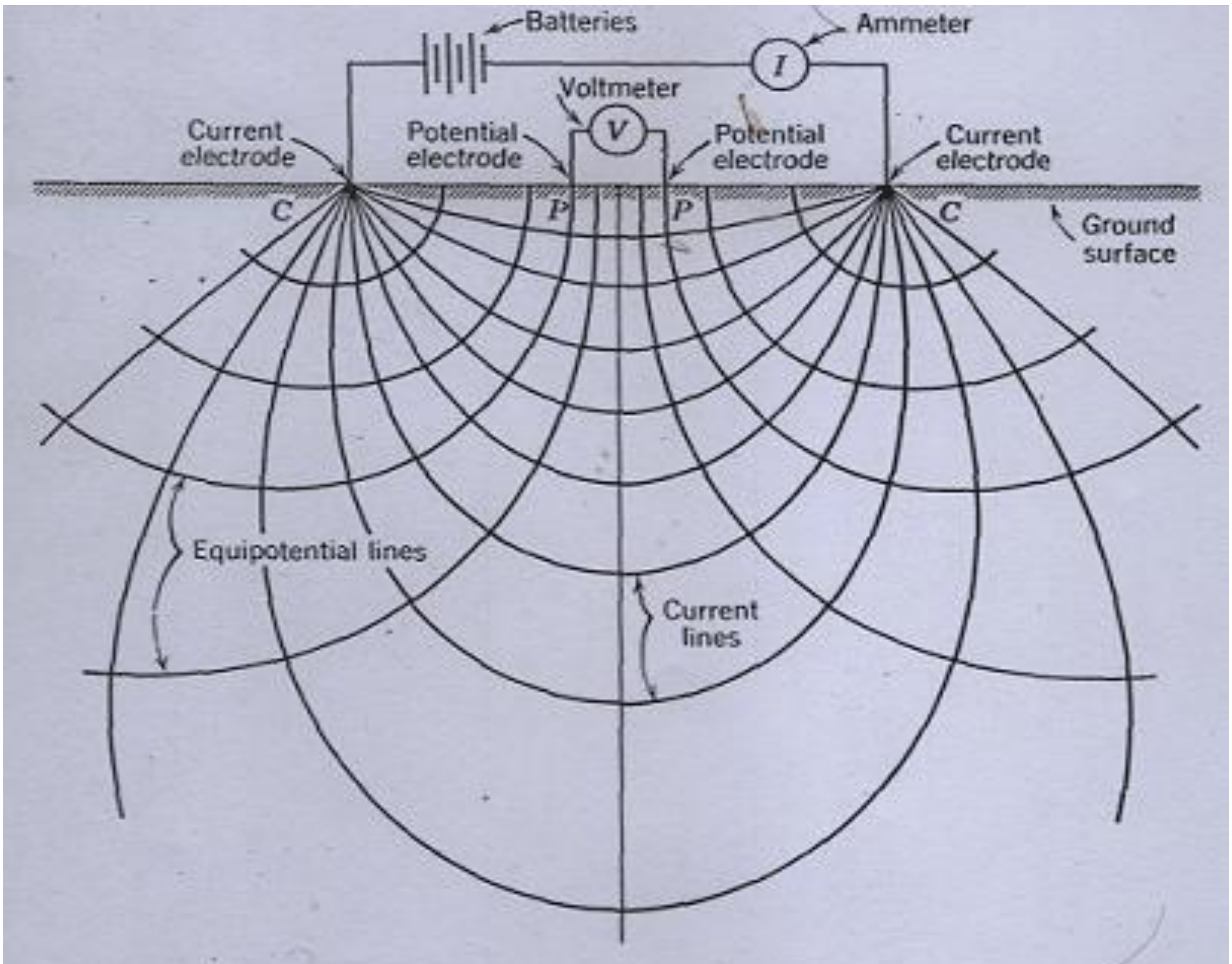


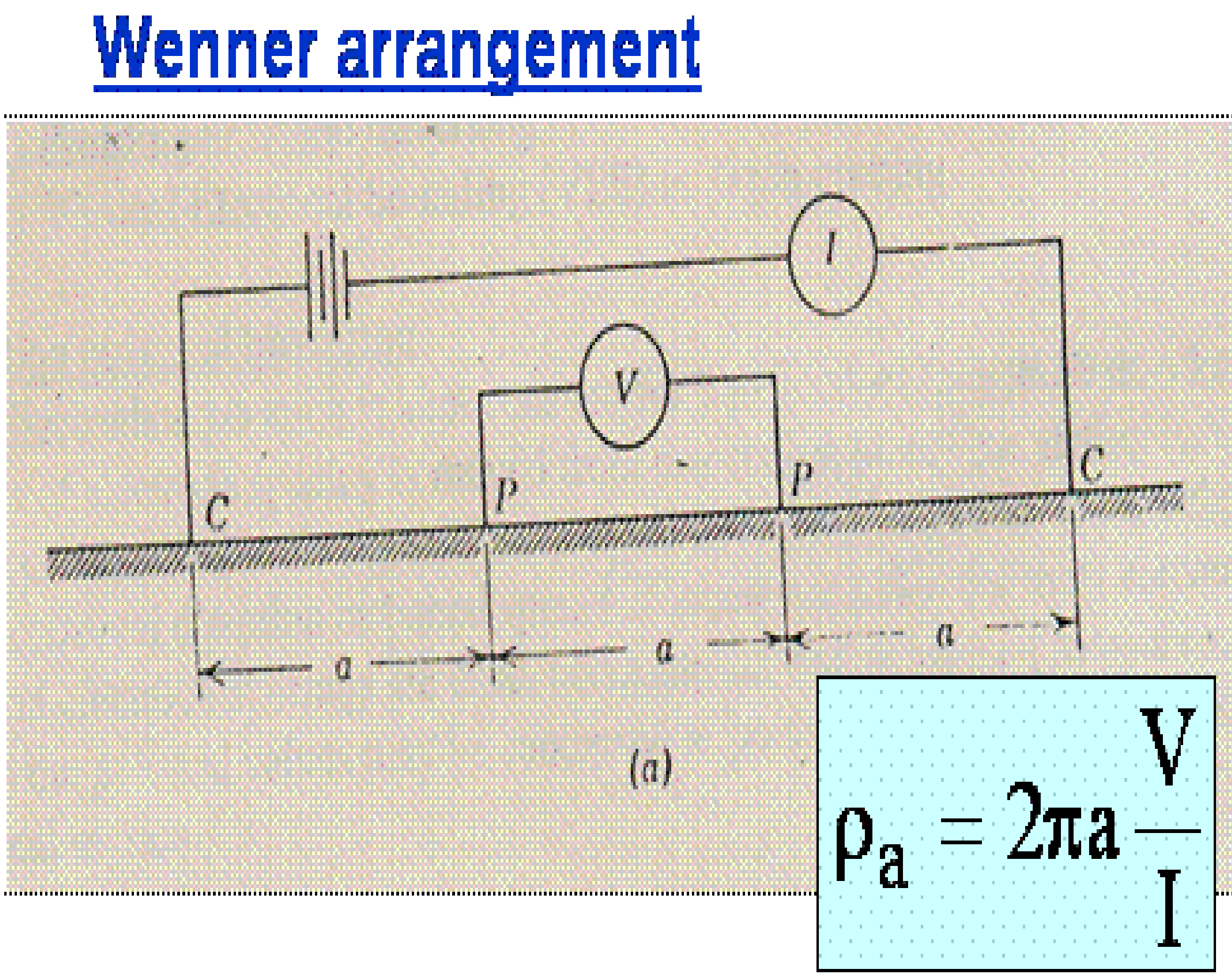
Fig. 11.4 Electrical circuit for resistivity determination and electrical field for a homogeneous subsurface stratum.

There are two types of electrode arrangement.

