**Industrial Instrumentation**
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**Lecture - 26**
**Nucleonic Instrumentation**

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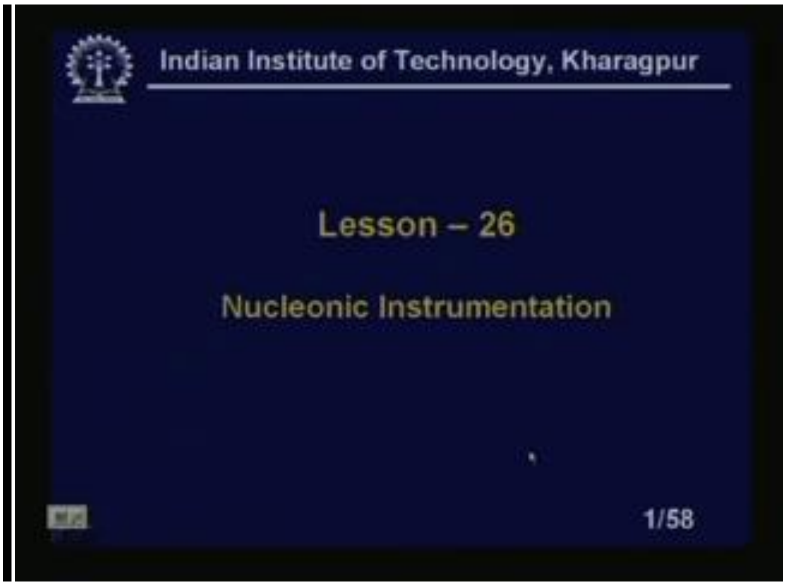


Welcome to the lesson 26 of industrial instrumentations. In this lesson basically we will covered a nucleonic instrumentation. Let us look at Nucleonic instrumentation means that we will use some radioactive sources and there will be corresponding detectors. And there are some advantages of this of this type of instrumentation, because we have seen that the in the in the lesson 25 we have covered a ultrasonic instrumentations. So, there are some typical advantages of the ultra sonic, but there are some cases like if you want to launch those ultra sonic waves the air it is just impossible where the radioactive rays can I mean move through earth that is the great advantage of this particular instrumentation. So, it is to be covered very extensively. Let us look at the contents of this particular lesson.

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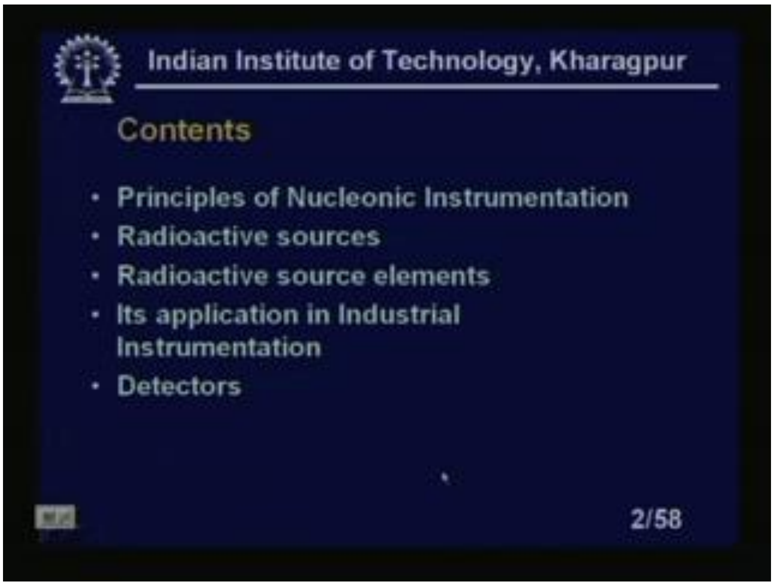


Contents: Principles of nucleonic instrumentation, radioactive sources, radioactive source elements, what are the different elements which will I mean which will make the radioactive sources? Basically radioactive sources means alpha beta gamma rays but what are the elements which will actually used for used actually used in nucleonic instrumentation? That we must study. Its application industrial instrumentations that you find the label gage there is typical applications of the measurements of the level then typical applications of measurements of the coating of shades and the rolling mills.

So, that various applications will find in this particular types of instrumentations. So, that you will cover in details all the different applications we will see then detectors what are the different detectors used in this type of instrumentation nucleonic instrumentation? Then also even though its little diverts us will cover the nuclear medicine, because the nuclear medicine also uses some detectors, some sources and some detectors which is very similar. So, there is some instrumentation there also, so we will cover in these under the head of nucleonic instrumentation will also cover the nuclear medicine.

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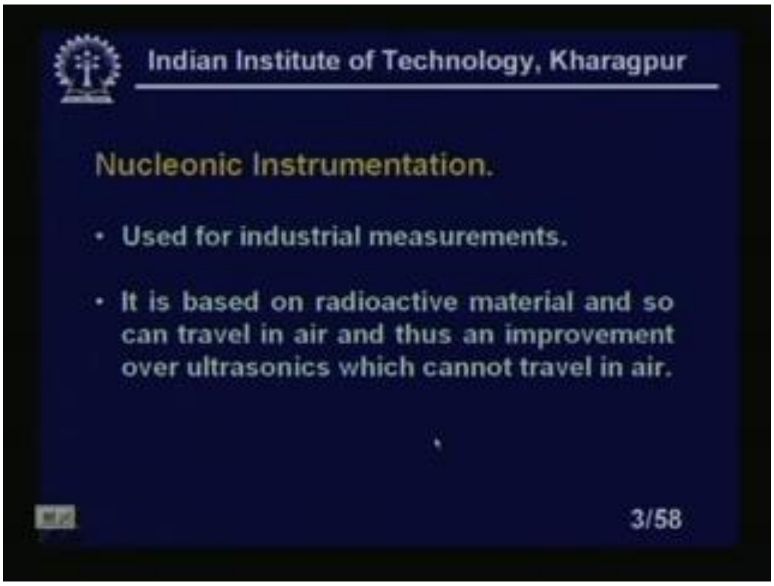


Now, nucleonic instrumentation looks like this. Used for industrial measurement it is based on radioactive material. So, can it can travel in air thus an improvement over ultrasonic's which cannot travel in air we have seen that if you launch the try to launch the air ultrasonic's waves in air it is almost impossible. And we have seen that in the cases like if I want to travel I mean using this particular pitch we made the level gages also. Because when the when the when the ultrasonic waves are traveling through waters and it is when its reach the top surface it is almost I mean negligible portions will be transmit in the air most of the portions will be reflected back from the top surface.

So, using that principle we made the level gages we have seen that thing. But this disadvantages also, because in many situations we may need to measure the, I mean we want to transmit the signals, because all these signals all these particular method. That means, ultrasonic methods or nucleonic instrumentations or non-invasive type of techniques. So, in some cases if I want to I mean launch this rays through the air it is impossible in the case of ultrasonic, but it is possible through the nucleonic instrumentations or radioactive sources.

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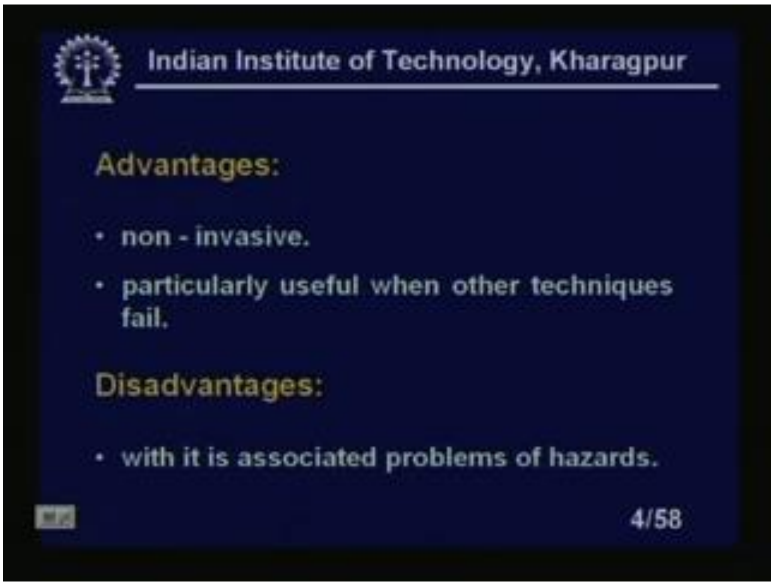


Advantages is non-invasive we have seen that this non-invasive are just I right now, I told it is non-invasive techniques. Particularly useful when other techniques fail in many situation will find that the other techniques will fail, because you will see the radioactive sources have some hazards unlike other sources. If I use any other conventional sources I mean if you use then radioactive source also always saturated with some hazards until unless it is justified that we have to use nuclear instrumentation. Nobody will allow you to use electronic I mean sources and detectors. Disadvantages; first of all with its associated problems of hazards as I told you.

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In application; let us look at density measurements, thickness and level measurements. This is the basic 3 measurements we will do; that means, density of a liquid you can measure, thickness of the surface we can measure, thickness of a coating suppose walks on a paper. That will also we can measure suppose very common examples we are telling that we had a stitch at record at almost all of you know. A stitch at record as used extensively in instrumentation, so it is even though we can make the data equations I can we can stored in a computers, but always people wants some hot copy also. So, if you want to store that type of signals suppose, I am I mean recording a signals of temperatures over 24 hours time with sampling of 10 minutes at every 10 minutes I want to record that signal that temperature on a strip chart recorder. One of the method is that you use that strip chart recorders, the thermal style as where thermal style as we move and the recording it looks like this.

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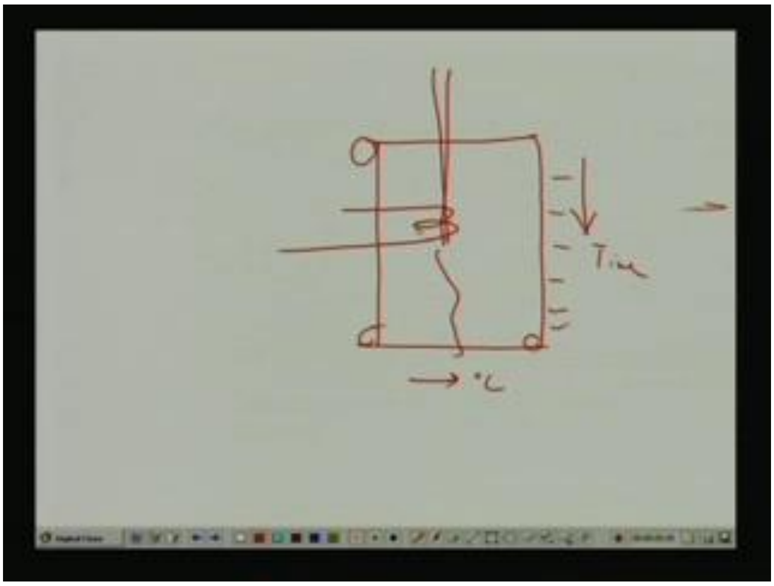


That means you see that, if I have a let we take a blank page. So, I have a strip it is moving right, so the style is coming down here. So, I am getting impression over this 1, so this in time and this is in temperature take this centigrade. So, I will get a temperature at any time what is the temperature of the particular process that can be viewed from this particular impression. So, they are at ink style as ink as a problem, because we have to refill every time. So, all this cassettes are also is there, but instead you if you can do that this entire strip entire piece of paper that is which is rolled here roll unrolled here. It is coming down in this direction. So, what will happen? You see that A impressions will, because if this is blackened this paper or some other color and coated with wax. These papers if it is coated with wax if this paper is coated with wax. So, what will happen?

You know that it will once if it is heated this suppose this style is heated then this style is heated. Then what will happen? You see this will give an impression, because the wax will melt up and it will give the impression from which I can record the temperatures. This is the one of the method I mean one of the applications of the instrument of the strip shot recorder in instrumentations. And, so they are the precisely I have I have to control the thickness of the wax coating over the paper. Uniformly you have to go it should not very thick, because it should be very thick then this hard style as cannot give an impression if it is very thin that might be useless to us. So, those precise I mean precision I mean coating we have to use. We can use a nucleonic instrumentations are method of measurement of the thickness.

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Humidity of grain is another method. I mean another examples of the, because in the grain if this always to store it. I need some particular humidity that is to be maintained for the good preservations of the grain. So, that measurement of humidity in the grain also can possible through nucleonic instrumentation. Determinations of material composition true detection. So, what is material composition? That can also be detected is possible through the nucleonic instrumentation, leak detection. That means, if there is a leak in the pipe and all those things; that can also be detected especial in underground pipe.

It is very difficult to know where the leak is it is possible to record through it is possible to find through nucleonic instrumentation. Also determinations of age of archaeological samples, because you see many Indians I mean our is a great country. Find that many places are old sculptures old I mean things are coming up I mean there are many sculptures are coming up right with my 2000 years old might be more than that. So, to know this age of this particular sample, we need some I mean some sort of radioactive sources and detected techniques by which I can tell you the age. So, there is another application though it is not much of industrial instrumentation, but this is another application are nucleonic instrumentation.

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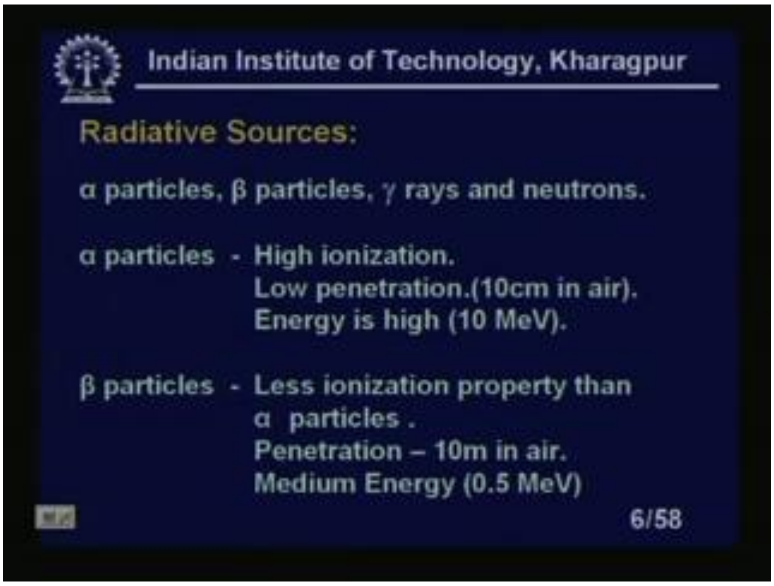


Now, radiative source or radioactive source, so this should be actually I should say radioactive source instead of radiative source. These are alpha particles beta particles gamma rays and neutrons there are 4 basic. And I mean there are some advantage and disadvantage of this particular method. So, we have alpha particles beta particles gamma rays and neutrons. Now, alpha particles it is high ionization. It will ionize a gas through which it will pass. Low penetrations only can it can pass 10 centimeter in air energy is high. That means, 10 and in electron holes which is quiet high suppose to be quiet high. Beta particles; it is less ionizations property than the alpha particles. It is penetration is much higher 10 meter in air and its energy is medium energy. So, .0 .5, so you can see that its energy is less.

