Experimental Physics I
Prof. Amal Kumar Das
Department of Physics
Indian Institute of Technology, Kharagpur

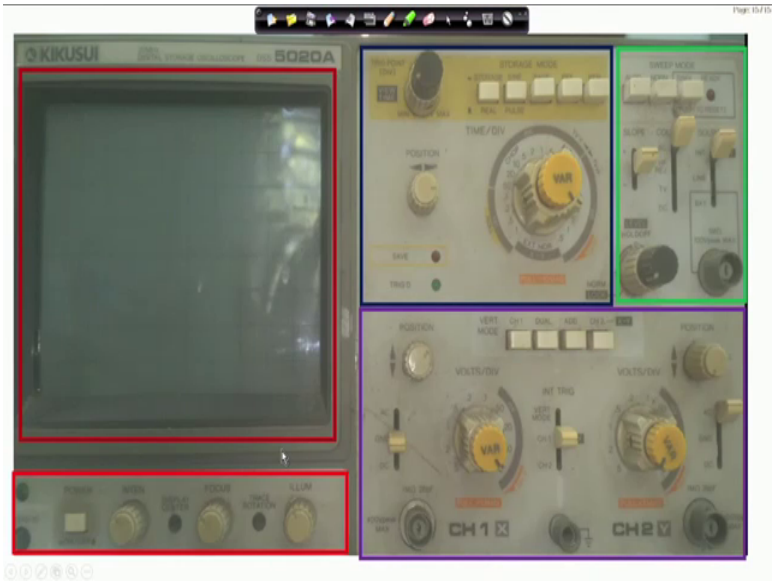
Lecture – 09
Basic apparatus (Contd.)

So, we will continue our discussion.

(Refer Slide Time: 00:30)

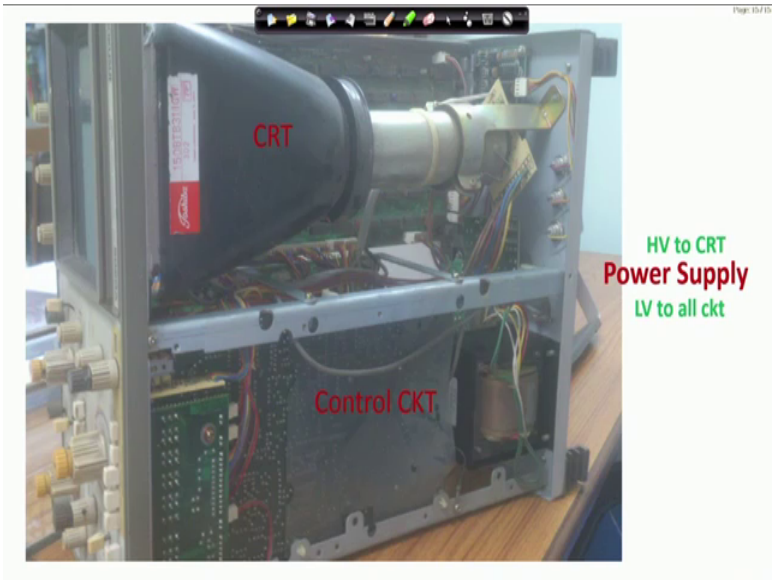
So basically we are discussing about the Cathode Ray Oscilloscopes - CRO.

(Refer Slide Time: 00:37)



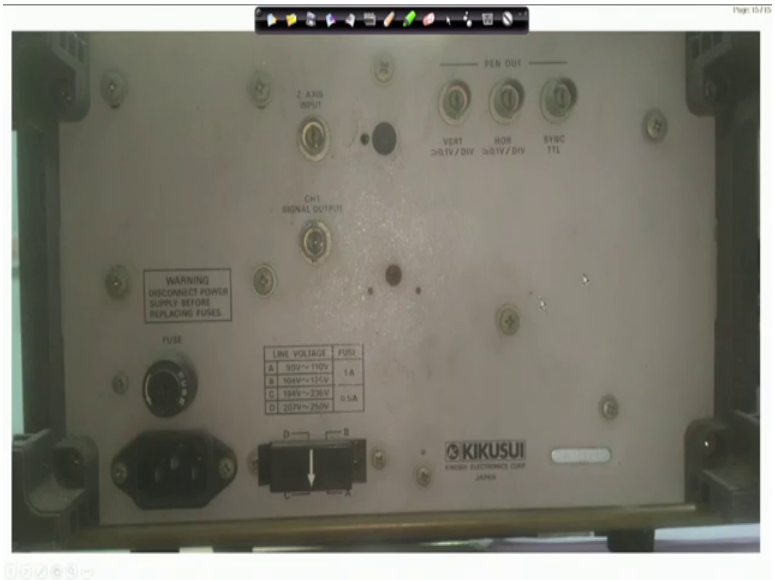
So, what we have discuss basically I have shown you CRO and I have shown you the front panel and back panel. So, in front panel as I told that there is a display screen and then display control. And other one is vertical control, and this one is vertical control and this one is horizontal control. And this part is triggering or sweeping mode sweeping control ok. So, basically what is inside that we are controlling using this front panel, so that is what I was discussing?

(Refer Slide Time: 01:40)



So, I opened this CRO, and showed you inside there is mainly two parts are there you see half portion is the cathode ray tube CRT, say it is a basically this part is display. And another part is control unit ok. So, we control this display this vertical control, horizontal control, triggering or sweeping right. And this other some part is here. So, this is the basically power supply. So, we give we have to apply.

(Refer Slide Time: 02:30)



So, in back side as I showed here. So, basically you plug in this power here. So, inside basically in this oscilloscope, we need a high voltage as well as low voltage. High voltage for this CRT, but we are applying we are giving this 220 volt, our line voltage is 220 volt, but here we need high voltage means it is around 1 kilo volt 1000 volt, and for other circuit we need a lower voltage. So, from one input, so we have to generate basically different magnitude of the voltage.

So, here you can see this I think this is a transformer. So, this for a higher voltage, it gives a higher voltage to the CRT tube. So, these are if I just open it and if this inside, so inside this main part is basically CRT cathode ray tube ok; and this cathode ray tube that is controlled by this control unit some electronics right. So, to understand the function what we have seen in front panel, so we have to know the principle of this CRT that I have discussed.