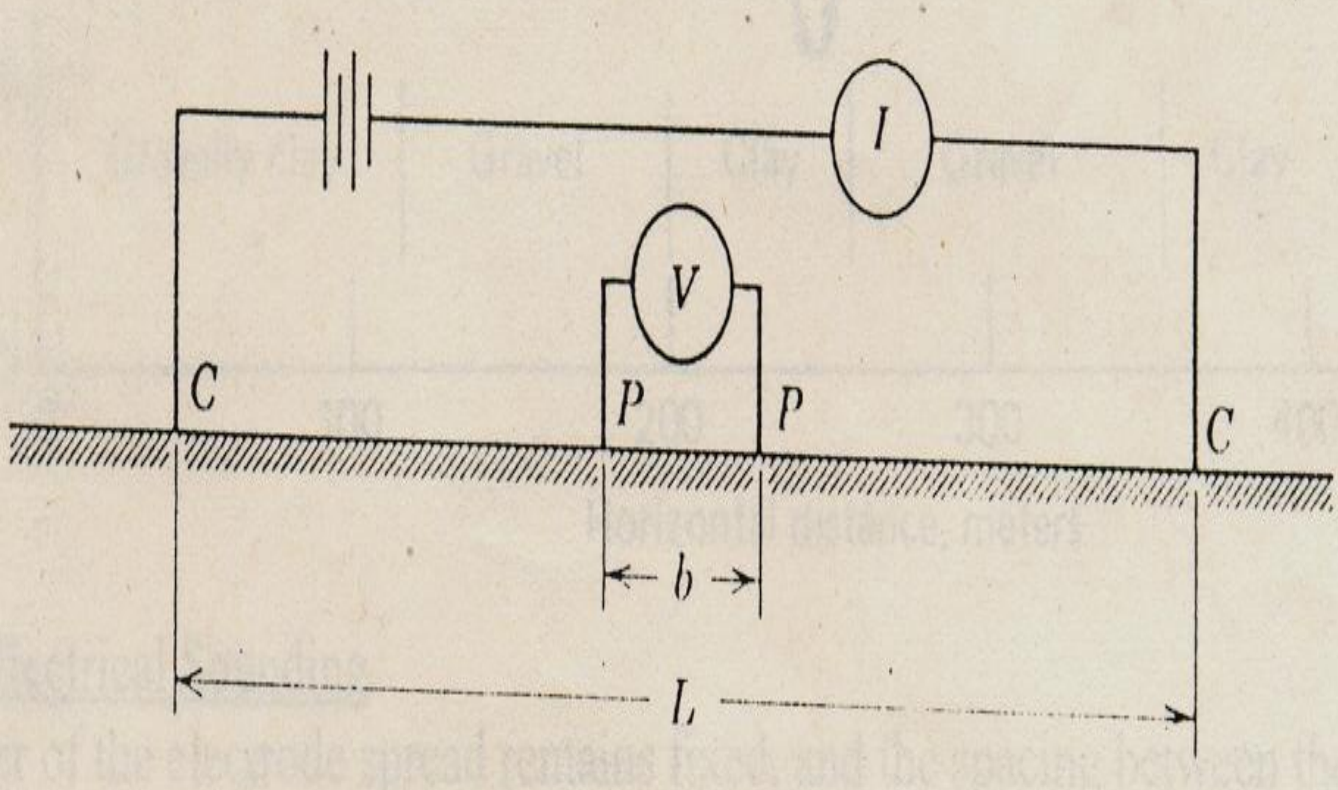
1 . Wenner's arrangement

2 . Schlumberger arrangement

Wenner' s electrode arrangement:



Schlumberger's Electrode arrangement:



(b)

$$\rho_a = \pi \frac{(L/2)^2 - (b/2)^2}{b} \frac{\Delta V}{I}$$

SOIL RESISTIVITY METER

ASHIDA SOIL RESISTIVITY METER is a vital, sophisticated electronic tool to explore the mysteries of the sub-surface world. IT is very easy to operate the instrument if the instructions are followed step-by-step & correctly, then the readings can be easily interpreted.

DIFFERENT TOOLS OF THE INSTRUMENT :

- Adaptor
- 4 nos. of winches to wind the wires
- 4 nos. of stainless steel probes.
- Maintenance free 6V battery along with the connecting pair of wires
- Battery charger for the 6V battery.
- 4 sets of wires for connecting the probes to the instrument. These are winded on the winches & have crocodile pins at the probe end.

- 4 sets of connecting wires having banana pins at both ends. These wires establish the connection between the winches &the adapter sockets
- Carrying case for all the accessories. Hard bound cover for the main instrument

IMPORATANT FEATURES OF SOIL RESISTIVITY METER

THE MAIN INSTRUMENT: when the instrument is opened with the lid hinged out at the left hand side we can see the following indicators/controls.

1. CURRENT INDICATOR:-At the left hand corner is the RED push-button marked as' CURRENT'. While operating the instrument, when this button is pressed, the meter indicates the current that is being penetrated in the ground(between P1&P4 circuit) if the meter indicates say 20 that means the actual current flowing is 50 milliamps(2.5 times of the meter reading).

2. VOLTAGE SELECTOR:-This switch is located below the current push button. The output AC voltage (50/100/200/400 VAC) is to be selected with this selector switch , at different stages.

3. RANGE SELECTOR:-The range selector switch is located below the voltage selector switch. There are 5 different ranges that can be selected viz.X1, X10, X100, X1000, X10000. IN the first range i.e.X1,the resistance up to 1 ohm can be measured. IN the second range(X10), resistance up to 10 ohm can be measured. Thus, for X100-upto 100 ohm, for X1000 ohm& for X10000-upto 10,000 ohms.

4. TERMINALS;-At the lower end, there are 4 terminals marked as P1, P2, P3 & P4.

Terminals P1&P4 are of red color whereas P2&P3 are of black colour.P1&P4 are connected to the extreme 2 probes(current probes) through which the current is injected in the ground.P2&P3 are connected to middle 2 probes that are called as potential probes and measure the potential created by injecting the current through the current probes.

5. ON/OFF switch:-With this toggle switch, the main battery supply to the instrument is Disconnected. This switch is to be kept OFF when the instrument is not in use.

6.'CAL'knob;-The calibration of the instrument is done with this knob. Once the instrument is calibrated for a particular range, this knob should not be disturbed till the required set of readings is obtained for that range.

7. METER:-The meter is used for three different functions.

I. CURRENT INDICATOR:-When the probes are connected to the instrument is switched ON and now when the CURRENT push-button is pressed, the meter indicates the milliamp.
(mA) current that is flowing through the ground. The full-scale deflection(100) indicates 250mA.

ii. BATTERY INDICATION-:When the push -button marked' BATTERY' is pressed, the meter shows the battery input voltage, along with the Proper connection (polarity).When the pointer is in the green region (7A)of the meter scale(4.5 to 7VDC) that means the battery voltage is sufficient to operate the instrument correctly. If the indication is less then the battery needs charging. If the pointer moves in the other direction (below ha 0) that means the battery is connected in the wrong polarity. Interchange the connections.

iii. NULL BALANCING;-This is the principle use of the meter. The actual readings of the ground survey are taken when there is a 'null balance 'i.e. the pointer deflection is towards the maximum left side towards 0.

8. NEON INDICATOR;-When the instrument is switched ON, the neon red lamp on the top of the meter glows, which indicates that the AC voltage is developed.

9. BATTERY CHECK PUSH-BUTTON;-At the right hand corner there is a push-button marked 'BATTERY'. When this button is pressed, the pointer deflection indicates the battery status (voltage).For proper results; the battery voltage should always be within the green zone (7A) of the meter.