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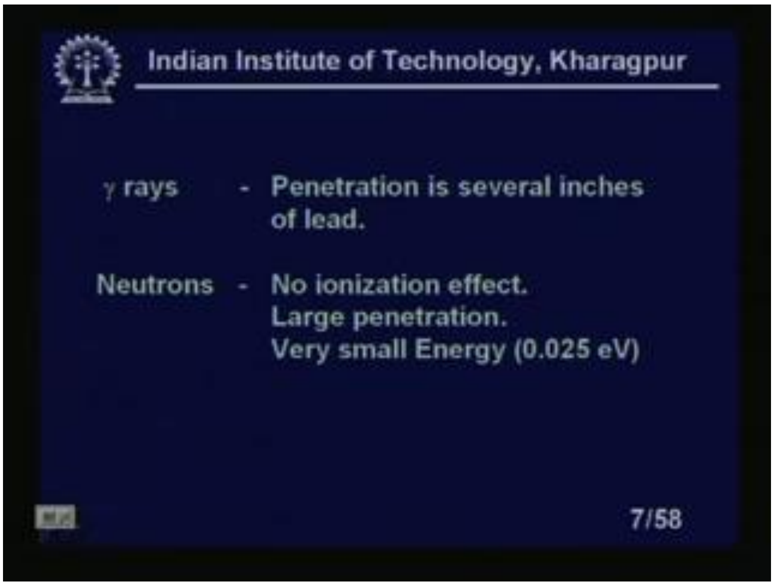


Then gamma ray is its penetration is several inches of lead, because lead is very difficult to penetrate through any other alpha beta particles will not penetrate through lead. So, that only the gamma rays can penetrate several inches, but if we use thicker lead gamma particles also cannot penetrate through it. Neutrons neutronic I mean neutrons has different source it has a no ionization effect. It has large penetration and very small very small energy 0.0 0.025 electron volt; you can see that how less it is.

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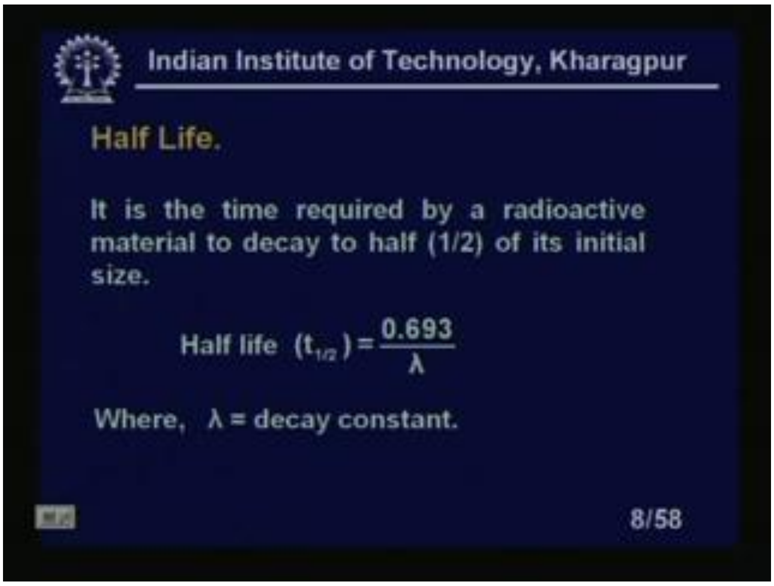


Now, half life it is a very I mean common form of I mean it is called parameters. Whenever you use you were using in a radioactive sources you must be aware of this half life period. Sometimes we need shorter half life period sometimes we need larger half life period. It is a time required by a radioactive material to decay to half of its initial size. It is time required by radioactive material to decay to half of its initial size. Mathematically it is I mean defined as half life equal to t 1 by 2 equal to 0.693 by lambda while lambda is decay constant.

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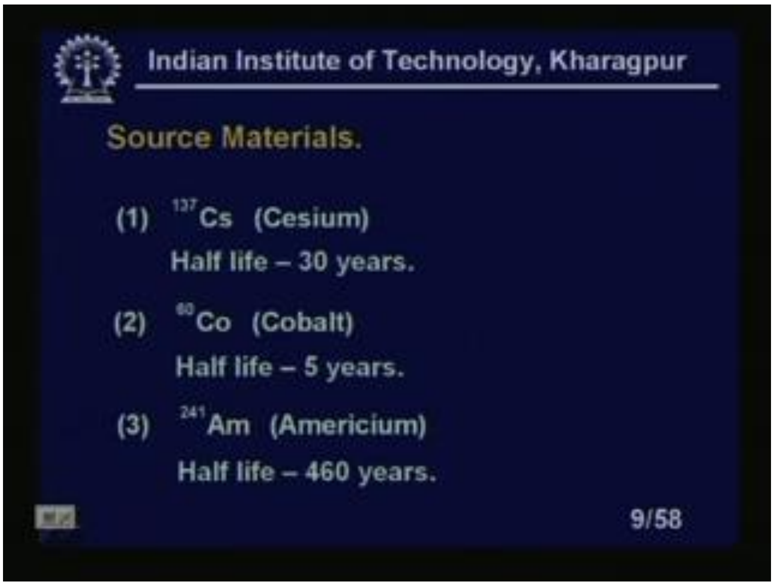

Now, source materials what are the different sources of this alpha beta gamma rays and neutrons? Let us look that. We have cesium 137 it half life is extremely small 30 that is problem we all of you are aware of the radioactive sources half life is extremely high. So, it will continuously it emit all these rays which are some of the rays are harmful to the human body. So, obviously, it will ray for 30 years half life is 30 years. Cobalt 60 half life is 5 years. Then we have americium 241 which is half life is 460 years is extremely high you can see.

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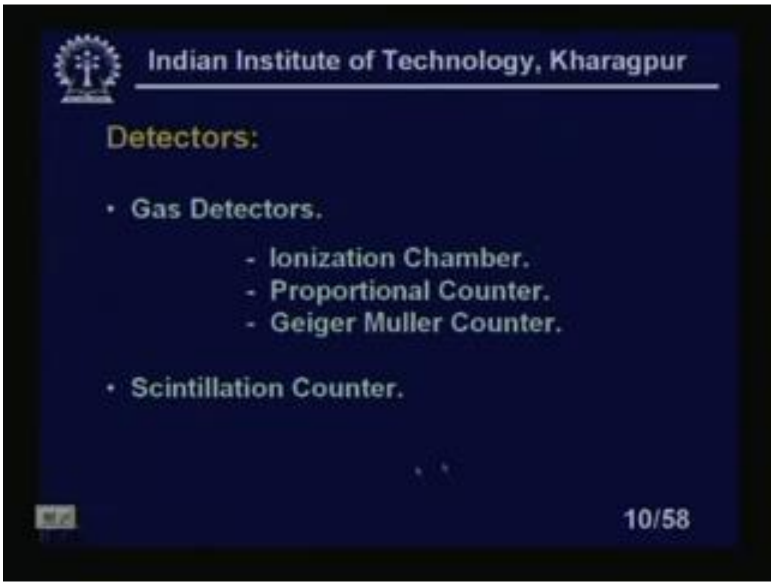


Now, detectors there are different sort of detectors we will use in instrumentations. In disturbance instruments we will slowly detect we will slowly explain all this 1 by 1. We have gas detectors gas will be ionized; that means ionization chamber; because once the gas is ionized I can say how much the ray is. Because if the rays passes through some I mean body; obviously some of the rays will be loosed and we will get some rays accordingly I can calculate. Then the proportional counter all these are basically gas detectors. Then we have Geiger Muller counter.

Geiger Muller is a basically German names there I am not writings. So, it will look like this. So, Geiger Muller counters, so we have a scintillation counter its pensively slightly different of the gas detectors I mean scintillation counters will discuss all these things in details. We have solid state detectors this basically solid state detector we will see what is the PIN junction diodes? We will see that 2 p and n junction in between 1 entry in junction will come. So, it will make a solid state detector.

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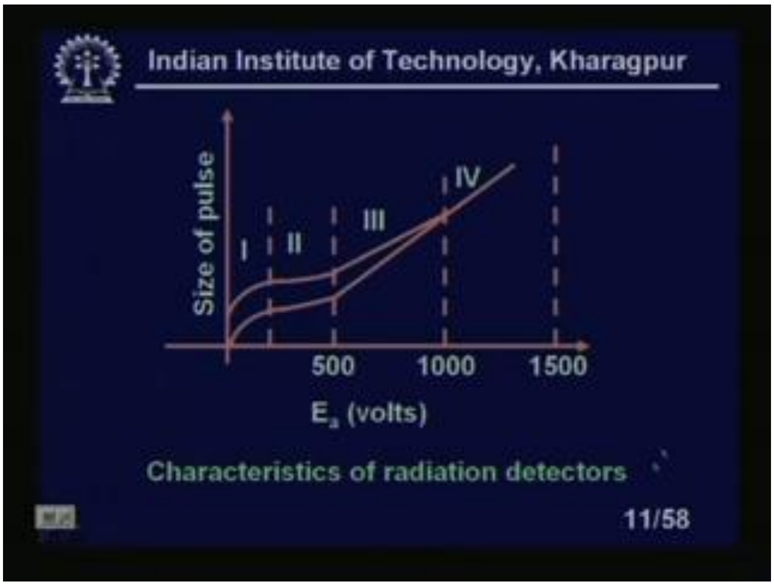


Now, this is a characteristic of radiation detectors. You see here its characteristics of the radiation size of the pulse and are it I mean volts you see that is different region, which region will utilize to which that we slowly avail to us.

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The gas chamber operating in the different regions are region 2 and ionization chamber region 3 proportional counter region 4 Geiger Muller counter.

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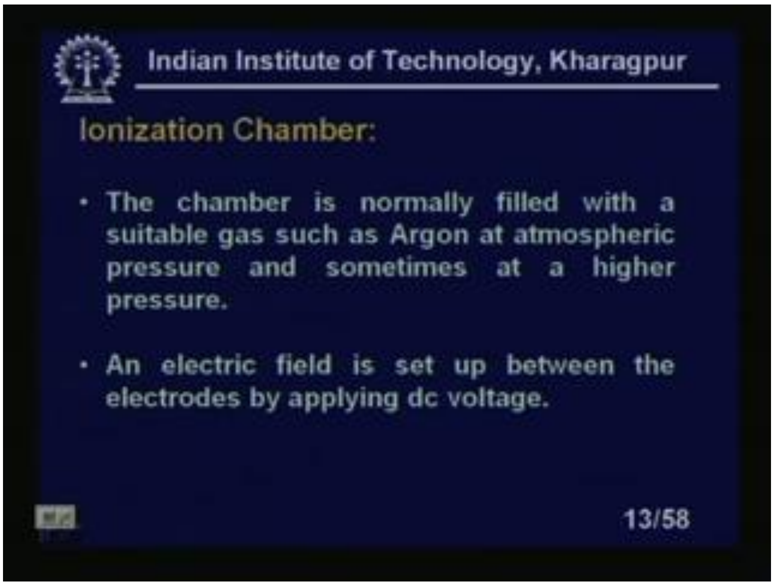


Ionization chamber; you see here the chamber is normally filled with suitable gas such as argon at atmospheric pressure. And sometimes at a higher pressure, it is always you can know this very in hot gas. So, the chamber is normally filled with suitable gas such as argon at atmospheric pressure and sometimes at higher pressure. An electric field is set up between the electrodes by applying dc voltage. An electric field is set up between the electrodes by applying dc voltage.

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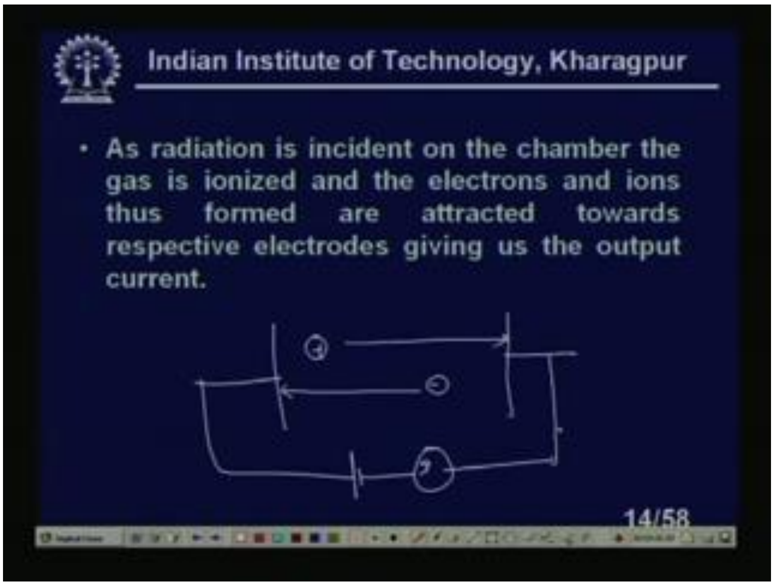

As radiation is incident on the chamber the gas is ionized. Obviously, and the electrons and ions thus formed are attracted towards respective electrodes giving us the output current, is it clear? Suppose I have we have discussed the ionization gages not yet the in the case of low pressure measurement. So, same basic principle is saying actually you see look at here. I mean if I have this 1; if I take this pen I have see gas is ionized suppose these are the ion getting a suppose I am putting a meter here 2 plates. So, the positive ion supposes positive ion will move this direction negative ion move in this direction. So, resulting some current which will detect by ammeter. So, how much current I will get that will be proportional to the ionization? The more the gases ionized I will get more and more current and the gas will more. And more ionized if there are more number of particles comes and fall on the chamber clear?

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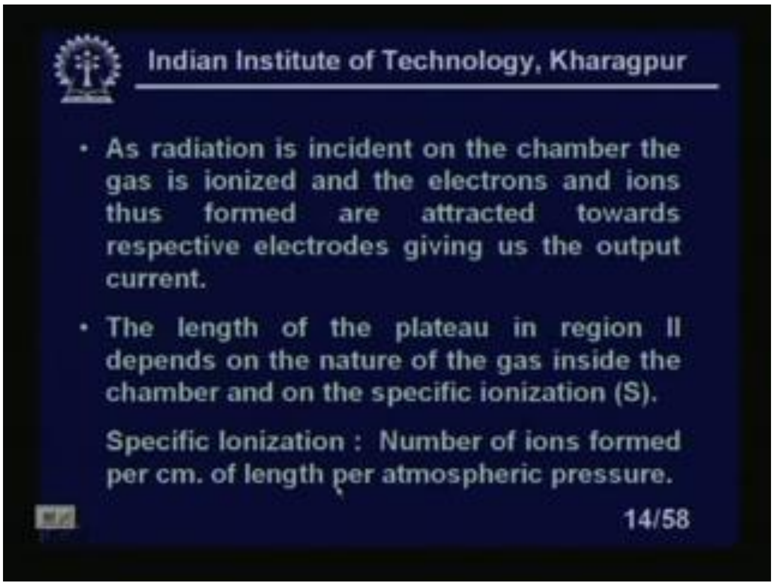


The length of the plateau in region 2 it depends on the nature of the gas inside the chamber and on the specific ionization. Let us go back let us length of the plateau you see here this is also we can refer we can go back to our origin discussions. So, the length of the plateau in region 2 depends on the nature of the gas inside the chamber and on the specific ionization. So, what type of gas is there? That is one factor and what is the ionization specific ionization work it depends on these 2. So, the length of the plateau will be there. A specific ionization is the number of ions is we have defined the specific ionizations. What is the specific ionization? Number of ions formed per centimeter of length per atmospheric pressure number of ions from per centimeter of length per atmospheric pressure.