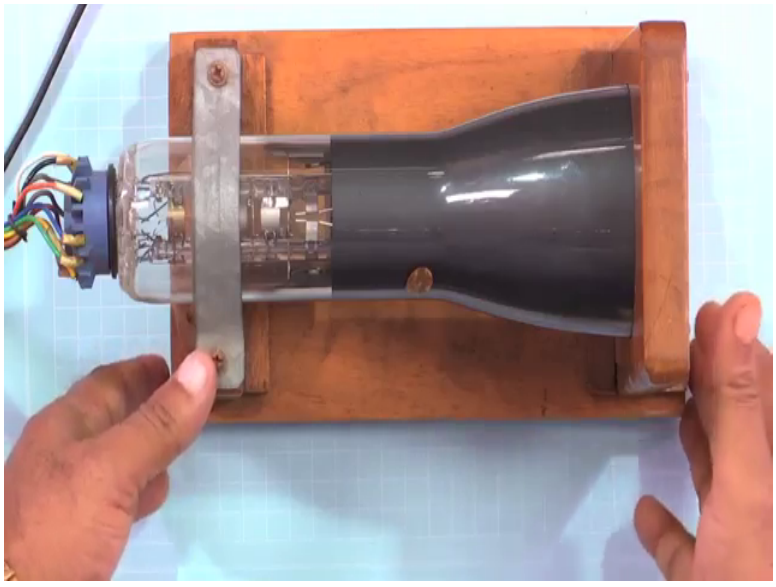
Now, whatever I have discussed that is principle how it is applied um. So, to know that one to see that one, so I will show you the CRT tube ok, and inside what is there that I

will show you. So, I will not take out this CRT tube, but similar CRT tube I have, and that I will show what are the things inside of this CRT. And we are controlling that one ah using this electronics ok.

So, I think yes. So, CRT tube is basically just to cathode ray tube it gives the cathode ray electron beam, it gives the electron. So, it generates electron beam, and it control the electron beam ok. So, to generate the electron beam, so we tell this electron gun, so electron gun basically it gives the accelerated electrons accelerated electron beams ok. So, many electrons ok, so they are moving. So, then that is beam; that beam now that electron beam, so that is manipulated ok. If I want to move this electron beam vertically, if I want to move this beam horizontally ok, so how it is done, so that is what cathode ray tube ok.

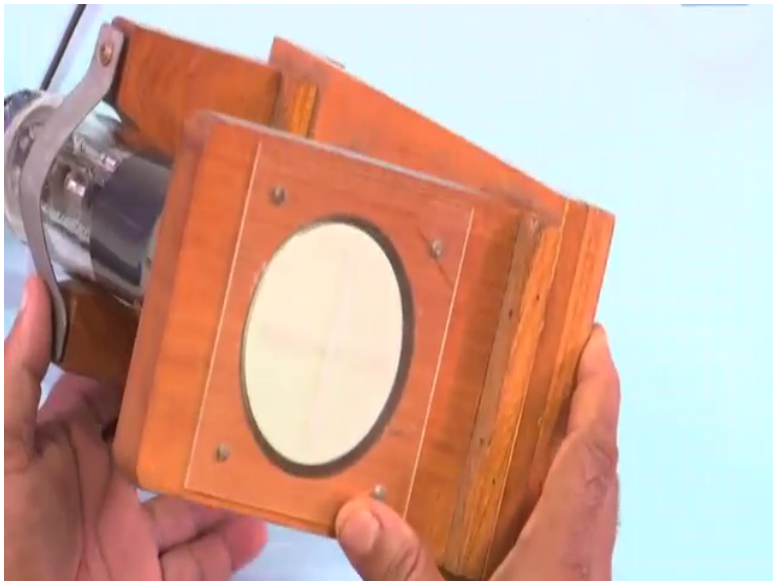
And this electron finally, will hit the screen phosphorous fluorescent screen and then it generates light and that we see the light. So, this what about light we are seeing on the screen that is basically indirectly we are seeing the in presence of electron, electron hitting the material phosphorent or fluorescent material, and it is give corresponding light we are getting corresponding light and thats what we are seeing. So, basically we are seeing the indirectly electron on the screen ok. So, this part is CRT ok. So, how it is don, so that I want to show you.

(Refer Slide Time: 06:55)



So, let us see the CRT cathode ray tube. So, here I have cathode ray. Tube this is the cathode ray tube ok.

(Refer Slide Time: 07:00)



So, it has a display and on display the screen, the scale is there you know this x scale - horizontal scale, and vertical scale ok. So, this is the display part, and this is the other part. So, here you can see here this electrical connection. And here what I need, I need to I have to get electron from where I will get I will get basically from material ok. So, from material how one can get electrons, how one can eject electron from the material? So basically you have to hit this material and material you have to take that is the lower work function of so with small energy electron will come out from this ah from this material.

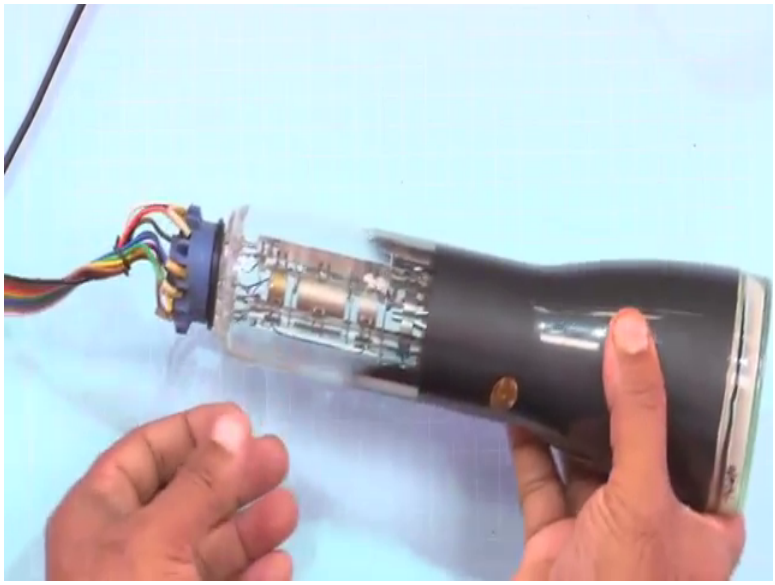
So, one part is just to generate electron, and electron will scattered in different direction you know it will not just ejected in a one direction it will scattered. So, you will get basically a scattered electron. Now, that electron I have to I have to basically focused that electron I have to focused means whatever divergence is there. So I have to make it collimated I have to make it unidirectional ok. So, focused one I want to make it diverge on this focused on ok.