The battery voltage indication may vary when the instrument is in OFF or ON condition. BUT in either case the battery voltage should never drop below 4.5VDC.This is the minimum voltage required to operate the instrument satisfactorily.

10. SENSITIVITY;-The black knob is situated at the right hand side, below the battery push-button. When this knob is situated at the right hand side , below the battery push button. When this knob is rotated in the clockwise direction, the sensitivity increases i.e. the deflection is more and the null balancing can be done more precisely.

11.TEN TURN POTENTIOMETER KNOB:-the 'R' knob is situated right below the sensitivity knob. It measures the resistance accurately. the least count of this knob is 0.0001 ohm

& when the full turns are completed, it measures 1.0000 ohm. thus, it will measure 0.0000 ohm to 1.0000 ohm 0n X1 range ,0.0ohm to 10.000 ohm on X10 range,0.00 ohm to 100.00 ohm on X100 range,0.0 ohm to 1000.0 ohm on 1000 range & 0 ohm to 10000 ohm on 10,000 range. In short, the reading obtained on the ten-turn pot is to be multiplied with the selected range, to get the actual reading.

B THE ADAPTOR;-The adaptor is to be attached with the main instrument. the P1,P2,P3&P4 pins are to inserted into the respective terminals of the main instrument. There is a band switch (or a series of 5 push buttons)
below the terminals of the adaptor. Each push button is pressed to select a particular range .Each press-button when pressed individually connects a standard resistor of known value across the instrument. The value of the standard resistor (OHM) is indicated below the push button. The actual calibration method using the adaptor is explained ahead.

C WINCHES;-There are four winches (reels).Each winch has a wire winded on it, which has a distinguished color. The open end of the wires has a crocodile clip connected to it, which in turn is to be connected to the respective probes. The other end of the wires is terminated on the banana socket located on the opposite side of the handle of the winch.

D PROBES:-4 stainless steel probes of appropriate size are supplied along with the instrument to use the instrument in WENNER configuration. One side of each probe has a sharp pointed end. This facilitates to hammer the probe in the ground. The probes are hammered in the ground in such a way that firm electrical contact is established.

E.BATTERY;-The battery supplied with the instrument is a maintenance-free battery of 6V 10AH rating. It has to be charged only with the matching charger provided along with. When connected to the instrument with power switch in OFF position, and the 'BATTERY' switch pressed, the meter shows the battery's charge condition. Even after continuous charging for 10 to 12 hours, if the meter's pointer doesn't go above 4.5V then that means that the battery has gone weak & needs replacement. CAUTION-DO NOT CONNECT THE BATTERY TO THE INSTRUMENT&THE CHARGER AT THE SAME TIME .NEITHER CONNECT THE CHARGER TO THE INSTRUMENT DIRECTLY. Remember to disconnect the battery from the instrument, whenever the instrument is not to be used for more than 1 hour. Ensure that instrument is OFF before disconnecting the battery.

F.BATTERY CHARGER;-The input to the charger is our normal household supply of 230VAC, 50Hz. The charger has 2 indicating bulbs. The 'AC ON' bulb indicates healthiness of the AC input circuit. The' DC ON' bulb indicates the healthiness of the DC output circuit. If either of the bulb does not glow, first check the respective fuse with mains OFF.NEVER SHORT THE DC OUTPUT TERMINALS,EVEN MOMENTARILY. This will permanently damage the charger .The charger is for indoor use only.

Soil resistivity meter :

Methods of operation

1. Two Pin Method

2. Four Pin Method

Two Pin Method:experimental readings:

Sr. No.	Range of the instrument	Reading	R Ohm(Ω)
1.	1000	0.204	204
2.	1000	0.192	192
3.	1000	0.236	236
4.	1000	0.241	241
5.	1000	0.167	167
6.	1000	0.287	287
7.	1000	0.363	363
8.	1000	0.317	317
9.	1000	0.402	402
10.	1000	0.283	283

11.	1000	0.292	292
12.	1000	0.257	257
13.	1000	0.264	264
14.	1000	0.222	222

Sr. No.	Range of the instrument	Reading	R ohms(Ω)
15.	1000	0.180	180
16.	1000	0.214	214
17.	1000	0.325	325
18.	1000	0.198	198
19.	1000	0.200	200
20.	1000	0.197	197
21.	1000	0.168	168
22.	1000	0.253	253
23.	1000	0.318	318
24.	1000	0.244	244

25.	**1000**	**0.277**	**277**
26	**1000**	**0.181**	**181**
27.	**1000**	**0.190**	**190**
28.	**1000**	**0.198**	**198**
Sr. No.	**Range of the instrument**	**Readings**	**R Ohms(Ω)**
1.	1000	0.079	79
2.	1000	0.170	170
3.	1000	0.055	55
4.	1000	0.128	128
5.	1000	0.177	177
6.	1000	0.189	189
7.	1000	0.150	150
8.	1000	0.118	118
9.	1000	0.115	115

Analysis Of Experimental Result:

- **The lowest resistance spot is marked i.e. 55 ohms & is considered to be the best spot in a given area, for maximum amount of ground water yielding, in that particular area.**
- **This point is the best spot for maximum amount of groundwater yielding in the particular area.**

FOUR PIN METHOD:

THIS METHOD IS USED TO DETERMINE THE DEPTH.