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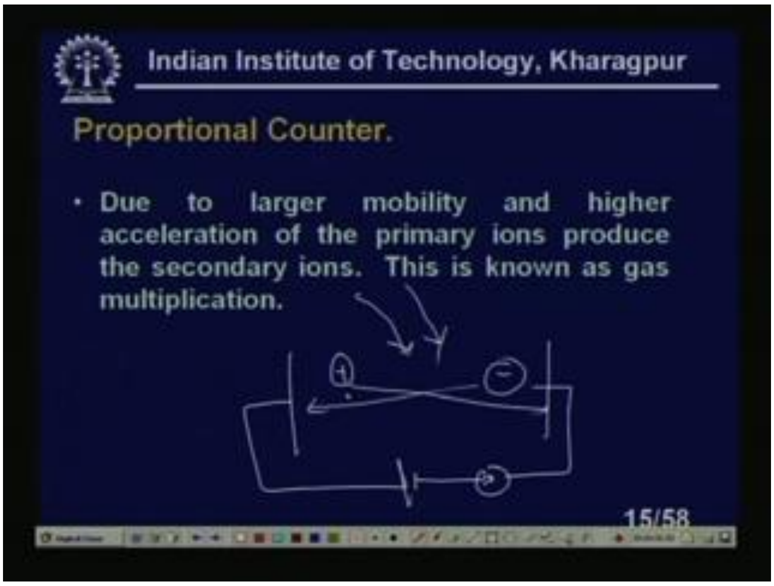


Proportional counter due to larger mobility and higher acceleration of the primary ions produce secondary ions. This is known as gas multiplication. Now, you see the when the ions move in a in a gas chamber, when the ions move in a gas chamber there are gas molecules and it will knockout some of the outer electrons of this. So, it will further produce some of ions; that means, a gas a when, because there is because you see that we have we have plate is not we have discussed. We have we have plates here I have positive ions negative ions and connecting this battery.

So, these rays are coming here ionizing the gas now, these will move with very fast accelerations in these directions. So, whenever it is moving it will may knockout some of the, it will may further ionize the gases or the molecules of the gas. So, it further ionizes obviously, the more and more current I will get. So, these are the secondary ions, because this the primary ions which is due to the incident rays whereas. When the rays will give when this I mean the ions moves through due to the electric charge due to electric potential on the both sides. So, it will produce secondary ions this is known as gas multiplications.

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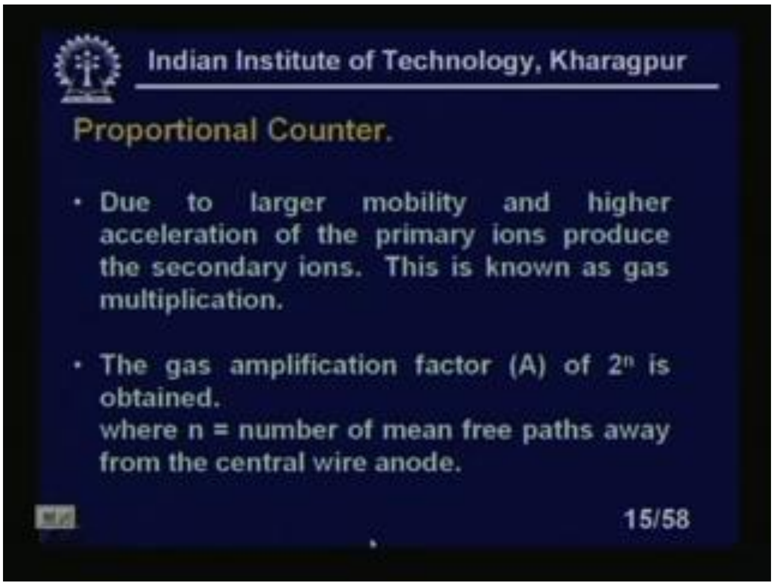


The gas amplification factor A of 2 by n is obtained where n is the number of mean free paths away from the centre wire anode.

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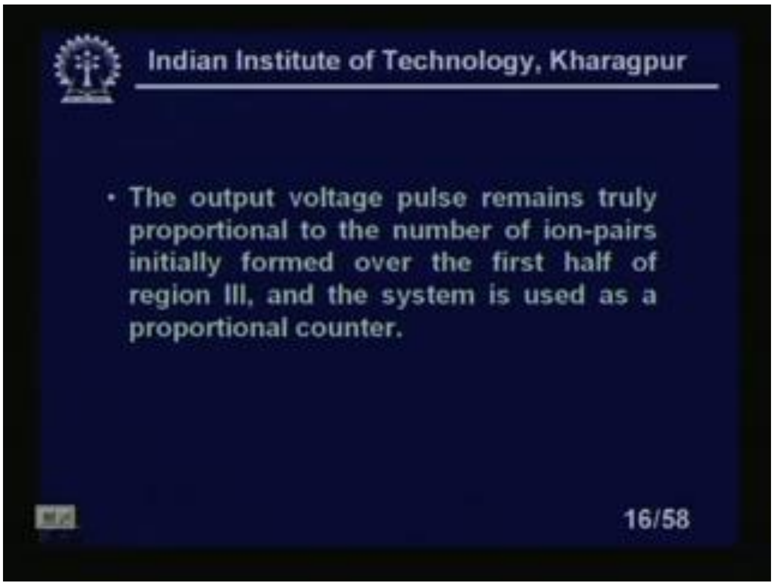


The output voltage pulse remains truly proportional to the number of ions pairs. Initially formed over the first half of the region 3 and the system are used as a proportional counter clear. The output voltage pulse remains is truly proportional to the number of ions formed, number of ion pairs. Initially from over the first half of the region 3 and the system is used as a proportional counter.

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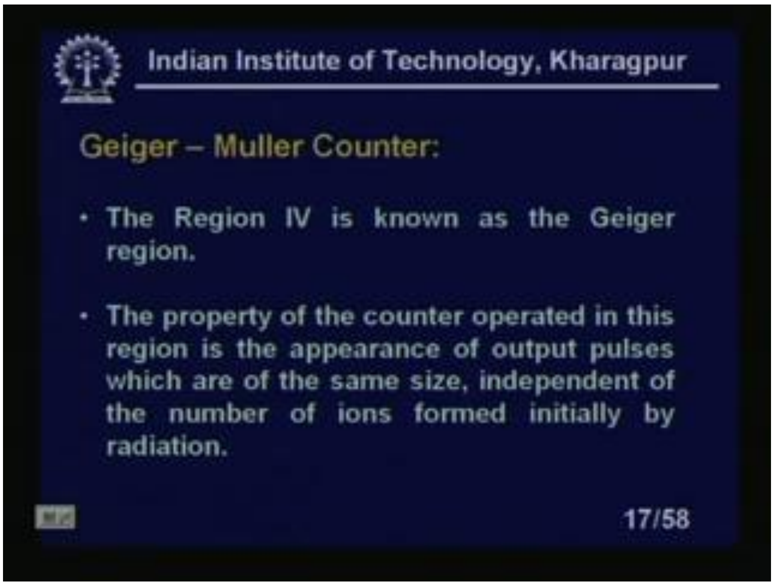


Now, let us look at the Geiger Muller counter again I am telling this is should look like this; that means, should be there. The region 4 is known as Geiger region of that characteristics cover the detector. The property of the counter operated in this region is the appearance of output pulses which are of the same size and independent of the number of ions formed initially by the radiation.

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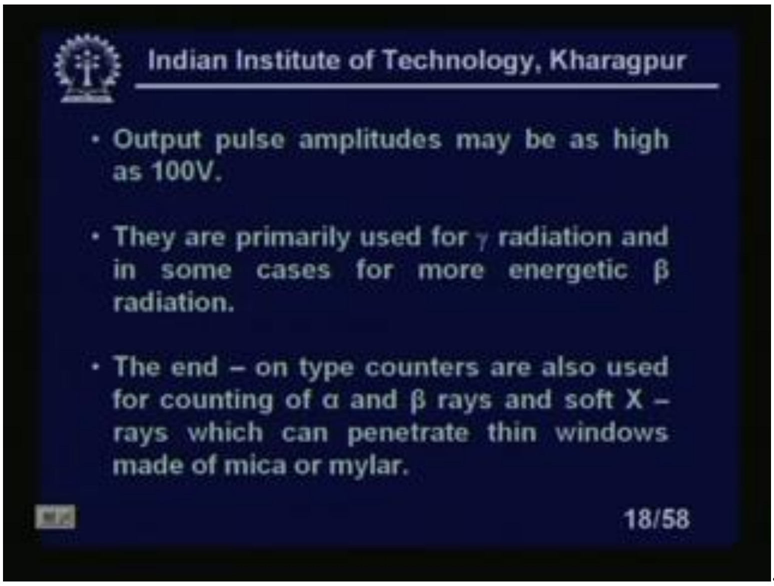


Output pulse amplitudes may be as high at 100 volts it is quiet high I do not need any further amplification. They are primarily used for the gamma radiations and in some cases for more energetic beta radiation that is we must know. The end-on type counters are also used for counting of alpha and beta rays and soft x-rays which can penetrate thin windows made of mica or Mylar. In some cases it can plated in some cases it cannot.

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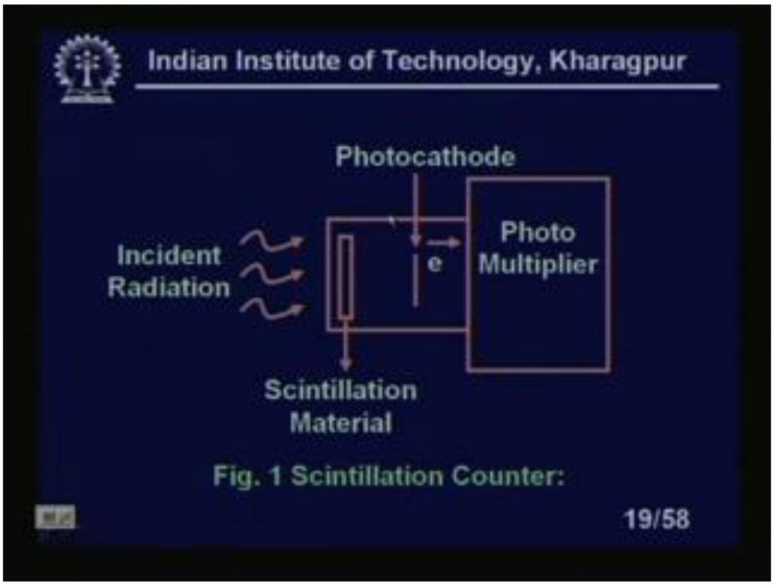


Let us look at these scintillation counters that is figure shown 1. So, this scintillation this incident radiations scintillation materials, we have photocathode photo multiplier photo multiplier tube is please note it is nothing but it will multiply, because this signal the current which will get is very small. Now, 41 function of this photo multiplier, because incident light will fall on this photo conducting materials. It will give some current, because some electron out of from will emit. It will give some current and photo multiplier is nothing but the photo multiplier tube. Actually it will enhance the current there is an immediate multiplications of the current. So, I will get higher output that is the reason we are calling photo multiplier tube.

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An incident radiation falls the energy is consumed and in the scintillation material and the scintillation material releases photons, which are turns detected by the photo sensitive cathode of a photo multiplier tube let us we repeat again. As the incident radiations falls energy consume in the scintillation material releases photons which are in turn detected whether photo sensitive cathode or photo multiplier tube.

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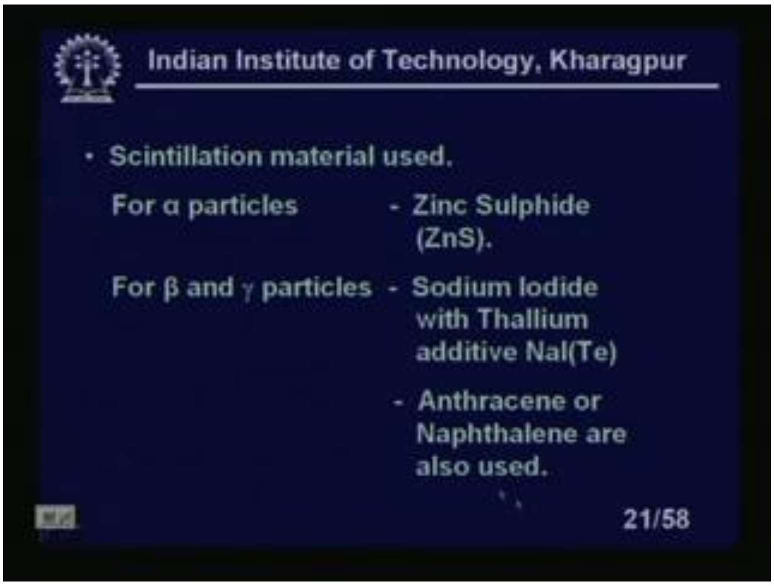

Scintillation materials used are for alpha particle zinc sulphide then for beta and our particles sodium iodide with thallium additive. Anthracene or naphthalene are also used these are the basic.

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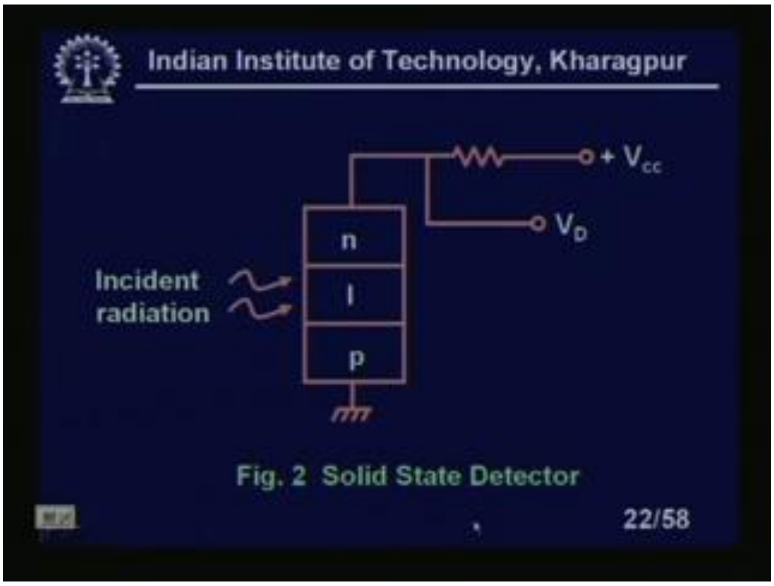


Now, this is solid state detectors as I told you they have been n type and p type regions. And we have been intrinsic I mean semiconductor in between the 2 I will get an output. So, that would be utilized, because I need a power supply. So, that it can be utilized for measurement.

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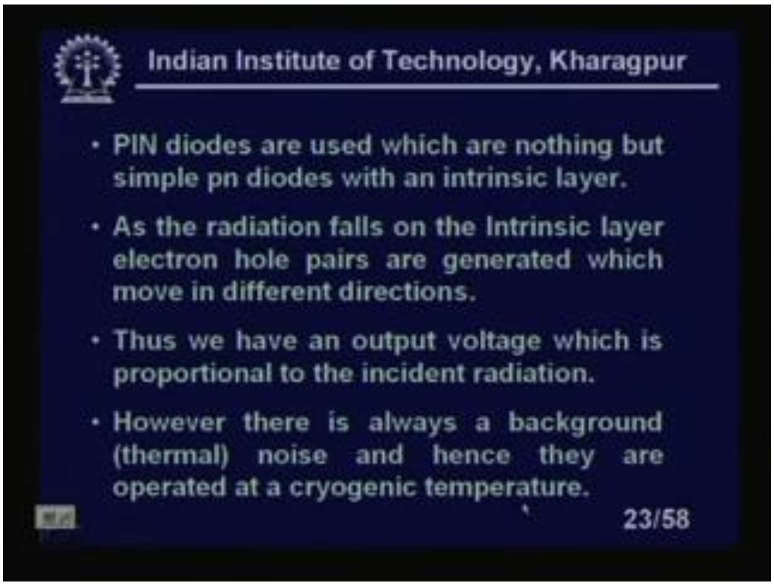

PIN diodes are used which are nothing, but simple pn diodes with an intrinsic layer. As a radiation falls on the intrinsic layer electron hole pairs are generated which moves in different directions. Thus we have an output voltage which is proportional to the incident radiations. PIN diodes are used which have nothing but simple PN diodes with an intrinsic layer. As the radiation falls on the intrinsic layer electron hole pairs are generated which move in different directions to different directions. Obviously, thus we have an output voltage which is proportional to the incident radiations. Without doing incident radiations I would not get any output voltage. However, there is always a background thermal noise and hence they are operated at a cryogenic temperature.