So, then ah I should have a option to control the control the I think number of electrons or intensity of the electrons ok. So, for that I should have a option if I want to moved electron in the beam, intensity of the beam should be higher, so I or lower, so that control

I should have ok. So, of intensity control, then focusing of the beams then acceleration of the beam ok; so from here that mechanism should be in this CRT tube, CRT, and then I will get accelerated there.

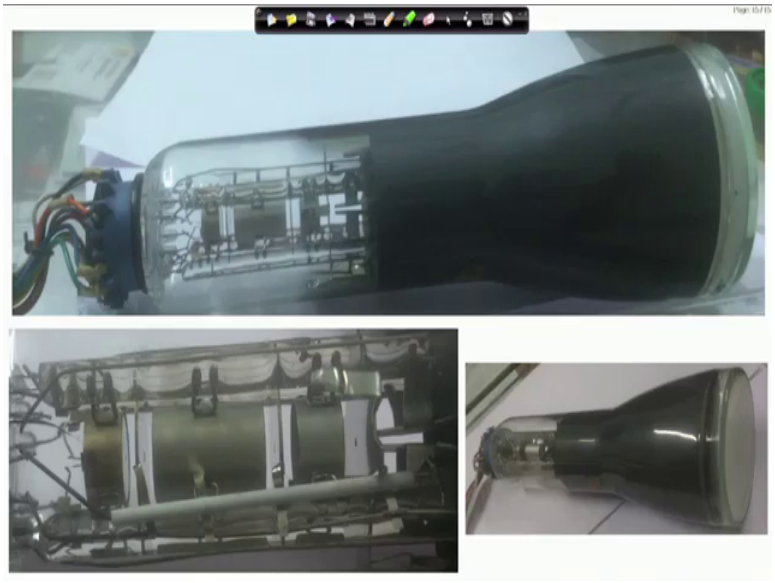
Then second part should be should have I should have this for manipulation of the electrons along the horizontal direction or along the vertical direction, so that option should be there ok. And then display part is there fine. So, let me just if I want to show you I have to open it. So, let me open it, I think it is the, so this is the use of screw driver you know since I can use so quickly I decided to open it. If you do not use you are not familiar with this one, then I think you will avoid do that, so that is why you should not have inertia so that will discourage you.

(Refer Slide Time: 10:29)



So, this let me take out. So, then I think this is the just stand wooden stand here you see. So, what is there, here? So, this you see this part, this is a one part, then second part, then third part ok. Then here you can see yeah I think I do not know whether it is it will focused it or not. So, this other part you see these the two plates are there you know. So, this is the capacitor plate. So, it is the vertical, it is vertical direction. So, two more plates are there inside that we cannot see that is basically two plates are along the horizontal direction, along the horizontal direction this is why these two plates are there, so that we cannot see. So, here can you see. So, I think the same figure I have taken picture, so here things which is clear ok.

(Refer Slide Time: 11:30)



Just check it here ok. If you see this part, this part I think I have to yes say this part you can see this is this part. So, this is basically it is generating electrons. So, we have filament, we have filament you see this, these two connection these two connection is basically for filament, and then we have cathode plate. So, this cathode plate is given some yeah I think I do not know this cathode plate is the I think we do not need any power, but to generating electron, but to accelerate the electron it is cathode ray means negative power is given. So, this is the wire have to give the negative power. This is the wire have to give the negative power. And these two connection is for these two connection is for basically for filament.

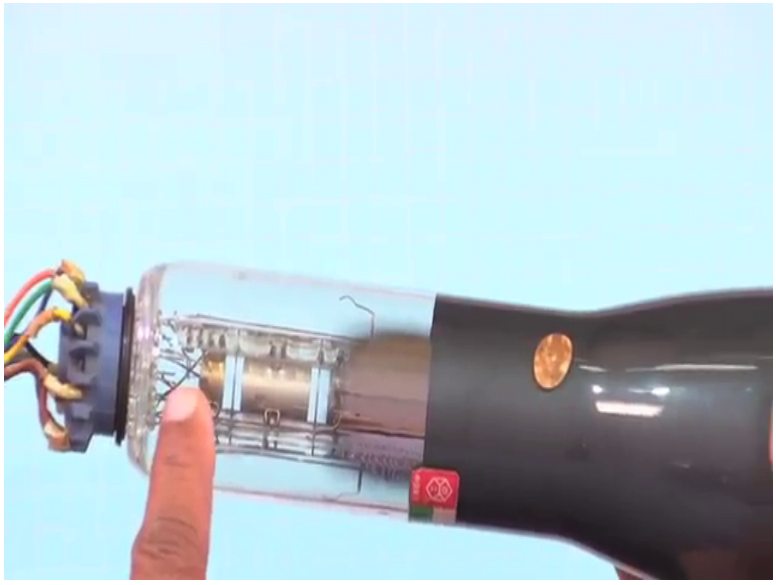
So, from filament these two connection is these two connection for filament this is the connection for this high voltage between the cathode and anode ok. So, this part is basically for generating electron. And you can see one a hole is there. So, inside here at the end of this cylinder, so there is a plate. And this one hole is there. So, this is basically grid we tell grid and then this another plate with hole, then this cylindrical part is basically for focusing, it is a lens kind of thing ok, it is a electrostatic lens.

So, basically it is the capacitor a cylindrical capacitor ok. So, if you give power here say a negative power, so when electron will go. So, whole surface will be negative all over the round, surface will be negative. And then when electron will pass through it. So, it will not go towards the surface. So, it will converse towards the axis ok. And it will pass

and then it will pass to takes another plate which having hole then it is here another yeah. So, there are different stage another hole plate is here, so that I will tell you what is this.