Procedure :

1. First place the instrument horizontally on the ground. Open the cover and rest it on the stopper on the left-hand side (hinge) side.
2. Take the pair of battery connecting wires, which have banana pin at one end and small crocodile pin on the other end. Locate the battery connection banana sockets (red+ &black-) on the left-hand side of the instrument. Insert THE APPROPRIATE WIRES IN THE SOCKETS. Connect THE OTHER END OF THE WIRES TO THE TERMINALS OF A FULLY CHARGED BATTERY. Keep a watch on the battery polarity while connecting.
3. Without putting the instrument ON, press the 'Battery' push the button on the instrument & confirm the battery voltage. The pointer on the meter must be within the green zone (7A) only, not more or less.

4. Hook the adapter to the edge of the instrument box. Make one to one connection for the adaptor sida P1, P2,P3&P4 to the instrument side Ensure that the wires are not cross-connected.

5. Press the 'X10' button on the adaptor .Note the resistance value given below this button.(say 6.66)

6. Adjust this value on the 'R' knob. Turn it clockwise till the digit 6 appears in the Main-scale window. Then, turn the knob further so that the sixty-sixth division of the circular (vernier) scale coincides with the marking.

7. Set the **Range Selector** switch on the instrument to 'X10' position.

8. Set the **Voltage Selector** switch to **50VAC** position.

9. Set the **Sensitivity Knob** to maximum position (clock wise).

10. Similarly, rotate the '**CAL**' knob clockwise to its maximum position.

11. Now after ensuring all the above setting, switch ON the instrument .The red neon indicates just above the meter will glow indicating the developing AC voltage.

12. The pointer of the meter will gradually move towards right hand side and at times may also move beyond 100. Rotate the Sensitivity Knob in anti clock wise direction to keep the pointer between 60 to 100 of the meter.

13. Now slowly rotate the '**CAL**' knob in anti clock wise direction. With this the pointer of the meter will also start moving from right hand side i.e from 100 towards 0.At a certain place, the pointer will stop moving toward 0 & will start moving back. The maximum deflection towards the left (0) is the piont of null balance & this method is called as **NULL BALNCING METHOD**.

14. At this particular point , from where the pointer starts moving backstop rotating the 'CAL' knob .Now this instrument is said to be calibrated for that particular range. In this case for X10 range.

15. Counter check the calibration by rotating the 'R' knob. The pointer moves in the opposite direction of the 'R' knob rotating direction.

16. Thus when the instrument is properly calibrated for a particular range,i.e the position of the 'CAL' knob is set properly , then the instrument will precisely measure the soil resistance ,within that particular range. This is how the instrument can be calibrated on-site & the possibility of taking wrong reading is eliminated.

17. Once calibrated for a particular range, the 'CAL' knob is not to be disturbed until all the reading in that range are properly taken. The 'R' knob is once again brought to its full 0 position .The X10 calibration holds good for X1 ,X10 &X10^2 ranges also.

18. Unpressing the adaptor button disconnects the adaptor from the main instrument and the instrument can now actually measure the soil resistance.

19.Arrange the probes at equal distance from each other say 1 meter .This horizontal distance between the probes is called as 'a' , in this case a=1 meter.

20. The probes supplied have a standard length of 50 cms. For the WENNER configuration of 1 meter , the probe arrangement is made as follows.

21. First of all mark the spot of interest on the ground i.e the spot at which the survey is to be conducted.

22. Measure 1 probe distance (50cms) on either side of the spot , and hammer the probes here .Thus the distance between the probes will naturally be 100 cms i.e 1 meter.

23. From these hammered probes , measure a distance of 1-probe length on the either side. Hammer the two remaining probes at these position .Thus the distance between the two adjacent probes is 1 meter .See to it that all the four probes are in one horizontal line.

24. For the simplicity of operation & understanding , note that always the probes on the left side of the spot under observation are called P1&P2 & the probes on the right side are called as P3&P4. The instrument in generally kept in the close vicinity of the spot.

25. Keep the winches near the main instrument & keep the wires sufficiently unwind so that the crocodile clips reach the probes that are hammered in the ground .Keep the P1&P2 winches on the left side of the instrument &P3&P4 on

the right.

26. See that your position in the field is like this:-

P1-P2-Spot-P3-P4 i.e

Probe P1 on LHS at 3 probe distance (150cms) from the spot.

Probe P2 on LHS at 1 probe distance (50cms) from the spot.

Probe P3 on RHS at 1 probe distance (50 cms) from the spot.

Probe P4 on RHS at 3 probe distance (150 cms)from the spot.

Thus the probes are hammered equidistant & the distance is 1 meter.

27. The wire are connected to the probes by the crocodile pins &the winches are connected to the adaptor by the iwres having banana pins at both the ends .Strictly observe that the probes are connected to the respective terminals on the adaptor i.e probe P1 is connected to P1 terminal on the adaptor and so on.

28. The adaptor must be also connected to the main instrument's terminal & all the switches of the adaptor must be in upressed condition(all up).