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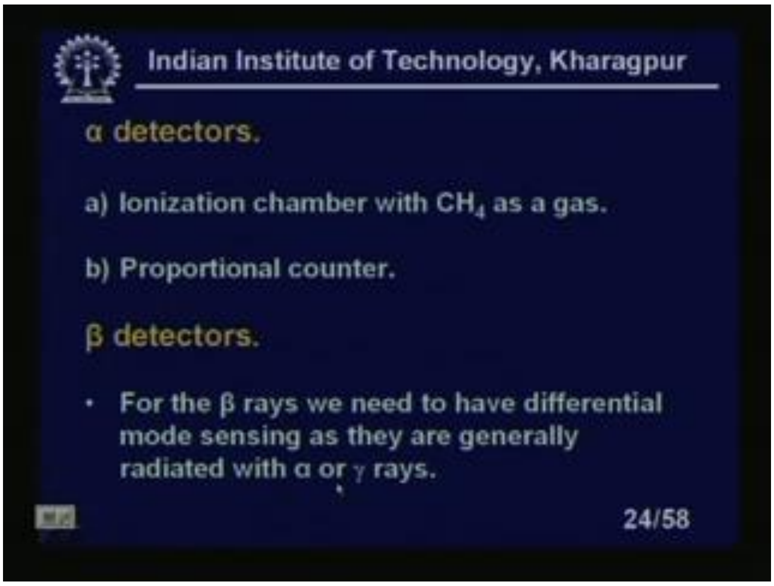


Alpha detectors, what are those alpha detectors? Ionization chamber with CH 4 as a gas, proportional counter. Beta detectors are for the beta rays, we need to have differential mode sensing as they are generally radiated with alpha and or gamma rays.

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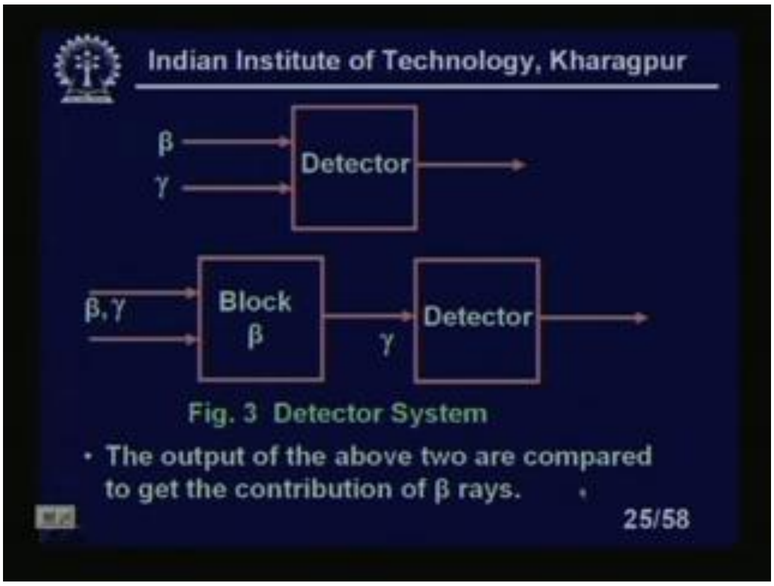


You see we have this detector system for beta rays detectors beta which will block betas, so through gamma, so it will come out of this. So, beta will be blocked. So, automatically detector will come out detector output will get. The output of the above 2 is compared to get the contribution of the beta rays, because here I am getting only gamma rays. So, I am these 2 will be compared so that I will get only the contributions of the beta rays.

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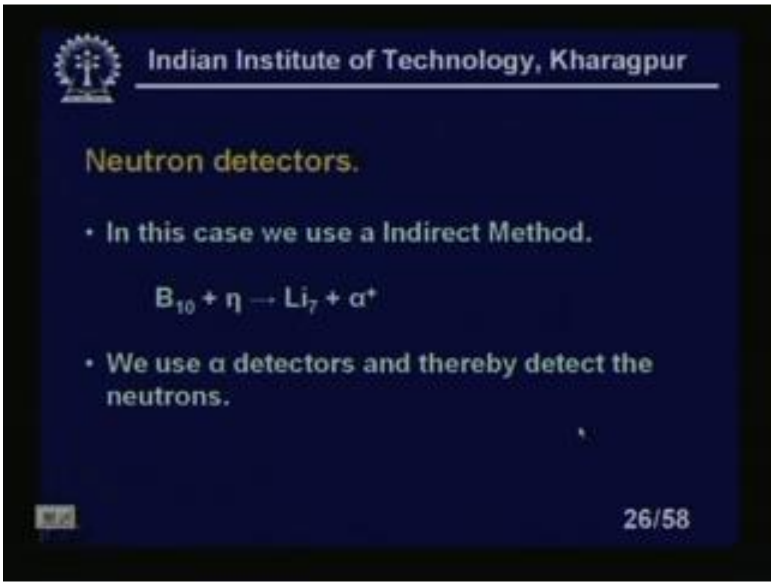

Now, neutron detectors are slightly different as you know in this case we use a indirect method, so B 10 plus neutron lithium plus alpha. We use a detector and thereby detect the neutrons. Obviously, will some detectors which will detect the neutrons.

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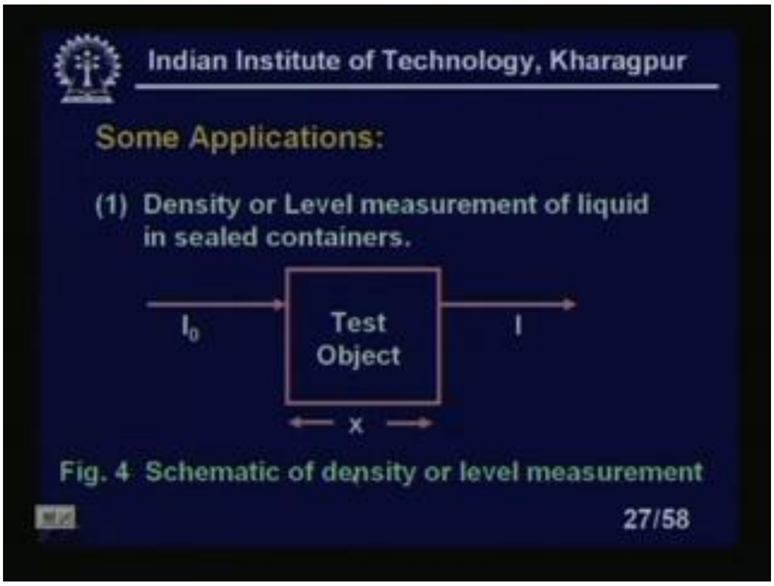


Some applications density a level measurement of liquid in sealed containers. In sealed containers if I do not if I cannot see from outside. Because in other all other conventional methods I must take out a sample and then I can measure the density, but in the nucleonic instrumentation is a non-invasive technique I can use to measure. So, it is for a sealed container I can measure the density as well as level of the liquid inside the containers. So, we have a test objects, so I am schematic of density of level measurement I am giving a ray we are getting outputs. This I am actually this output we are measuring how?

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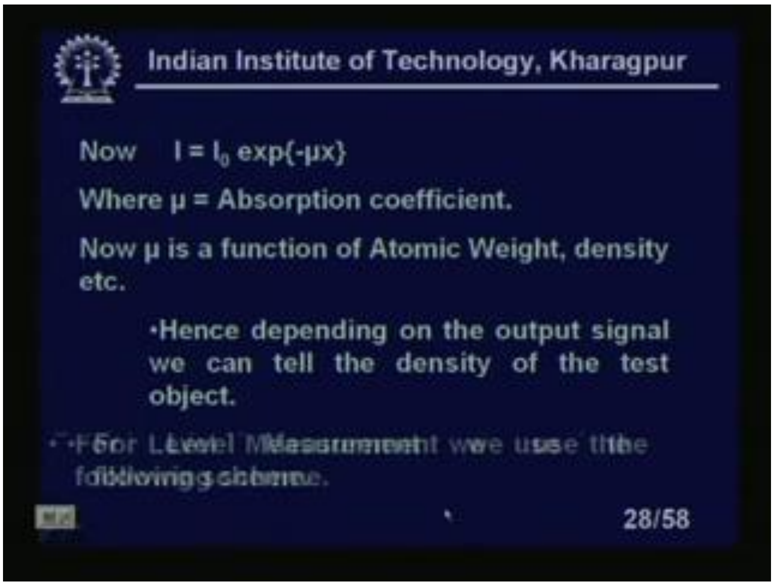


Let us look at I equal to I naught exponential mean into X this is basic expressions. Obviously, what is that? Let us look at I will be I naught will be always higher than I. So, I equal to I naught exponential minus exponential of mu x where mu is the absorption co-efficient. Now mu is the function of automatic weight and density etcetera, mu is a function of atomic weight and density etcetera. Obviously, that will vary the, I will be varied in this case please look at right this will vary this I will vary clear? Hence depending on the output signal we can tell the density of the test object. By looking at the output signal I can look at the density of the test object because atomic weight if the density changes. So, the atomic weight will change sorry if the, I can change the density if the density changes that value of I will be different. So, atomic weight is the same the densities density might be different that will be the same. For level measurement we use the following scheme.

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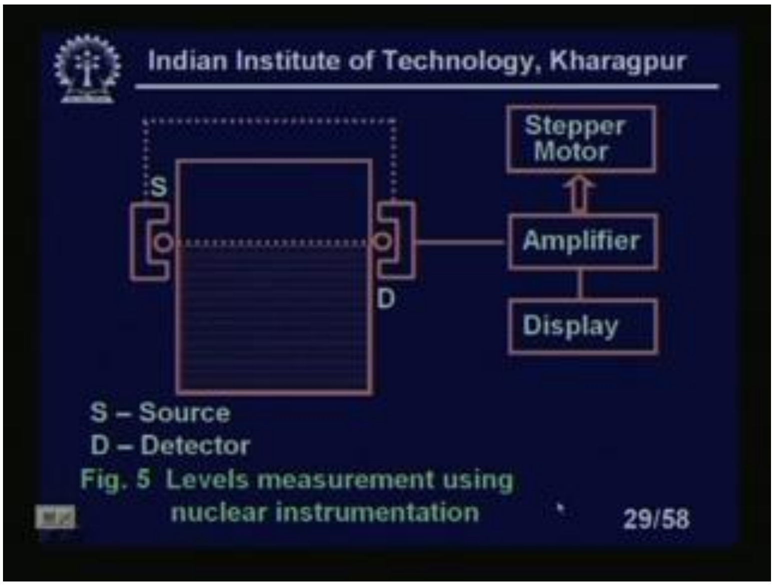


This is the scheme of the level measurement. So, we have source you see here we have a detector here and. So, this is a levels measurement using nuclear instrumentation. So, I have a liquid here. So, how it works? Let us look at when passing through the fluid the absorption will be more and hence the amplifier output forces the stepper motor to move the source and detector to move upward. You see what will happen? So, when passing through the liquid this will. So, it will always try to move this stepper motor to move it upward. When they reach the interface the absorption falls and thus we know that the level is reached clear.

Let me do it again, so the something like this if these 2 systems, these I mean let me take; that means, this stepper at the source and detector will be initially at the bottom here. So, it will move up how it will move? So, it will be detected, because there is source and detector ((Refer Time 28:35)) stop. Because incident ray and I mean this radiated ray and the detector ray will be different, because it will slowly move excuse me we have I mean stepper motor I mean assembly. So, that what will happen? It will slowly move now, whenever it will reach the top surface what will happen? There is the difference of the receiving signal, so at that time you can immediately stop it and see that what is the level? So, that will tell you the level of the system right, clear.

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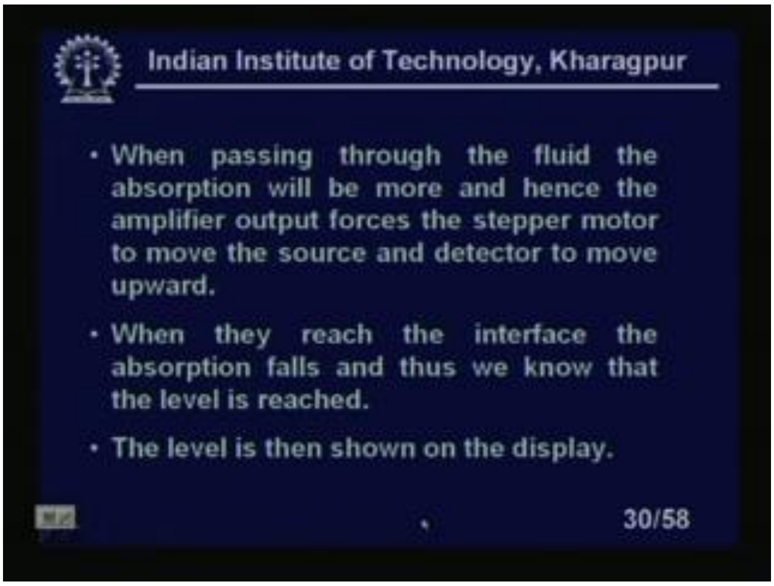


So, when passing through the fluid the absorptions will be more and hence the amplifier output forces the stepper motor to move the source and detector to move upward. So, into the liquids the large absorptions of the open particles, so that I will get a less output. And the detector side and when they reach the interface the absorption falls. So, no now, we know the level has reached. So, now that I mean positions can be reflected position that were movement of the stepper motor can be calibrated in terms of there, because you see even though I am here. I am showing you actually in practice if it is sealed container you cannot see them inside. So, outside should be calibrated sorry.

So, this outside should be calibrated that mean they should be graduated like this 1, because these you cannot see this all this level even though this. So, whenever these through this one absorption will be high. So, I will get a difference when the signals. So, whenever it reads this top surface that is the top surface of this level absorption will fall so; obviously, detector output will be different. So, that time I can I can stop the motor and can see this one this is forcefully when the absorption always it will move up step by step it will go out even that is not a continuous, but it will work. So, at this point I can measure it and tell the level of liquid inside this vessel which is sealed from outside we cannot see it from outside excuse me. When they reach the interface the absorption falls and thus we know that the level is reached the level is then shown on the display.