So, main part is just to generate electronic filament, it is cathode then grid ok. And then these are plates, so this is the of electrostatic lens cylindrical capacitor basically ok, and then it is going a different plates are there. So, these plates are basically it is accelerated in stage by stage you know. So, this voltage is not given it has directly from cathode to anode, so in between different stage. So, these plates are used for basically applying this anode voltage in different stage. So, one first part is to tell this pre accelerating voltage pre accelerating anode voltage and then accelerating anode voltage, so in that way.

(Refer Slide Time: 15:07)



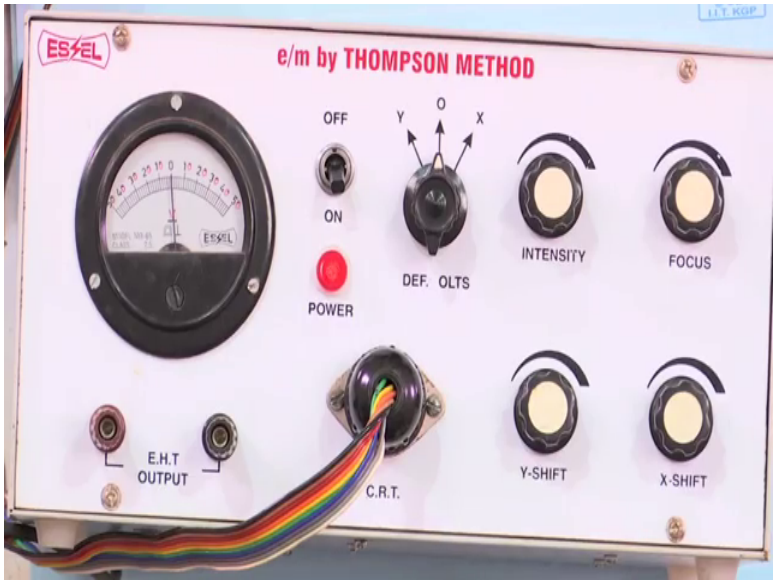
So, this let me come back here. So, this in this here also you can see you know yeah I think let me yeah so this part as I told this part is. So, this main part one is main part one is this part is for producing electron filament cathode and grid also at the end of this is the grid is there. And another main part is here focusing ok. And these plates are with hole, these are using for pre accelerating voltage, and then and these two plates here as I showed you yes inside here two plates. These are for vertical deflection. It is a just capacitor plate you know it is not parallel plate, but distance are increasing linearly.

So, there is some reason because to defect the electron around this it is with the higher range, so that is why it has not make it parallel, it has just make it this divergence one ok, so that is the reason nothing else only parallel plate you can think that distance are

increasing gradually ok. Now, I will show you. So, it is very interesting you know that is just you are you are generating electron, and you are seeing electron on the screen not directly indirectly in terms of light.

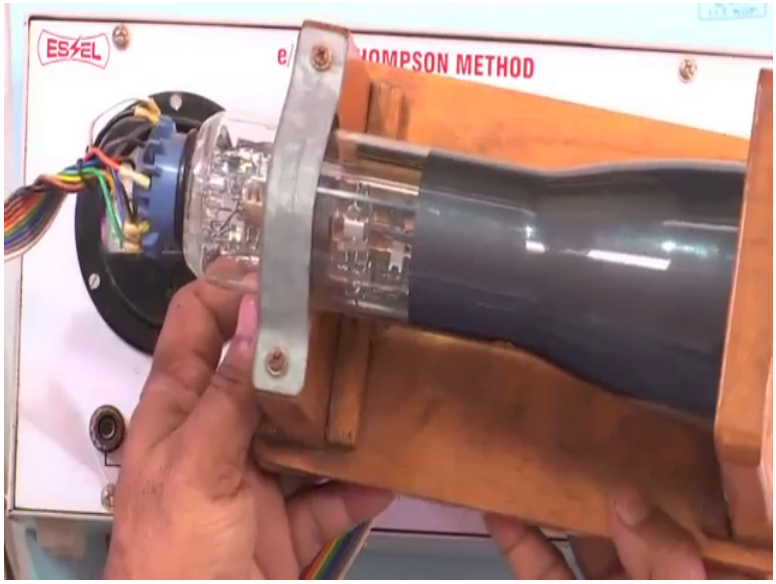
So, I will show you yes, I will show you I think now I will put back it here I will put back this one here yes. Now, I have put back yes. So, this scale is on this on this ah screen. So, I have put back now I have power supply I think I will show you power supply, I will show you power supply. Yes, I think if I want to show you this power supply I have to take it in.

(Refer Slide Time: 17:24)



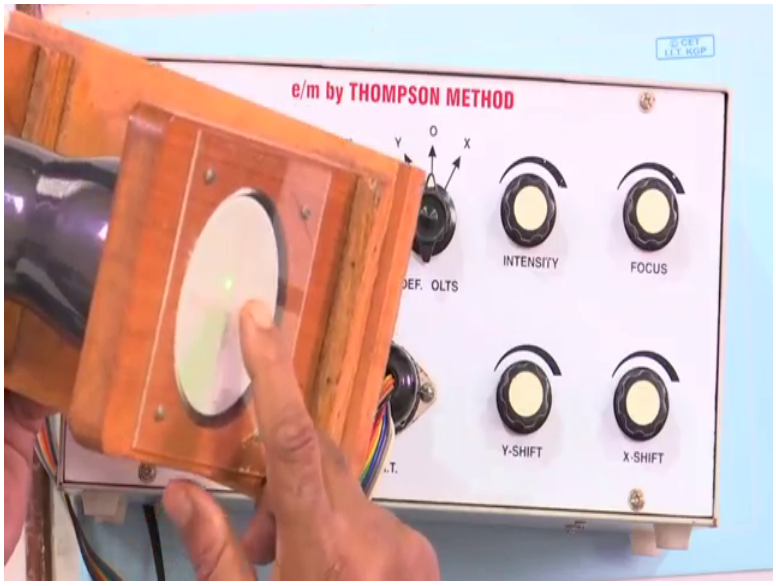
So, this is the power supply for this cathode ray tube CRT. So, it is the power CRT here written CRT per given to the CRT tube. Then what is a on off ok. So, I will I will switch on it, power is on right. Now, here this see here when I switch on, I should I should see I think I should clamp it otherwise it may. So, I should see this electron, let me just yes I think I should clamp it, and that is what and do in otherwise. It may slip and then tube may get damage ok fine.