29. Note that the calibration of the instrument must be done first,before connecting the probes to the instrument .Also while taking the actual reading of the soil the

adaptor must be disconnected simply by ensuring that all the press buttons are unpressed.

30.The sensitivity knob is at maximum position .Next , ensure that all the connection are tight & secure & there are no lose connection .Also make sure that all the connection are are not broken or damaged anywhere .Now , the instrument can be said to be set for the field operation & actual survey can be conducted.

i. The instrument is now switched ON.

ii. The neon lamp glows & the pointer of the meter starts moving 0 to 100.Sometimes it ay go beyond 100.In that case , bring the pointer within the scale by rotating the sensitivity knob anti-clockwise so that the pointer also remains steady.

iii. Press the push button marked 'Current' The meter will show the current in milliamps (mA) that is being penetrated in the ground .The minimum requirement is 100mA.The full-scale indication of the meter is equal to 250mA.Thus the current should be never less than 4 division. More the current, sharper will be the reading &more the voltage ,lesser will be the current flow. Thus to get the best reading start with lower voltage ,say 50VAC.For dry &hard terrain select 100 or

200VAC. In case of very dry, sandy surface where the current is likely to get diffused, 400VAC is to be used (Note that 400VAC range should be used only if required as it consumes lot of power &discharge the battery soon).

iv. Now slowly & steadily rotate the 'R' knob in clockwise direction (the initial position of this knob was 0.00).The pointer will start moving from RHS to LHS .Continue rotating the 'R' knob .At a certain position,the pointer will stop moving in the forward direction &will start moving back. Observe minutely, this division on the meter back .Let this position be say 33RD division on the meter.

v. Rotate the 'R' knob so as to bring the pointer to the 33RD division (maximum deflection towards left).

vi. Switch OFF the instrument.

vii. Note the reading on the 'R' knob .If it is 0 on the main scale &54 division on the circular (vernier) scale , then it is interpreted as 0.054.This reading is to be multiplied by the range on which this reading is taken i.e X10 as in this case. Thus the 'R' value comes to 0.54 . Another examples of X10 ranges are as follows.

a. 0 on main scale & 5 divisions (after 0) on the circular scale gives 0.05.

b. 0 on main scale & 55 divisions on circular scale give 0.55.

c. 5 on main scale &55 division on circular scale gives 5.55.In our first example we got R=0.54 .This value substituted in the formulae p=2aR

where p(spelled as rohe)= The apparent resistivity.(The unit is ohmmeter.)

2 = constant ,whose value is 6.28

a = The horizontal distance between the two probes (Mtrs).

R = Resistance value obtained as above ().

Thus in our example p=6.28*.1*0.54=3.39 ohmmeter.

31. The second reading in now taken as follows

i. The instrument is already in OFF position , after taking the 1st reading

ii. Bring back the 'R' knob to 0.00 position.

iii. Unclip the probe P1 , remove it from the ground and firmly hammer 3 probes distance (1.5 mtrs) from its previous position .Clip back the crocodile pin to it.

iv. Fix the probe P2 in a new position ,1 probe distance away fron its previous position .

vi. Similarly move probe P4 3 probes distance from its previous position &probe P3 1 probe distance away from its previous position.

vi. Thus in short the probes are again equidistant but now the distance is 2 mtrs.

vii. The 50cms (0.5mtrs) length of the probe facilities distance measurement & the use of a measuring tape is avoided, If by continuous use the probes wear out & become short one can use a measuring tape .Or a separate 50 cm rod can be kept for the distance measurement purpose.

vii. Now we start R measurement for 2 meters distance .Ensure that all the 4 wires are properly connected to its respective probes .Switch ON the instrument.