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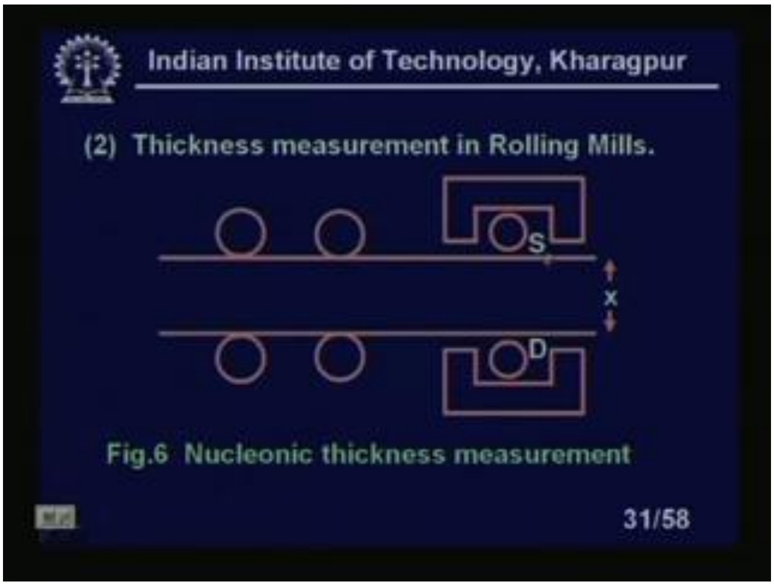


The thickness measurement in rolling mills is very common you see here nucleonic thickness measurements. So, I have rolling mills rolls are coming on this of the basically rolls which is from the inwards from rolling mills; that means, I have a roller. So, rolling measures thickness then which is I am getting a proper shape I want to measure accordingly how much pressure I will give on the roll that can be determines. That means how much pressure I will give on this particular roll? How much pressure it will give on this accordingly if I give more pressure the thickness will be small. The thickness will be reduced whereas, if I give less pressure. So, the thickness will be large and large, but I have to measure the thickness at this is a continuous measurement. So, that it will control and I can give the signal feed back to this rollers. So, that accordingly pressures will be given on this and I can control the exact thickness of this devices an exact thickness of the roll sheet which is coming out from the rolling mill in a steel plant. Let us look at principle I will source and detector find no problem.

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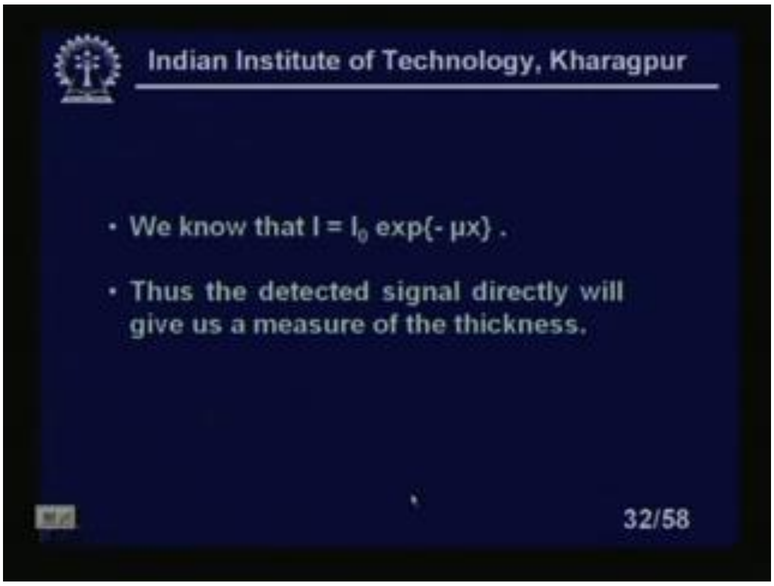


We know that again I equal to I naught exponential minus mu x. Thus the detected signal will directly give us a measure of the thickness. So, the, if I have a calibrated output suppose I have something I have made the calibrations. Accordingly I know that for this suppose 5 centimeter thickness of the rolling sheet I know the what will be the value of I if I I naught is constant. So, I will use that principle so; obviously, if I continuously I will detect I which the other set where I detect I. You see I will detect I at the detector and there is a pre-assigned value of I for these thickness 5 centimeter thickness what will be the value of I if I do not get it suppose if it is less; that means, thickness is more . So, I should press this roller. So, the thickness will be a proper size. Thus the detected signal directly will give us a measure of the thickness right which can be utilized to control the thickness of the rolling sheet which is coming out of the rolling mill.

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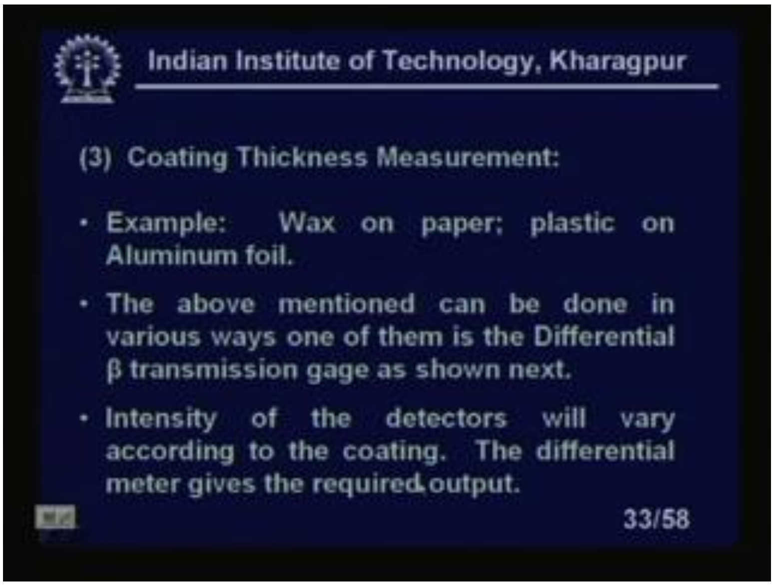


A coating thickness measurement coating thickness measurement I have give an example 1 of the new example of the coating thickness is that, I told you in a strip chart recorder that strip chart is coated with the wax. So, that type of situations I need to control the thickness even though it is described it is a fine coating. So, it determinations, because whereas, in the rolling its quiet large compact where is it is a fraction of a millimeter on the coating, whereas there it is the much higher it is a multiple multiples of the millimeters. Example; wax on paper plastic or aluminum foil this is a good example wax and paper is a good example which is used as I told you in a strip chart recorder. The above mentioned can be done the above mentioned method which have discussed can be done in various was one of them is the differential beta transmission gage as shown in next. What is that intensity of the detectors will vary according to the coating and the differential meter gives the required output.

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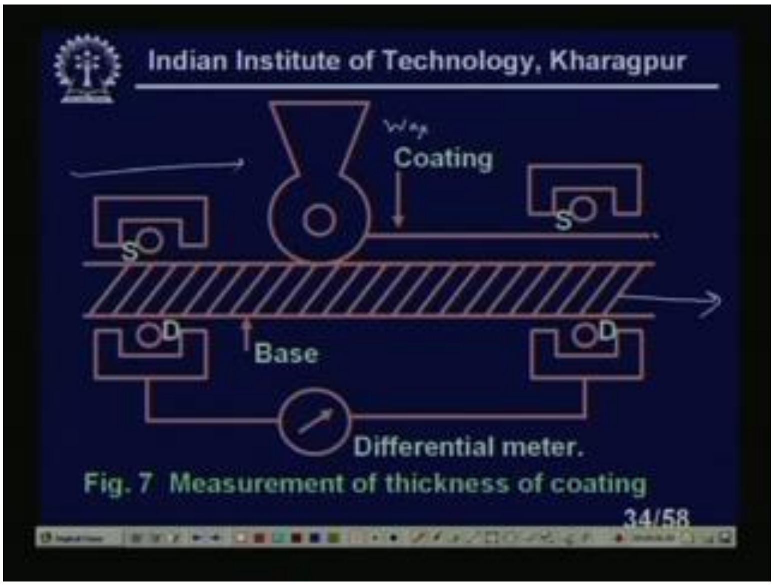


Let us look at fine I have a coating which is coating is coming through this 1 let us look at. So, I have a coating this is a coating on the, I have a source I have detector on this side. So, this is actually suppose this is actually paper on which I am making the wax coating suppose this is wax this is a wax coating. So, wax is coming through this 1 and making a coating. So, I have a source and detectors; obviously, this thickness of the detector output you see here. So, there will get a some I mean I have a source I have a detectors here. I have a source also see this is continuously coming through this one.

It is continuously going this role is continuously moving in this direction then what will happen? You see here, so this source detector will give you some output I know some differential the some pre-genering differential output I will, because why we had made like this 1, because this thickness will be very small. So, I need some differential arrangements. So, that it will I will get more deflections are more output. That is the reason this differential arrangement you can say that whatever the principles which have used for the thickness measurement of the rolling sheet can be utilized.

But if I utilize that principle then will chances lot of error, because the thickness there, it is quiet high it is few centimeters whereas, here it is few millimeters. So, I need some differential arrangements I have some output here and if I get this one I will get some output so; obviously, this output will be lessened this output. So, this output will be higher and this output will be lower. So, I will get a differential output that can be calibrated in terms of the thickness of the coating of the wax clear.

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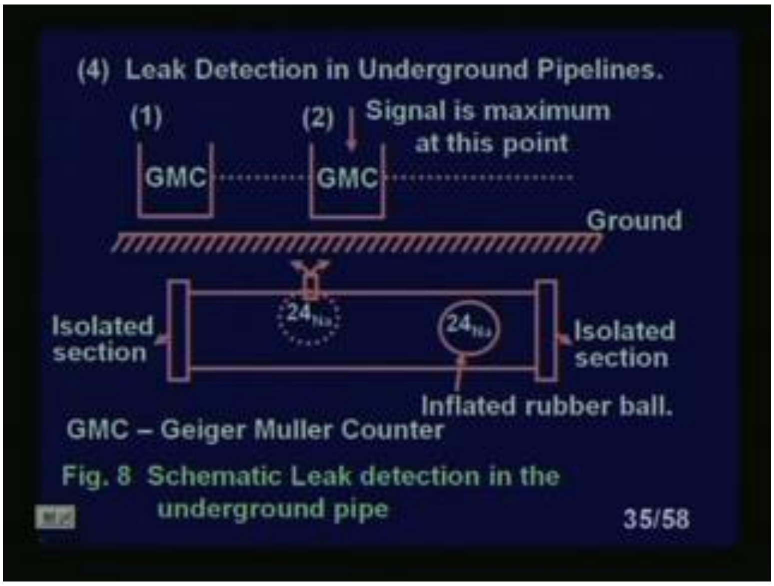


Now, lead detection in underground pipelines see it is very difficult to if I have leak in the underground pipelines special in the municipality in the cities. So, it is very I mean utilize, but it should be safe as that same time, because if I use radioactive sources that half life will be extremely high that will be problem. You see this one of the example how you can detect? If I if there any leak in the pipe this is a taking a section of the pipe there is a ground. And this pipe is obviously, installed few meters might be 1 meters might be half meters below the hour or the surface level of the road right or the foot path. Now, what actually the principle look like this we are using here Geiger Muller counter. Basically Geiger Muller counter is used to Geiger Muller counters are using to detect the, I mean leak in the pipe. How? Let us look at…

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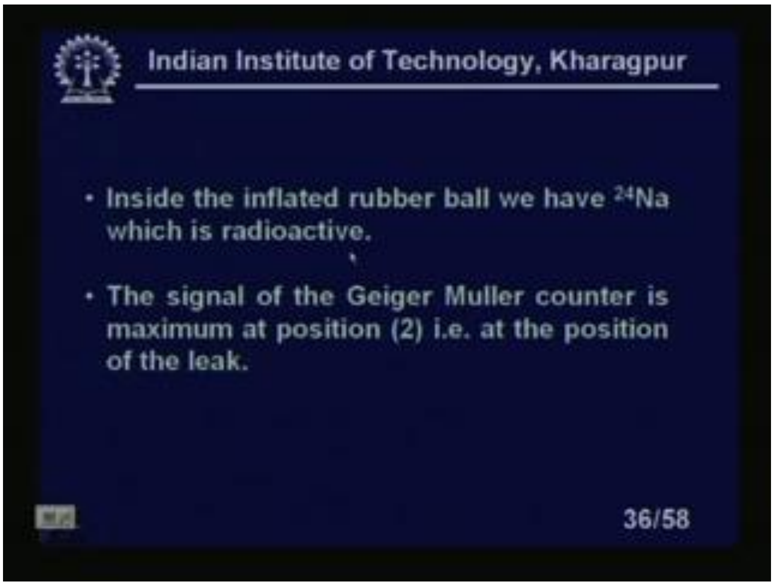


Inside the inflated rubber ball we have sodium 24 which is radioactive. Clear inside the rubber ball let us look at again inside the rubber ball. We have sodium 24 which is radioactive that with inside the rubber ball we have the sodium 24 clear fine which is radioactive. The signal of this Geiger Muller counter is maximum at the position 2 that is at the position of the leak? Suppose here we have a I mean position 2 this is a position 2. So, signal at the position 2 will be higher, because there is an, if there is a leak in the pipe, because it is slowly moving. So, leak in the pipe, so I can detect that way. So, signal of the Geiger Muller counter is maximum at the position 2 that is at the position of the leak, right.

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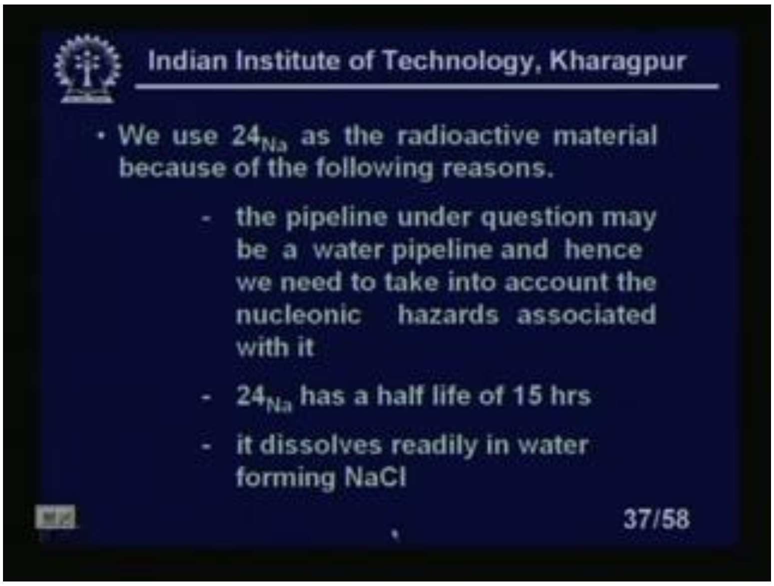


We use 24 sodium as the radioactive material, because of the following reasons, because of its half life basically the pipeline under question may be a water pipeline. And hence we need to take a count the nucleonic hazards associated with it. So, it should only nucleonic hazards the hazards that is we should look at 24 sodium I mean sodium 24 is half life of 15 hours, so it is very short. So, its dissolves readily in water making sodium chloride that is common salts; that is great advantage of this particular sodium right. So; obviously, it dissolves and make the, I mean common salt as no problem, because almost there is always some water is chlorinated for purifications. So, if we use the sodium; obviously, there is a leak also of sodium 24 for our see it will not make any harm to human being.