(Refer Slide Time: 18:32)



So, I when I switch on, what I will see on the screen, it is the CRT ok. So, just I switch on. I am seeing one spot here one spot one spot on the screen, but it is not at the center ok. Now, this just using this part, using this part using this, so I should not touch, because this is a high voltage is there. So, using this part, so this a filament then cathode ok. So, this is getting power and basic power is there within x plate, y plate focus and intensity ok.

(Refer Slide Time: 19:30)



So, I am getting accelerated electrons beam which is hitting the screen at this place, and I am getting I am seeing it in terms of light. Now, as I told that on power supply you see here it is a Y-shift, X-shift means vertical control and horizontal control. Here you can see this focus at this intensity. So, I am changing this one intensity, I am changing this one. So, this intensity of the beam is you can change is it. The intensity of the beam you change. So, when I am rotating this block, what I am doing ok. So, in CRT what is happening.

So, basically as I told this to change the intensity. So, basically we are changing the voltage in grid. So, which one is grid as I told this that that ah filament and then cathode. And in front of that there is a there is a plate with hole as here you can see there is a plate with hole. Here you can see there is a plate with hole right there is a plate with hole, not this plate, not this plate. So, it is just at the edge of this. So, one plate with hole ok, so that is basically grid.

Now, you imagine if in grid if I apply negative voltage, so electrons whatever coming eject getted getting ejected from the cathode, so that electron will not come forward ok. So, it will field retard it. If I apply positive voltage, now electron will be accelerated ok, it will come towards that plate and passing through this holes ok. So, if I apply more and more negative voltage, I can decrease the number of electrons passing through these hole. If I increase the higher volt positive voltage and in giving higher and higher voltage, so I can increase the number of electrons passing through the holes, so that way we control the intensity of the electrons means intensity of light.

So, that is what here I am rotating knob here, I am rotating knob means I am changing the voltage at the grid ok. So, this is the intensity and that focus as I told this that cylindrical part is there ok, cylindrical part here you can see the cylindrical part is there. So, this is basically lens electrostatic lens. So, it is a voltage is applied to it is a like capacitor plate, you know it produce electric field. Now, electric field is the basically it will produce electric field, radial electric field. And this radial electric field is outside it is a this surface is basically negative charge. So, then electron will not go towards the surface, it will go towards the axis of this cylinder. So, thus all electron going towards the axis of the cylinder. And then there is a hole you see so they will pass through this hole that way I am converging focusing the electron.

So, here that ah this focusing part as I think intensity I have to increase intensity I have to increase. Now, focusing this we are making hard for you know or it is the it is you see this now focusing it will be very nice point ok, so that is the basically focusing control. It is focusing of the electron beam. So, this when I am rotating this knob what I am doing I am just changing the voltage of this cylindrical capacitor nothing else.

Now, X-shift, Y-shift, as I showed you this here I can see only vertical part, only I can show I can see this these two plate capacitor plate is vertical and horizontal that two are there, but it is a inside that I cannot see. I cannot show you. So, in figure also this is nicely you can see this part ok, figure this is the two plates,fine. So, and here also here also you can see it is here, you know these two plates as I showed you yes these two plates ok, this is a vertical plate.

So, similar horizontal plates are there inside horizontal plates are there. Now, I am basically here we are. So, Y-shift means is a voltage is given to the vertical plates and X-shift means voltage is given to the horizontal. So, I am changing this one. If I change say it is a Y, so it is going towards vertical you see, but it is not. So, I have to rotate it I guess I have to locate, yes, it is now still slightly more I have to yes, let me check it you know, the opposite direction I have to just rotate to align with the scale to align with the scale, yeah now it is vertical more or less ok.

So, here actually when I am rotating this knob, what I am doing I am just applying the changing the voltage in the vertical plates. So, now, we see the importance of the capacitor plate I showed you ok. Two parallel plates just two piece of parallel metal plate when they are separated, and if we apply voltage we can generate electric field ok. So, that that whatever I showed this component it is a this principle is used here ok.

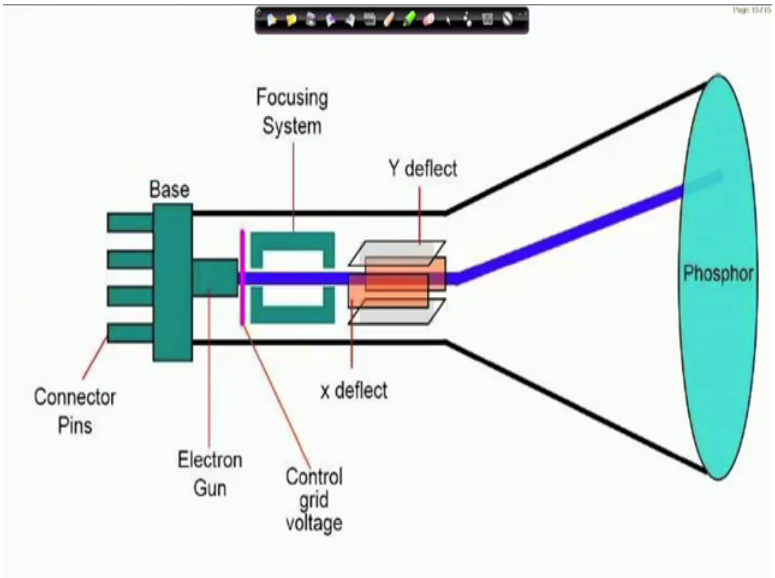
So, if we are not familiar with the with this kind of components whatever we learned from our definition ok, so you cannot think of using ah in your in your instrument whatever you want to design or whatever you want to plan. So, this is a nice application of this parallel plate capacitor you know so which is producing the electric field. And because of this electric field I am able to just change the position of the just I can change the position of the electron beam along the Y-axis ok. Similarly, along the X-axis I can change ok.