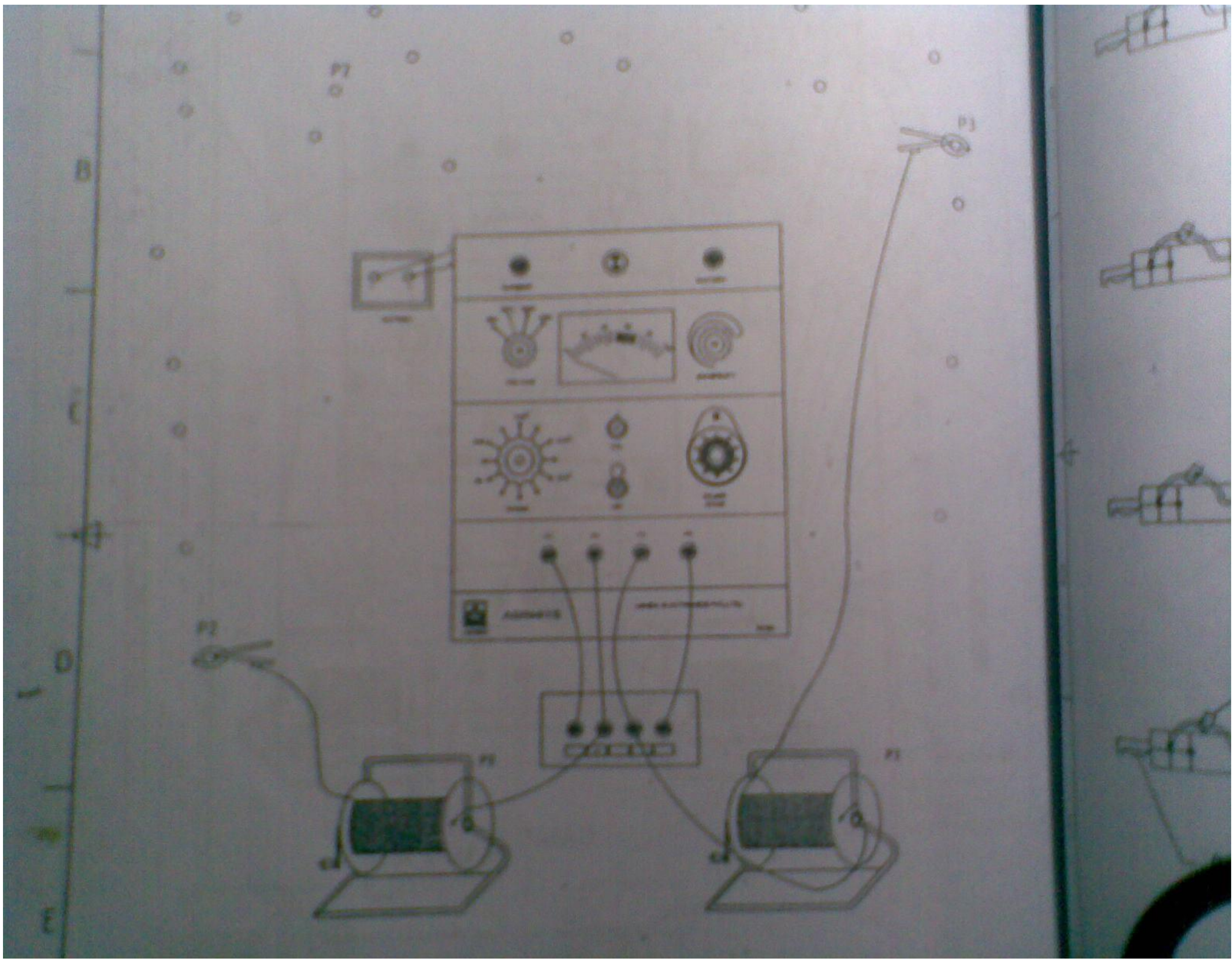
ix. Bring the pointer inside the scale by rotating the sensitivity knob in anti-clockwise direction. Keep the pointer in a steady state between 100 to 60.

x. Rotate the 'R' knob in clockwise direction, which was brought to 0.00 position .

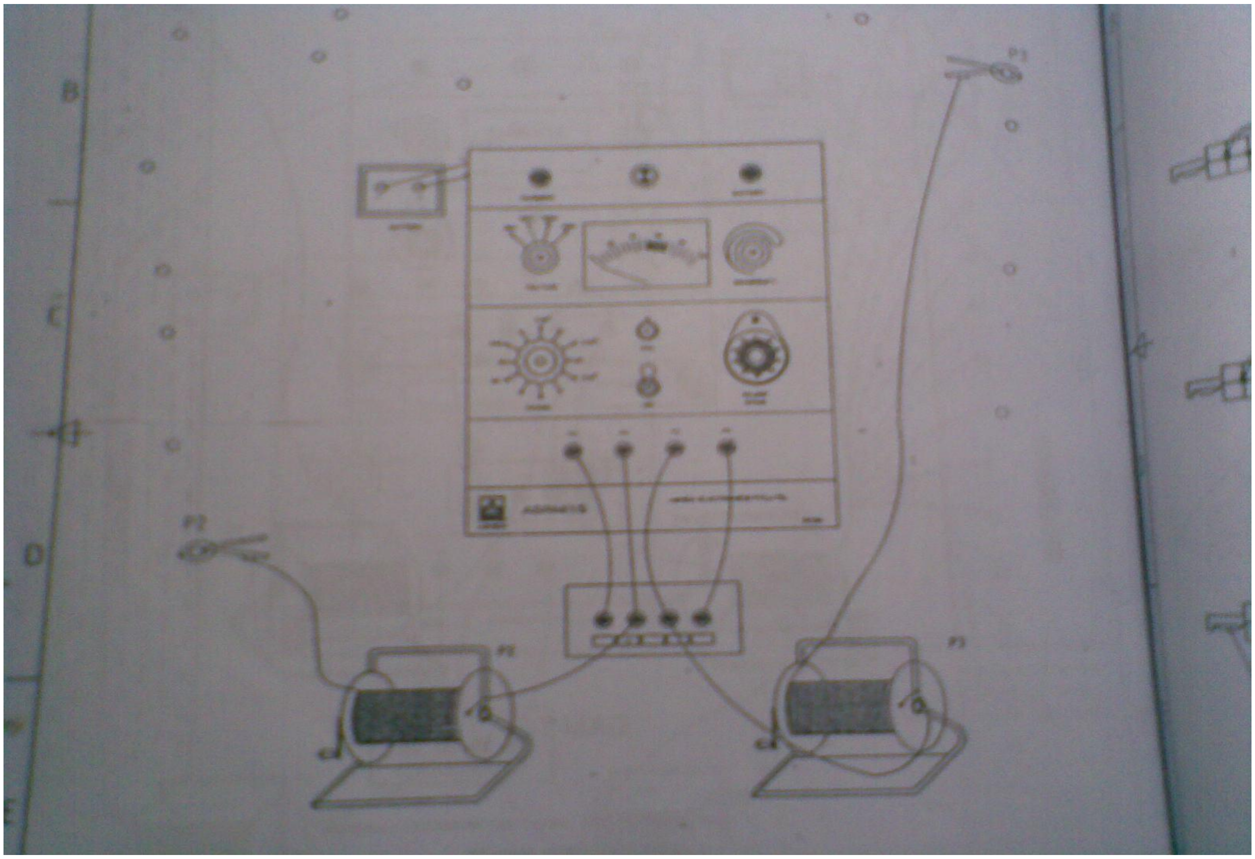
xi. Repeat step iv &v of 30 above and switch OFF the instrument.