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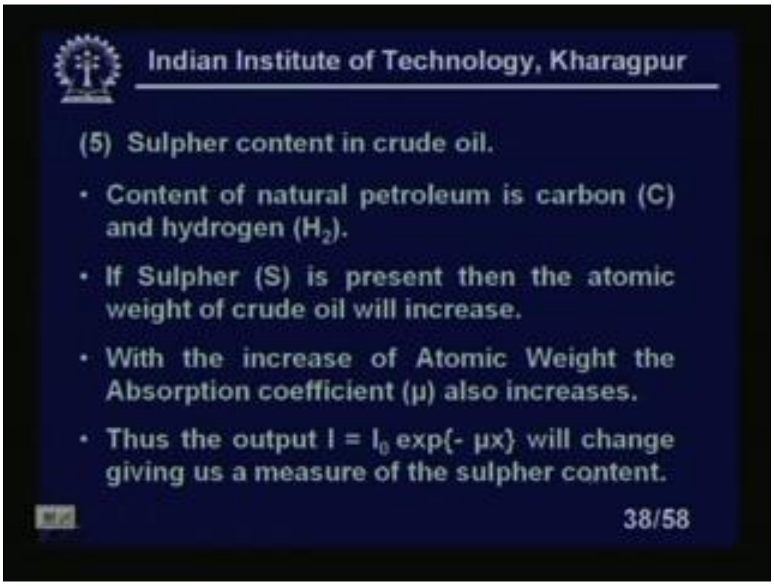


Now, also it is used for the nucleonic instrumentation used for sulpher content to measure the sulpher content in crude oil. Contents of natural petroleum is carbon and hydrogen that is it is an assume it is called hydro carbon industry all in industry we will always call as hydro carbon industry. If sulpher is present then the atomic weight of crude oil will increase. Because as we say we have seen that the atomic weight will increase if atomic weight will increase. What will happen? With increase of atomic weight the absorption coefficient mu also increases, what is that equations?

We have seen that equations what is that equations the equation looks like this I I naught exponential minus mu x. So, the increase of atomic weight this mu absorption coefficient mu will also will increase. Obviously, so the I will be different is not it right I will be different if we it expand it. So, what will happen? It will be negative terms so; obviously, if the mu increases. What will happen? So, the, I will different. So, by this I can measure this sulpher thus the output I equal to I naught exponential minus mu x will change giving us a measure of sulpher content in the crude oil.

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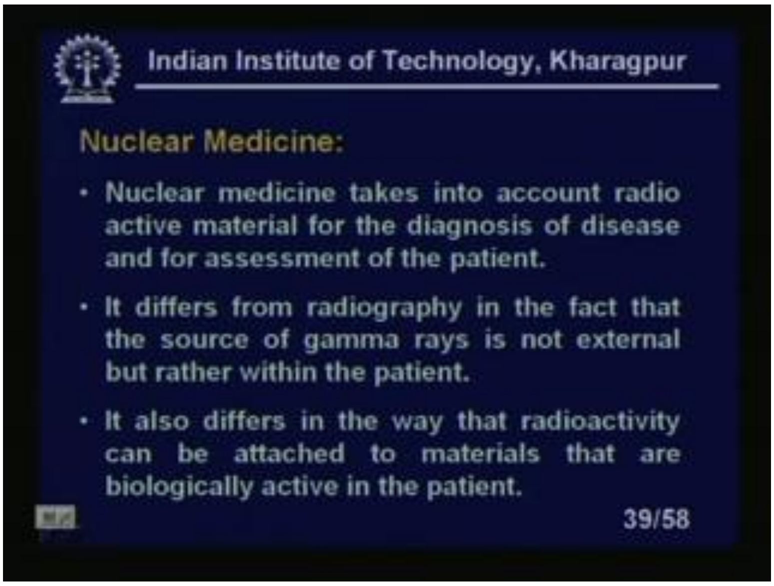


Now, let us discuss little bit of nuclear medicine as I told you already are also, because in context of the nuclear instrumentation we should discuss somewhat nuclear medicine. Nuclear medicine takes into account radioactive material for the diagnosis of disease and for assessment of the patient. It differs from radiography in the fact that the source of gamma rays is not external, but rather within the patient that is the difference between the radiography and the nuclear medicine. It also differs in the way that the radioactivity can be attached to the material that the biologically active in the patient.

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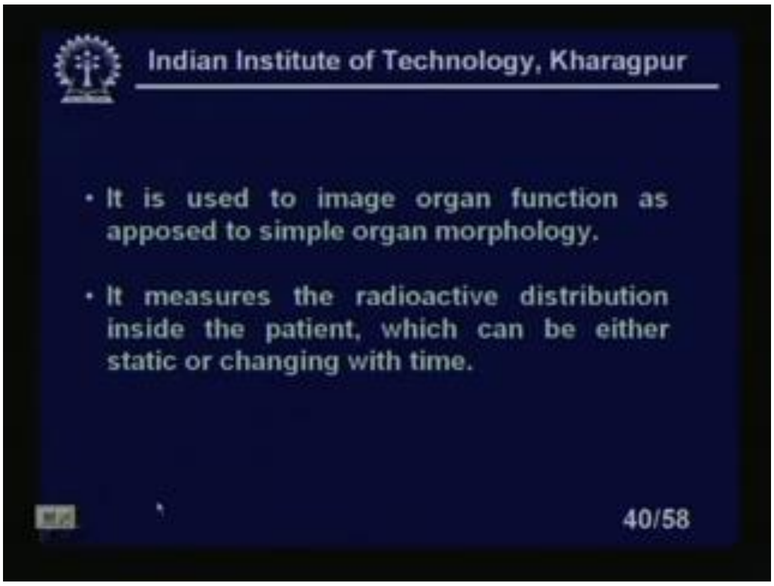

It is used to image organ function as opposed to simple organ morphology. I am sorry this will be opposed. It measures the radioactive distribution inside the patient which can be either static or changing with time.

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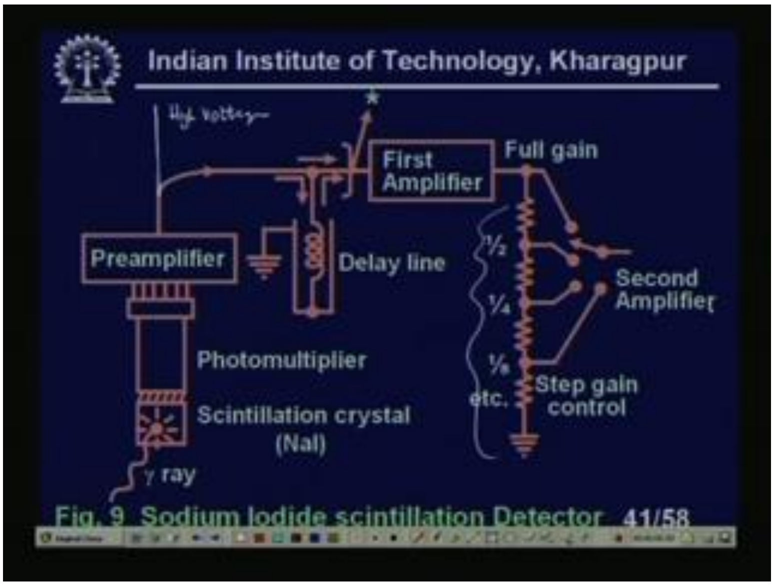


This is a typical example of the sodium iodide scintillation detector you see what will happen? We have a gamma rays coming we have a scintillation crystals sodium iodide in your photo multiplier tube. We have a preamplifiers we have a delay line then we have a further amplifiers I am getting a large gain. Obviously, there should be high voltage that we have not drawn it should be a high voltage section is necessary, because photo multiplier tube needs a high voltage to operate. So, I am getting a current and I will get I mean further amplifiers say this is an attenuator, so accordingly I will get a full gain here. Obviously, that is the simple system switch we were using this see I can get the step gain or I can get different gain of the systems. This is the simple attenuator all the instrumentation peoples always we know the people do like this one right.

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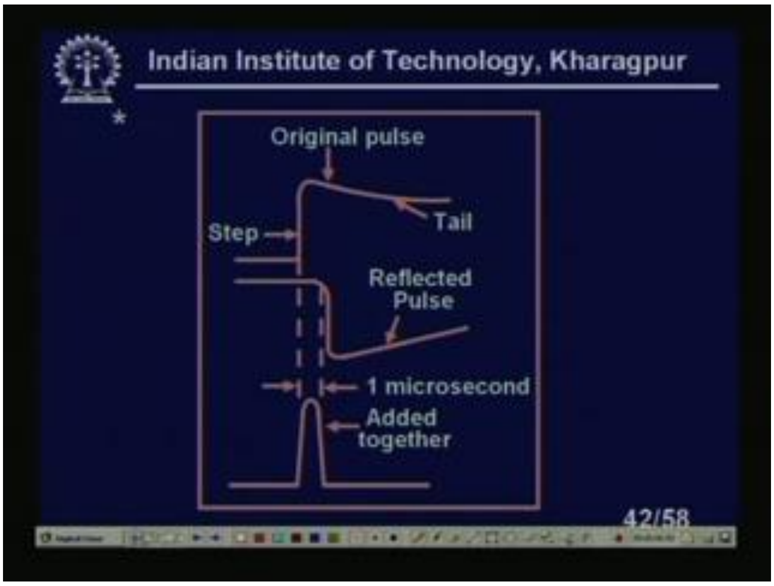


Now, original pulse you will you see you look at here. I am sorry you see this actually how it walks actually this I have shown how the pulse looks like, because I cannot show it here. So, I took the next page how the pulse I mean this output after this scintillation crystal coming from preamplifier how it look like? Let us look that. You see this original pulse now, the reflected pulse is coming like this and if I can combine these 2 I will get this pulse. This pulse is utilized for making the detection combining this 2 pulse because the other will be canceled out. I will get a pulse like this pulse will be utilized for making the detection and for the diagnosis purposes.

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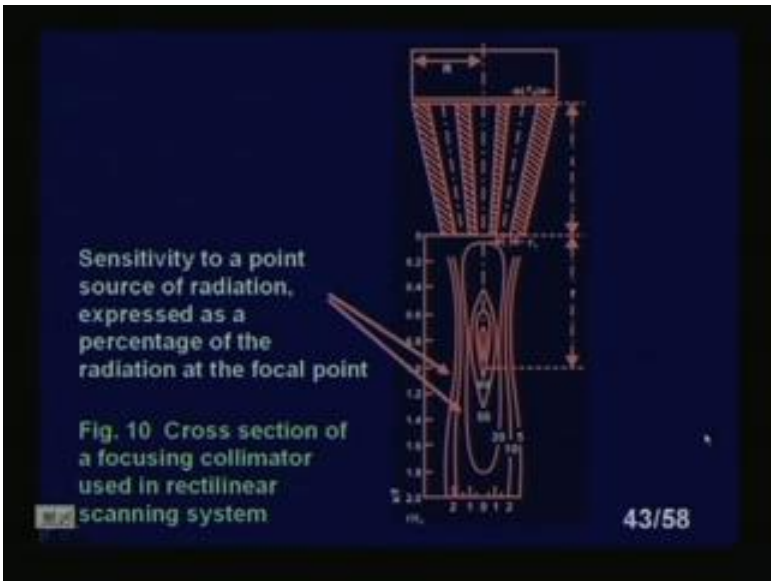

You see this is a cross sections of the focusing collimator used in the rectilinear scanning system. Now, all the scanning system is basically you know the any scanning system whether it is a CT scan or it is a I mean the television camera scanning. Basically you know there is a whenever there is rectilinear motion; that means, the motion of the detector. We makes by directions rectilinear motion is the motion in two direction x y directions I will call it as scanning right. Here is a cross section of a focusing collimator used in the rectilinear scanning system is a sensitivity to a point source of radiation express as the percentage of the radiation of the focal point right, you can see here.

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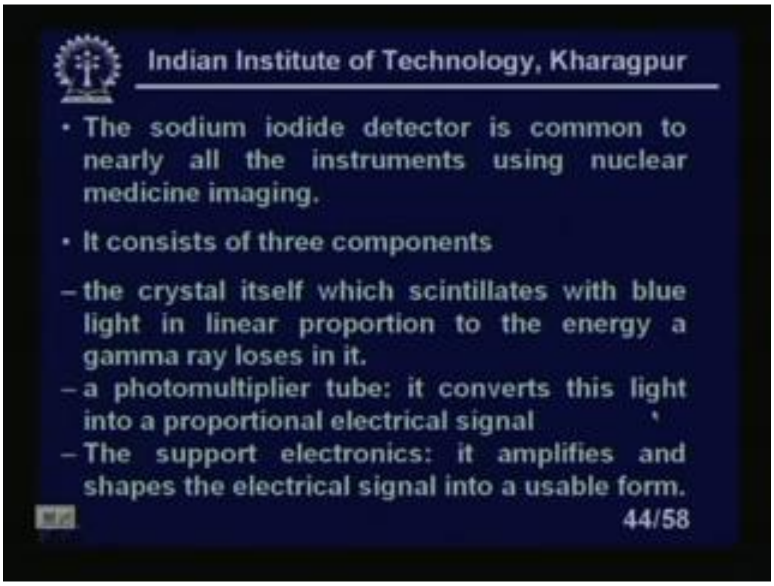


The sodium iodide detector is common to nearly all the instruments using nuclear medicine imaging. It consists of 3 components the crystal itself which scintillates with blue light in linear proportion to the energy of gamma ray losers in it. A photo multiplier tube it converts this light into a proportional electrical signal. The support electronics it amplifies and shapes the electrical signal into a usable form.

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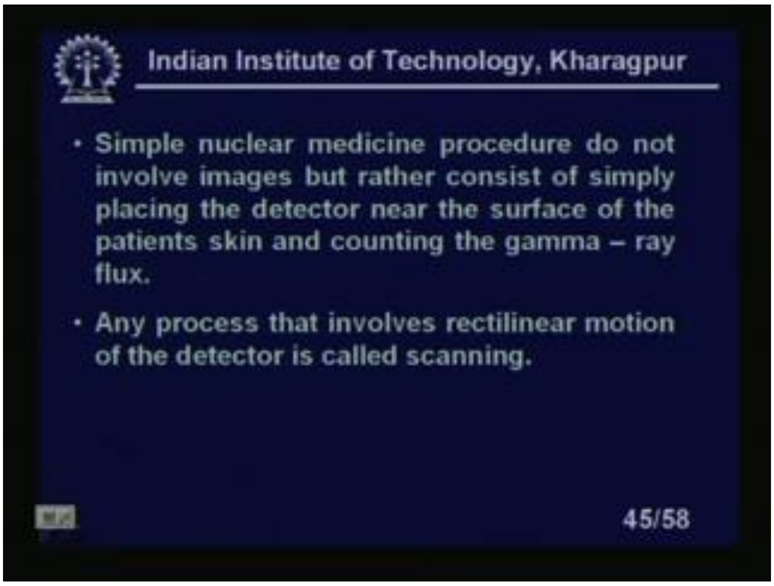


Simple nuclear medicine procedure do not involve images, but rather consists of simply placing the detector near the surface of the patients skin and counting the gamma ray flux This is very common example; obviously, non basic any process that involves rectilinear motion of the detector is called scanning that I told you earlier.

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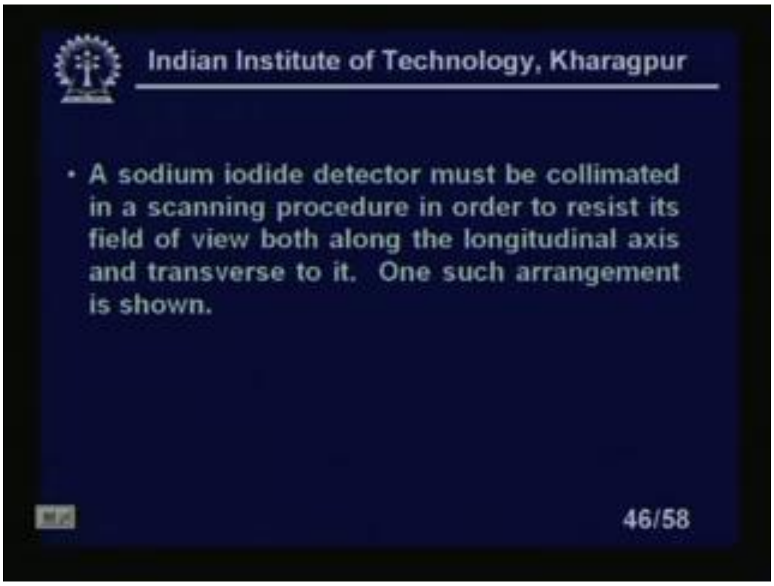


A sodium iodide detector must be collimated in a scanning procedure in order to resist its field of view both along the longitudinal axis and transverse to it. One such arrangement to shown in the figure right which we have shown I mean what is that? See, how it is collimated here shown here right? Source sensitivity of point source detection thus of radiation expressed as a percentage of the radiation at the focal point a sodium iodide detector must be collimated.