So, this nice demonstration how to produce electron beam accelerate electron beam how to see it, how to how to deflect it ok. So, using the electric field we can deflect. So, this is simply this so some force acting on this on this electron beam right which force is acting, so the Lorentz force. Lorentz force F equal to q into charge, q is charge into e electric field plus b cross v is velocity of the electron b is the magnetic. Here magnetic field is not there, electric field is there. So, using electric field I can shift it. Using magnetic field also because here accelerated here accelerated electron beam right electrons are there. So, they are moving with some velocity.

So, if I apply magnetic field, then also I can deflect ok. So, using electric field, using magnetic field, one can deflect the electron beam ok. So, here I showed you the using the electric field, we are shifting this electron beam. So, here just I will show you quickly this using magnetic field also, one can I have bar magnet let me let show you let me. So, this is the bar magnet right, this is the bar magnet I think. So, I have a beam to show you it has come ok. Now, can you hold this magnet, just two magnet and change the direction I think you have to come here, yes, just apply two magnet I think I have to show student yeah just apply magnetic field you hold it ok. Yes, you see just you can shift; you can deflect the electron beam using the magnet also ok.

So, just simple demonstration I gave you using the electric field or a magnetic field this ah electron beam we can we can deflect the electron beam. So, this is the basically demonstration of this CRT. So, what is there inside and I think I will switch of this one.

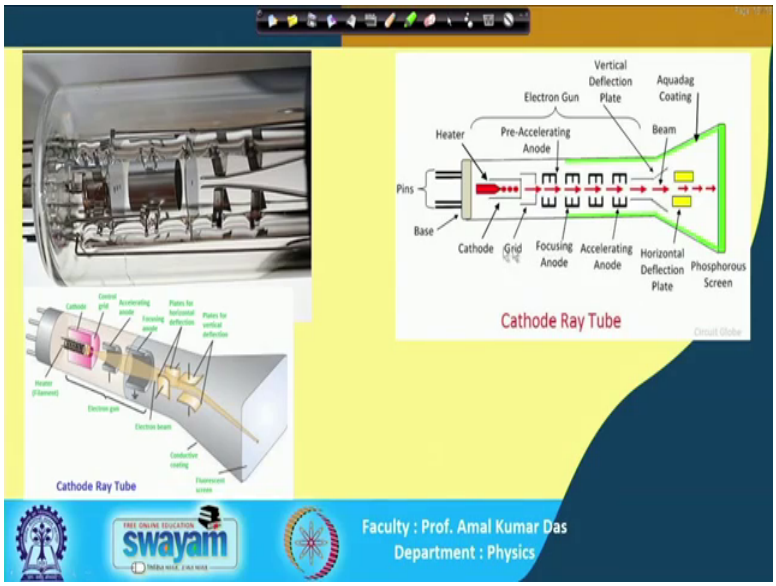
(Refer Slide Time: 29:35)



So, it is a very nice demonstration one can learn many things. So, this as I told this it has in picture. So, main part is focusing, and then this electron gun giving the electron, and then focused electron, then y deflection, x deflection right as I different part as I showed you.

(Refer Slide Time: 29:56)

(Refer Slide Time: 29:59)



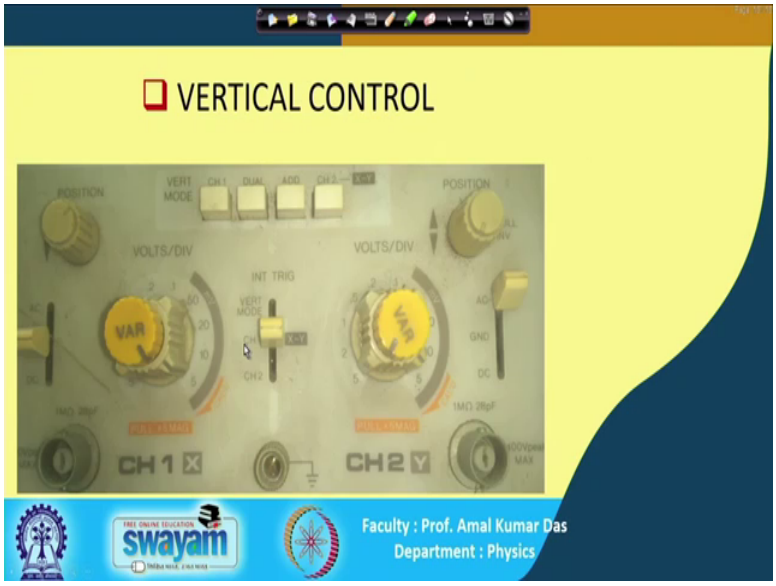
So, more details it is not that simple slightly there are some as I told that this is the filament, and then this is the cathode ok. This grid as I told this grid in details I think it is a ok. This is the grid right, this grid as I told. And then these are focusing anode and this you see this one this plate with hole as I showed you plate with hole, plate with hole these are basically pre accelerating anode ok. So, anode voltage is given step by step.

So, pre accelerating anode say then accelerating anode. So, whatever this plate with hole we are using. So that is basically it is the stage wise anode means we are giving the positive voltage higher and higher and higher. So that way we are changing giving voltage in different stage and electron is passing through these holes of this plate ok, so then it is going. So, we are getting beam and it is going to this ah hitting the screen and this is the plate horizontal plate. And this is sorry; this is a vertical plate this is the horizontal plate. So, everything except this deflection a horizontal deflection plate, I have shown you in the pitch in the real tube.

(Refer Slide Time: 31:23)

So, this you see display in front panel you have seen the so this is there. So, intensity not it is now I have come back to CRO. So, in CRO in front panel what is that this is a one part, display screen and display control. So, intensity knob is there then focus knob illumination that is different, illumination just to illuminate the screen so some separate arrangement is there. So, if we forget that that one, but here changing with this is not focusing and this intensity is changing the intensity right.