xii. Read the 'R' knob position .If the main scale reads say 0& the circular scale reads say 34 division than the total reading is 0.034.It means the value of the resistance R is 0.34.Remember that our range is still set at X10.Thus as per the above given formulae p=6.28*.1*0.34=2.13ohm-meter.

Finding out the depth of the ground water



ADAPTER CONNECTION

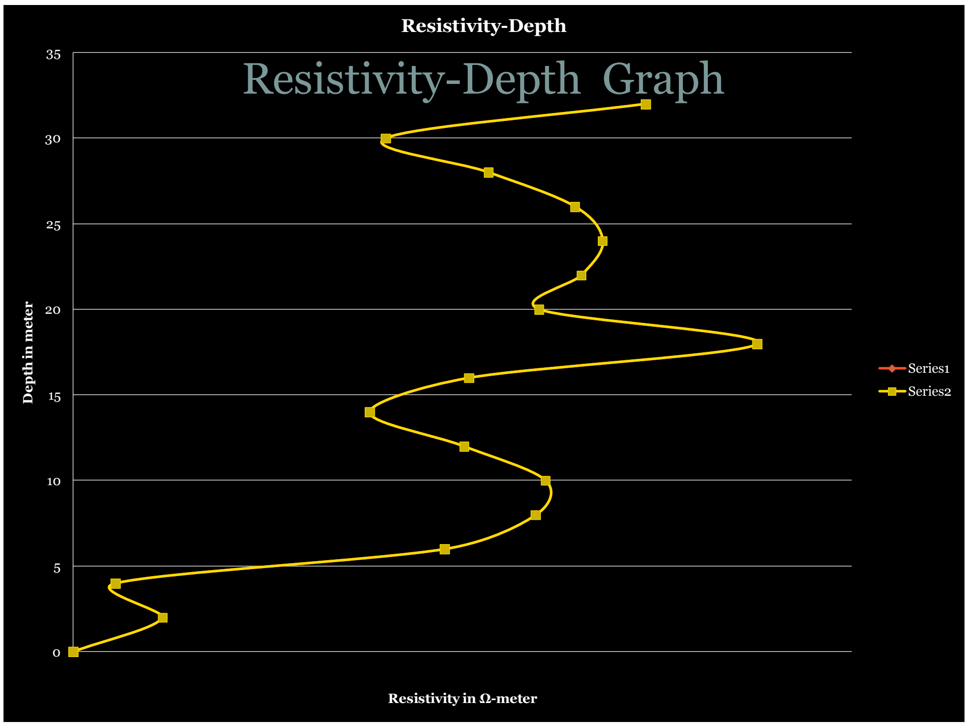


B
C
D
P1
P2
P2
P3

Readings of four pin method

"a" depth in meter	Range	Readings	'R' obtained	Resistivity ρ=2 π a R	Remark
1	10	0.122	0.000	2.1430	Surface soil
2	10	0.055	0.550	6.9080	Soil
4	10	0.013	0.130	3.2656	Soil
6	10	0.076	0.760	28.6368	Soft rock
8	10	0.071	0.710	35.6704	Soft rock
10	10	0.058	0.580	36.4240	Soft rock
12	10	0.040	0.400	30.1440	Soft rock
16	10	0.028	0.280	22.8592	Hard Murom
18	10	0.027	0.270	30.5208	Soft rock
20	10	0.042	0.420	52.7520	Hard rock
22	10	0.026	0.260	35.9216	Soft rock
24	10	0.026	0.260	39.1872	Soft rock
26	10	0.025	0.250	40.8200	Soft rock
28	10	0.022	0.220	38.6848	Soft rock
30	10	0.017	0.170	32.0280	Soft rock
32	10	0.012	0.120	24.1152	Hard Murom
34	10	0.019	0.190	44.1484	Hard rock

Resistivity- Depth graph:



Analysis of result:

1. From the graph we conclude that at the depth 14 meter and 30 meter there are water zones.

2.We can get water with the help of wells and bore wells .

3.Exploration of different strata with depth .

Final result:

1. The best point for ground water is the point having least resistivity i.e. 55 ohm.

2. The water zone is at a depth 14 meter and 30 meter.

3. We can get water by well or bore well.