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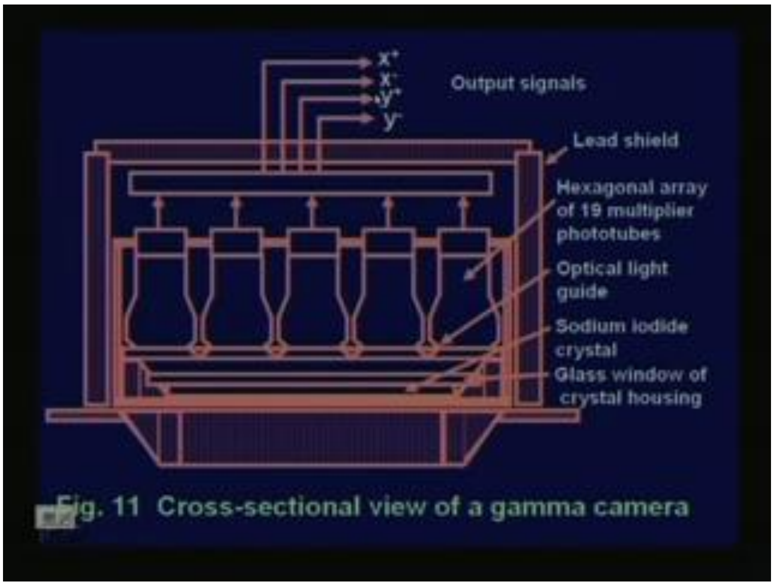


Now, the cross sectional view of the gamma camera, lead shield; lead shields are all sides. You see we have a lead shield on all sides all the sides we have lead shield; we have a hexagonal array of 19 photo multiplier tubes these are photo multiplier tubes. We have a sodium iodide crystals here glass window through which you can crystal house. You can see this crystal housing the optical light and this is sodium iodide crystals. You can see here we are getting output signal x x plus and y y plus which can be given to a like oscilloscope systems the horizontal plates and the vertical plates to get the proper picture of gamma camera.

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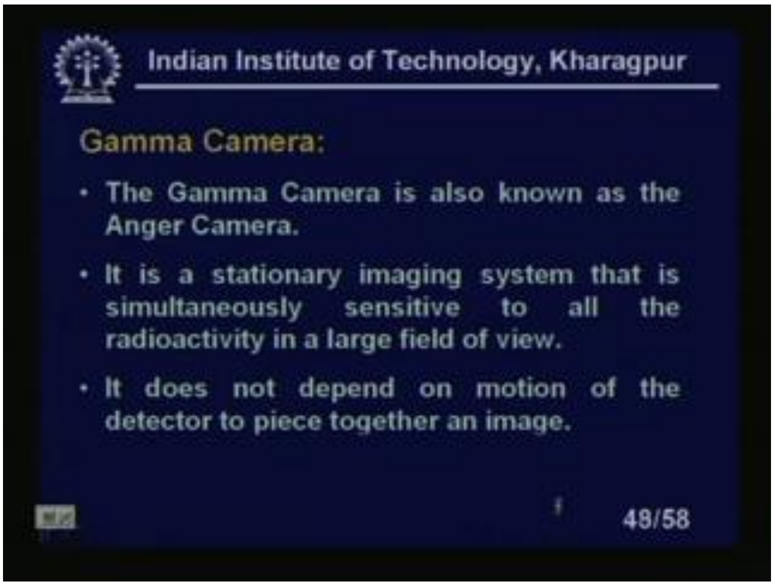


The gamma camera is also known as the anger camera. It is the stationary imaging system that is simultaneously sensitive to all the radioactivity in a large field of view. It does not depend on motion of the detector to piece together an image right.

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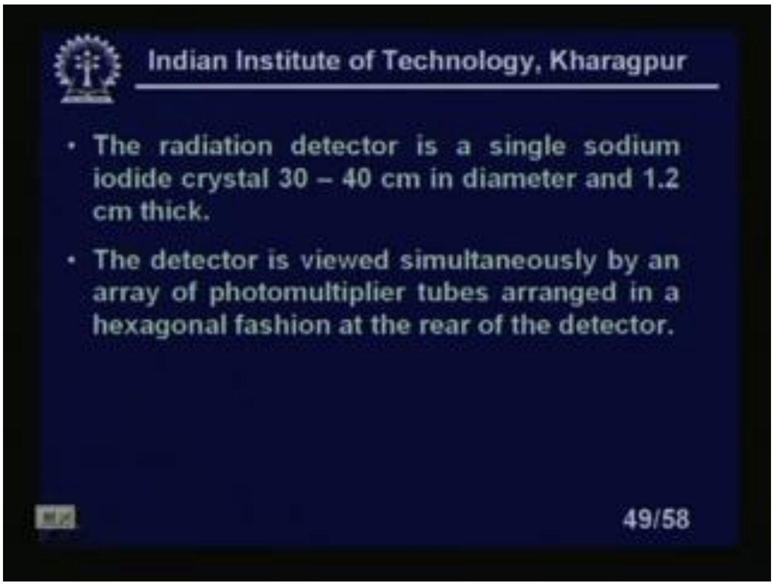


The radiation detector is a single sodium crystal 30 minus 40 centimeter in diameter and 1.2 centimeter thick. It is quiet large you can see the detector sodium iodide crystal 30 to 40 centimeter in diameter and 1.2 centimeter. The detector is viewed simultaneously by an array of photo multiplier tubes arranged in a hexagonal fashion at the rear of the detector as shown in the figure just we have shown. You see in the detector is viewed simultaneously by an array of photo multiplier tubes arranged in a hexagonal fashion at the rear of the detector.

As the gamma ray enters the sodium iodide crystal the scintillation light spreads and each photo multiplier tube picks up a fraction of this light right clear? However the gamma ray enter, let us go back again. Gamma rays enter through this thing we have sodium iodide crystals it is scintillation lights it is going to the photo multiplier tubes I am getting the vertical output clear? As a gamma ray enter sodium iodide crystal the scintillation light spreads and each photo multiplier tube picks up the fraction of light.

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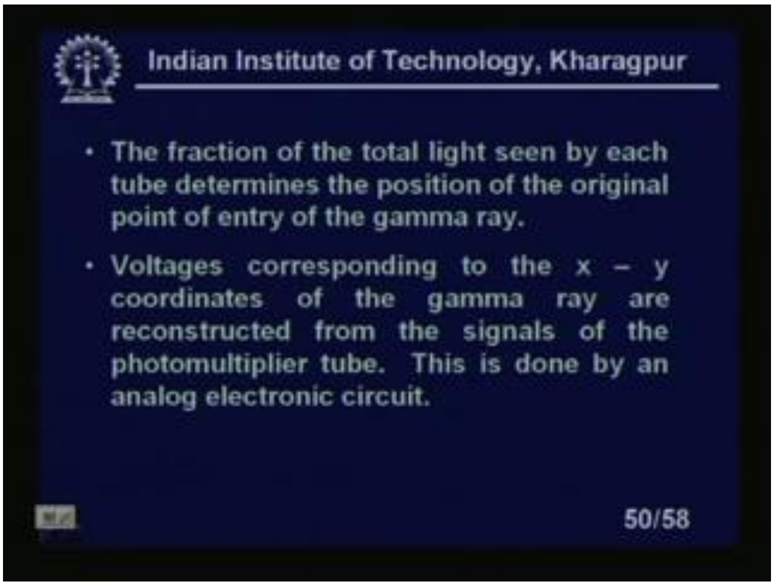


The fraction of the light seen by each tube determines the position of the original point of entry of the gamma ray clear fraction of the total light seen by each tube determines the position of the original point of entry of the gamma ray. Now, voltage corresponding to the x-y coordinates of the gamma ray are reconstructed from a signals of the photo multiplier tube. This is done basically where the analog electronic circuit.

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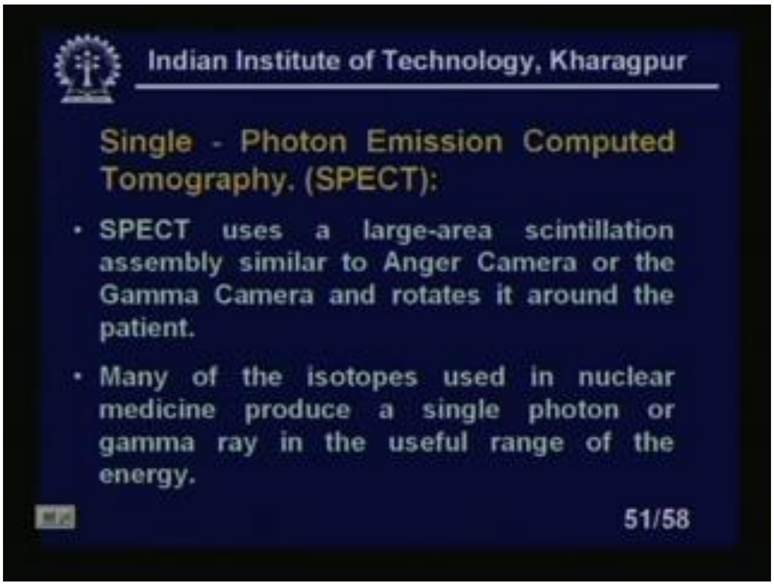


Now, in the single photo emission computer tomography it looks like this a SPECT uses a large area scintillation assembly similar anger camera or the gamma camera and rotates it around the patient it rotates around the patient. Many of the isotopes used in nuclear medicine produce a single photon or gamma ray in the useful range of the energy clear.

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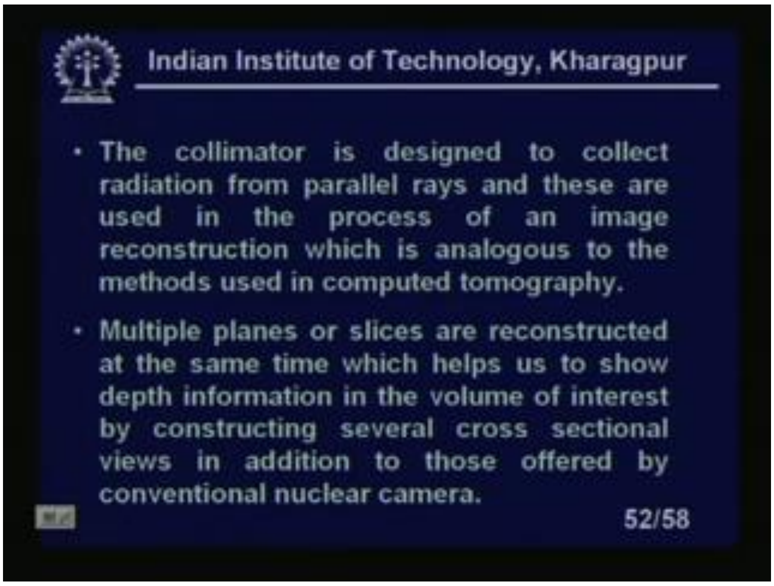


The collimator is designed to collect radiation from parallel rays. And these are used in the process of an image reconstruction which is analogous to the methods used in computed tomography. Multiple planes or slices are reconstructed at the same time which helps us helps us to show both information the volume of interest by constructing several cross sectional views in addition to these offered by conventional nuclear camera.

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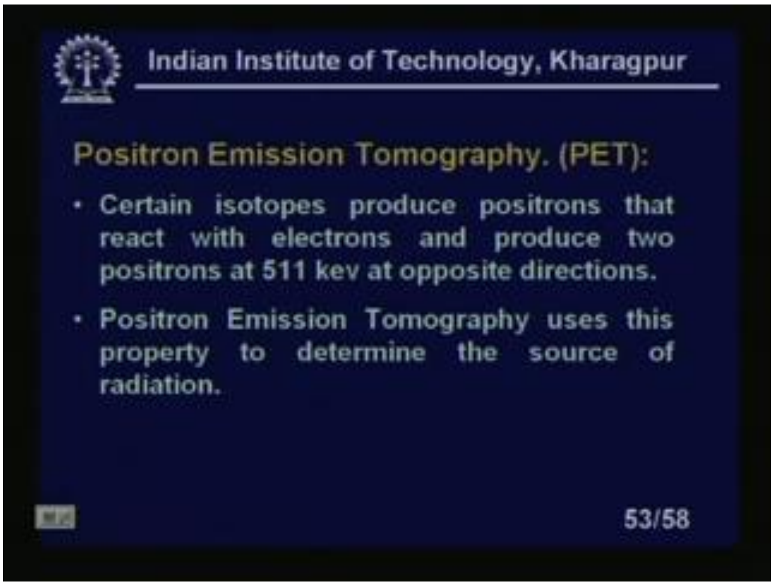


Now, positron emission tomography is slight different. Certain isotopes produce positrons that react with electrons and produce 2 positrons at 511 kilo volts at opposite directions. Positron emission tomography uses the property to determine the source of radiation.

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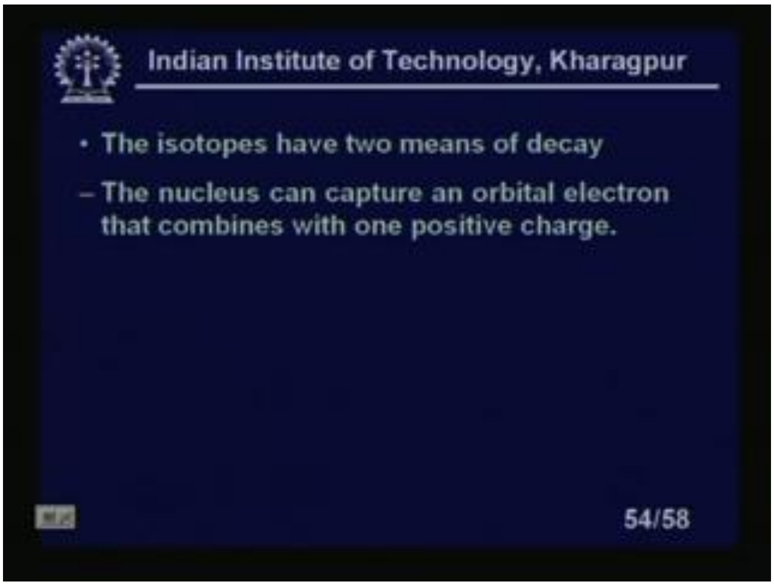

The isotopes have two means of decay the nucleus can capture an orbital electron then that combines with one positive charges. So, the nucleus can capture one orbital electron that combines one positive charges and nucleus can emit a positive charge in the form of positron that combines with the external electron right. So, these are 2 method by which you can I mean method of decay of the isotopes; obviously, all the radioactive materials basically is decay that you must know.