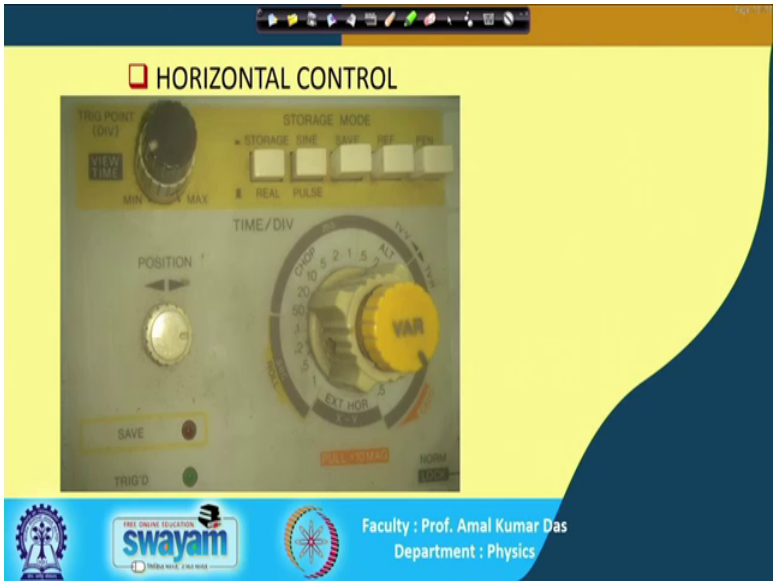
(Refer Slide Time: 32:02)



And then another vertical control as a vertically this, so we are changing the position of the electron beam right. So, we are applying basically voltage and they have voltage is calibrate with the scale, so that you can change this ah scale. So, voltage per division it is given here voltage per division. So, when you are rotating. So, here this two are two are there. So, basically just forget another one another one is same. So, here this ah this we tell channel ok; So that means, in y plate vertical plate, we give the signal using this using this ah connection ok.

And here you see position here written position ok. So, vertically whatever I showed them in CRT tube, vertically we are we are changing if you changing the voltage ok. So, if you give signal, so the way signal voltage in the signal will change, so that will that will be the plate voltage ok. And that how so depending the magnitude or peak value of this signal, so here you can take the change the scale ok.

(Refer Slide Time: 33:37)

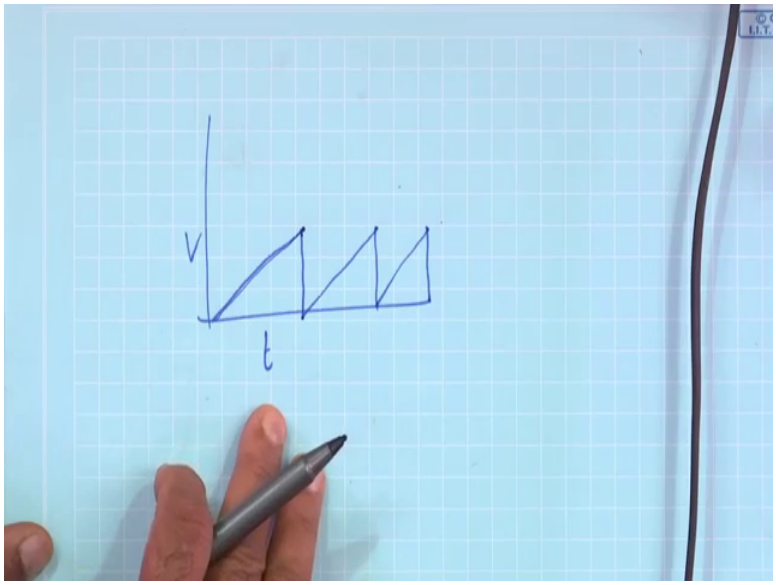


So, that is the y direction or a vertical direction. So, one can control the volt along this direction so through the vertical capacitor plate. Similarly, this is the horizontal control in a y plate horizontal plate. So, here this is this is basically in this plate. Again we are changing the voltage, we change the voltage, but we are changing voltage in scale of time you know.

So, in y plate we are changing the voltage ok, and here we are changing the time basically, but capacitor plate will not understand time. So, we have to give voltage scaled

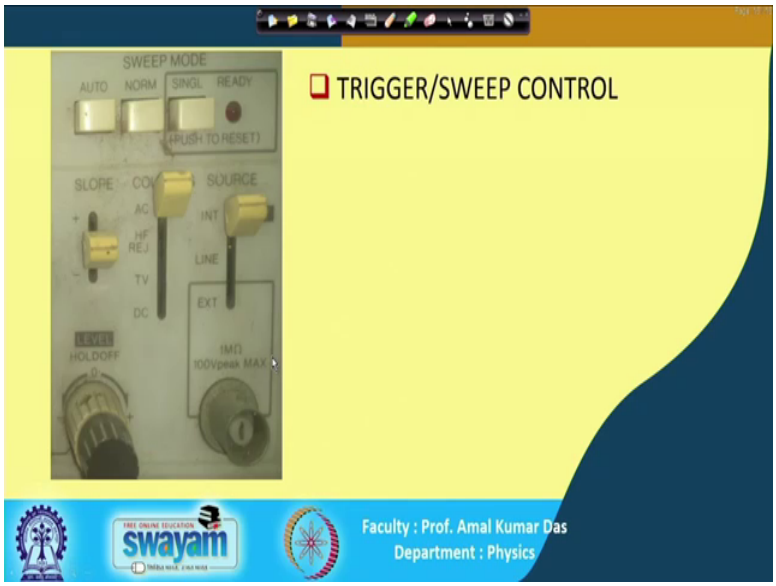
with time. So, how we can do? So, if voltage changes linearly with time, so that type of signal if we give then this is basically you can voltage you can calibrate with time or time can be calibrated with the voltage. So, that is as that type of signal is given to horizontal control horizontal plate. So, that is basically this ah is a saw tooth kind of saw tooth kind of waveform or signal is given to the horizontal plate ok.

(Refer Slide Time: 35:13)



So, saw tooth, saw tooth means this type of voltage. So, I think this voltage change linearly and then come back linearly come back linearly come back ok. This is voltage this is time. So, it is a linear relation you know proportional. So, s that means, you are scaling time with voltage or voltage with time. So, whatever the voltage is change in the horizontal plate, so that you can take as a change of time ok. So that is why it is the so you are changing here whatever in terms of time there basically that you are changing the voltage in y plate ok.