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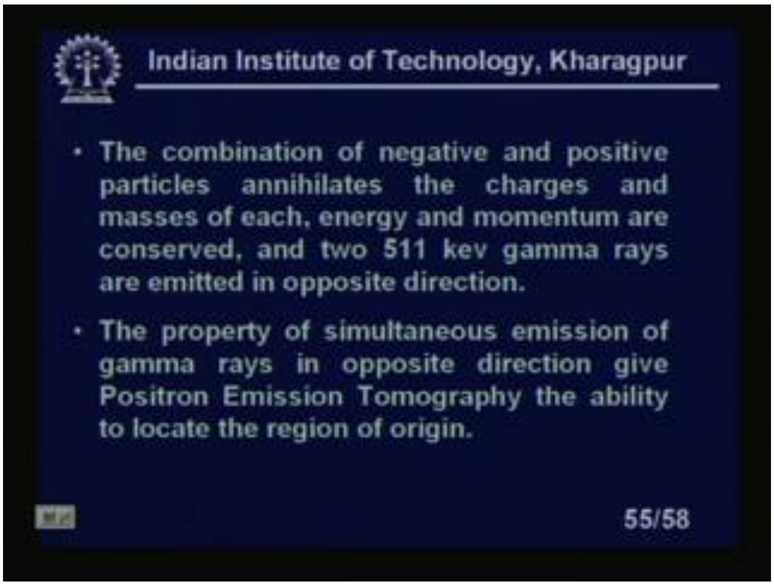


The combinations of negative and positive particles annihilates the charges and masses of each. Energy and momentum are conserved and two 511 kilo volt gamma rays are emitted in opposite direction. The property of simultaneous emission of gamma rays in opposite direction gives a positron emission tomography and the ability to locate the region of origin right. So, that is the necessary I mean you must know the origin.

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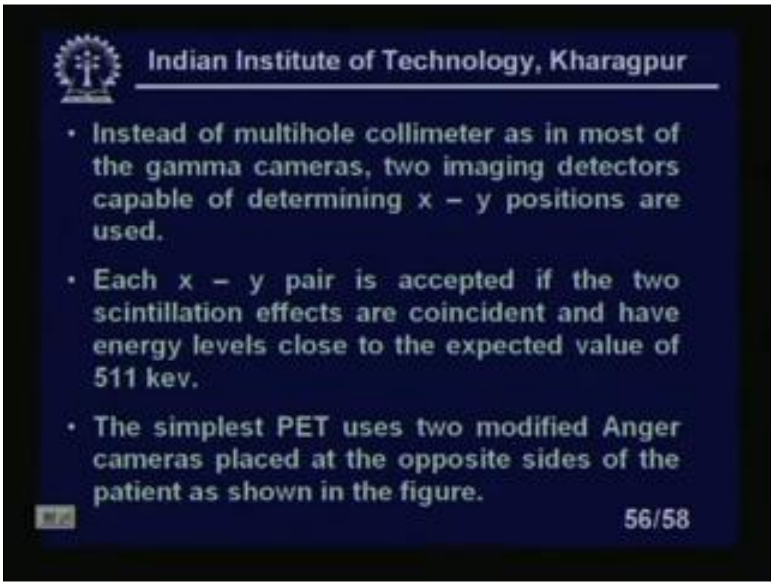


Instead of multiple multihole collimeter as in most of the gamma cameras two imaging detectors capable of determining x-y positions are used right. And each x-y pair is accepted if the two scintillation effects are coincident and have energy levels close to the expected value of 511 kilo electron volt. The simplest PET uses two modified anger cameras placed at the opposite sides of the patient as shown in the figure.

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You can see this is a paired camera how the, is rotating. So, that continuous, so it is rotated in this directions. So, it will in directions, so the patient will be covered by 2 angular camera and please note that in the nuclear instrumentation the horizontal is a great problem. So, you have to think of all this whenever you are using what type of I mean radioactive materials you are using though the half life. And all these things is not that large, but the amount of ratio you have to think also the proper hazards. And it is sometime environment list they are show until unless you can manage with some other instrumentation which is known as hazard. Hazard as like ultrasonic or any conventional instrumentation of level gage and density measure that is to be used.

But in some situations as I told you like the detections of the leak in the pipe underground or suppose the in a close containers I want to know the level of the liquids. And all things, it is very difficult to specially it is sealed of the might be closed it turned does not matter because if I have a inside electronics already installed inside. So, I can send some installed inside I can detect, but if it is separate content suppose a cylindrical drum I want to know the how much the liquid contents which we cannot save from outside? So, that type of situation I can use this type of radiation technique. So, this is to be basically I mean all you have to be careful that I told you several times. That means, they can manage with other instrumentations systems and mention non-hazardous other systems. We are not suppose to use the radioactive sources right. So, with this I come to the end of this lesson 26.

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Welcome to the lesson 27 of industrial instrumentation. In this particular lesson, we will study basically the measurement of magnetic field. Basically 2 sensors we consider though the title of the lesson of magnetic field, but we will find that specially the sensor the second sensor which we had. So, we will we will study the measurement of current measurement of power all those things, but the first sensors that is the search coil is basically used for measurement of magnetic field. And second 1 is the, that will that can be used for measurement of magnetic field as well as current.

In fact, we will find that this particular sensor is extensively utilized though it is named that it is used for the measure of the magnetic field. But you will find it is extensively used for the measurement of current especially high current as well as the measurement of position of the proximity sensor measurement of power multiplication of the 2 signals. This all those things we will see what are the different applications areas of this all effectors users.

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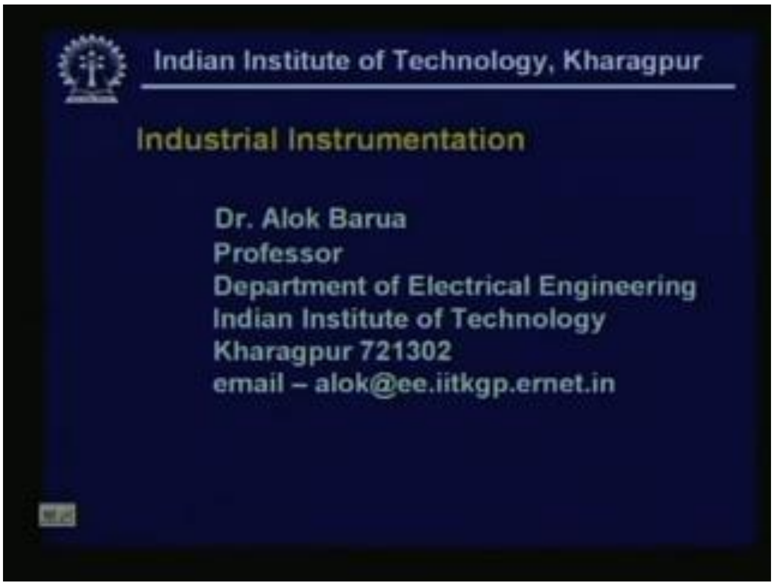


Let us look at the contents and all those things.

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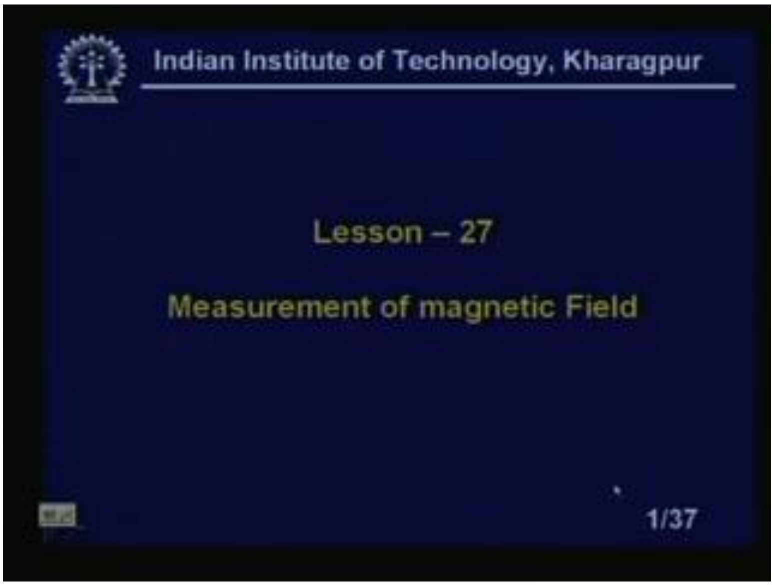

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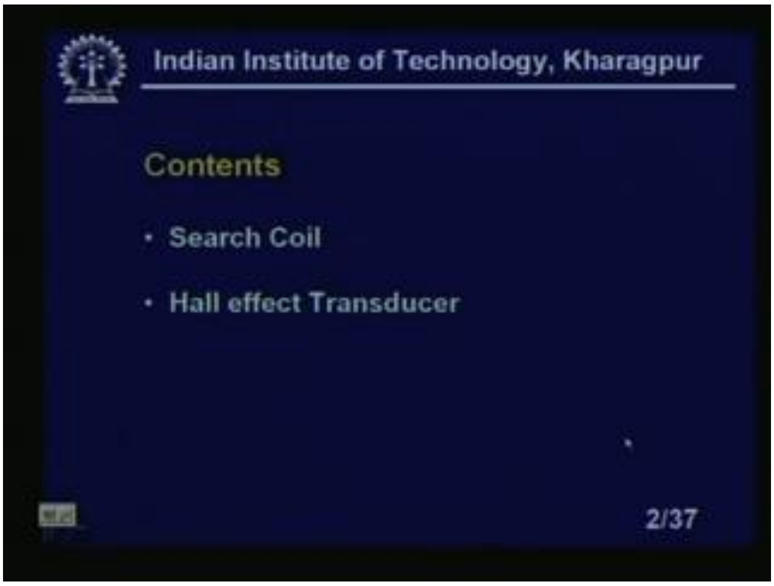


Contents are search coil magnetometer; search coil will basically discuss here. So, magnetometer search coil looks like this that you have a as we know that if a magnetic field that if you know some coil anywhere some voltage will be develop. So, using that principle that voltage will measure and that voltage will be calibrated in terms of magnetic field. If the other things remains constant; obviously, we find that the output voltage will directly proportional to the magnetic field. So, that is the search coil or magnetometer search coil sometimes people call magnetometer search coil sometimes we call it simple search coil right. And second transducers, we will consider in details is half effect transducers as I many times amplifies or something like. That means, I will apply magnetic field which is coming through this going out this right I am applying a current electric current which is entering through this and going out of this. That means, I have applied some voltages that it is in some current is flowing. If I apply a voltage magnetic field here we will find that across these 2 surface this and this a potential will be developed that potential is actually we call it half coefficient right.

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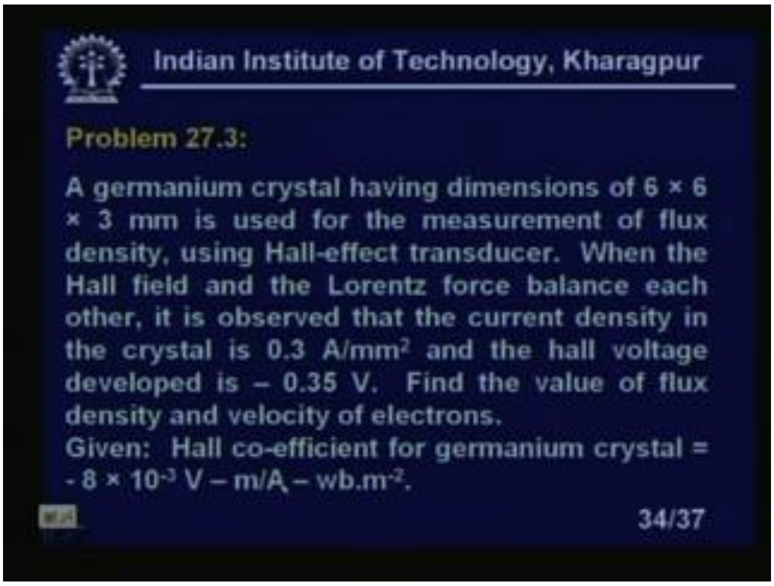


Let us look at the problem again this is our problem. So, given hall coefficient for germanium crystal equal to minus 8 into 10 powers minus 3 volt meter ampere Weber meter square.

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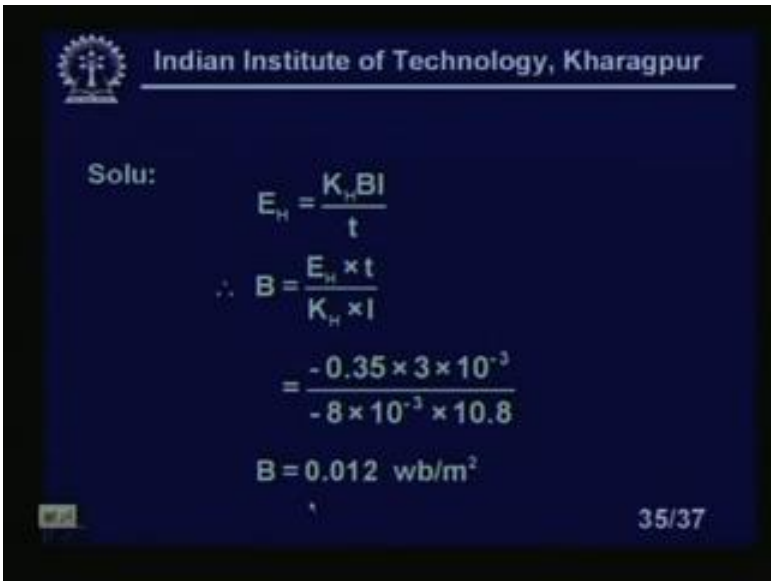


Solutions; Eh equal to KhBi by t we have seen. So, B equal Eh into t by Kh into I. So, this you just put all this value of B. So, B equal to 0.012 Weber meter squared.

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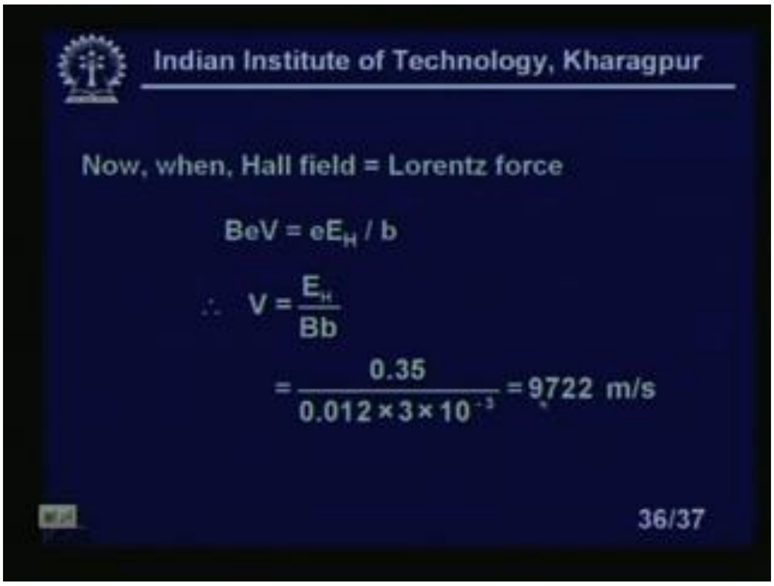


So, now, when the half field equal to Lorenz force must have a balance. So, I can write it is the moment of the velocity; V is the velocity of the electrons inside the all sensors. So, eEh by b. So, V equal to Eh by B by small b let me go, yes. So, which will give you the speed of the electrons as 972 these are all the dimensions of the hall plates, b is the dimension hall plates 9722 meter per second. With this I come to the end of the lesson 27 of industrial instrumentation.