(Refer Slide Time: 35:56)



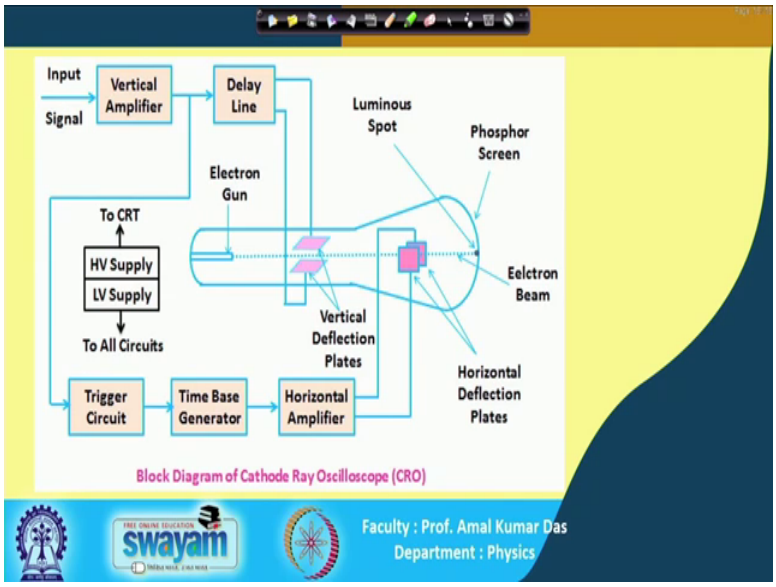
So, this is the part third I think last part is triggering and sweeping. What is that? It is the you see x scale, x, x-axis is the time ok, and y-xis is the voltage of your signal now signal is given to the y plate ok, but in x plate voltage we are giving that in terms of that is a time separately. Now, these two we have to synchronize right. So, say problem is you see this time that scale is changing very slow, and then your voltage that signal is very is a fast ok, so then you cannot so it is difficult to see this waveform or this change y scale is change very fast ok, but these voltage change is very slow ok. So, that we have to we have to synchronize ok. So, we have to match with these two because from different source it is coming. So, we have to match it.

Another things is that so when this sweeping will start in this x axis and when this signal will start to enter ok; so this two it may not be synchronized ok. So, we have to make sure that when signal start to enter, so that time the sweeping should start ok. So, sweeping already started and then signal is in then, then there are problem ok. So, we have to so that is that is called triggering, basically when signal is entering that y scale deflect this y sorry x scale it should know then it should know then so that it can start immediately that time same time ok. So, that is basically triggering.

So, this details things are there and that triggering that is given to different externally it can be given internally it can be given or from line ah power also one can take it. So, this in detail some other so some functions are there ac dc etcetera. So, main things I

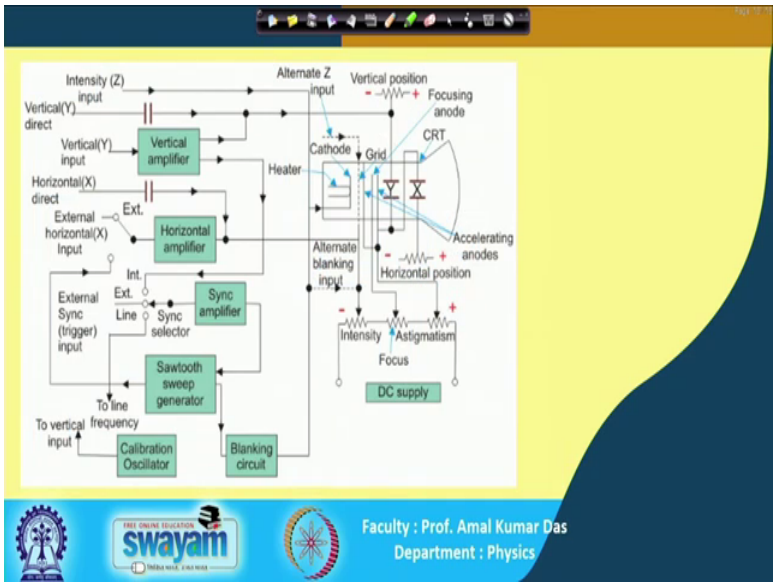
discussed this you will learn when we will use in lab during the experiment. So, at a time if I tell everything so it will be confusing. So, these are the so whatever if in front panel we are doing basically inside what actually is happening inside what is getting changed so that one should know I think from this learning I think now you should be able to realize actually rotating knob inside what is happening what you are doing basically so that you should understand.

(Refer Slide Time: 39:12)



And, so in detail circuit is just here I have shown. So, from internet I have taken these pictures. So, I should acknowledge ok. So, this is whatever I have discussed. So, in details inside that circuit on to a circuit was there.

(Refer Slide Time: 39:31)



So, more details even it is a more details are here. So, I will not discuss much, but already I have main things I have discussed.

(Refer Slide Time: 39:39)

So, last part is what we have learned is it only we learn this CRO cathode ray oscilloscope, and we will use in our laboratory for experiment only this we learn or something else huh? So, whether this knowledge whatever we learn today whether this knowledge is applicable to other application? Yes, you see how x-ray generated, how ion beam is generated ok. So, these two ion beam so accelerator very big accelerator you see

if you want to electron beam here, cathode ray tube is giving electron beam accelerator electron beam, if I want to get accelerated proton beam, if I want to get accelerated ion beam means ion of silicon ion of say cobalt etcetera ok. So, this we can we can get this accelerated ion beam. And for that this big accelerators are there and this ion beam accelerated ion beam is used in the mainly in different purpose.

So, one purpose is for implanting some foreign metal inside a some other material ok. So, implantation is very important for p-type, n-types semiconductor producing p-type, n-type fabricating the semiconductor ok. And X-ray machine we have seen X-ray is very important and in hospital ah X-ray machine is used to take the pictures image of these our bones ok. So, this X-ray machine how X-ray is generated there. So, basically they are the same principle accelerated electron is hitting here screen their accelerated electron is hitting a material target material and then from that target material this X-ray is emitted. So, it is the same principle ok.

Here it is hitting the display means target, so its light is emitted from there, but if you use the higher energy electrons. So, then this target material will not emit light it will emit X-ray. So, the same principle is used in for generating X-ray and higher version of this X-ray machine is basically synchrotron very big machine and very useful for research an[d] yes. So, this so this is the additional application, you will understand if you understand the principle of CRO, CRT, ok, not (Refer Time: 42:32) CRT.

Thank you for your attention.