SNS COLLEGE OF ALLIED HEALTH SCIENCES- COIMBATORE 35

DEPARTMENT : RADIOGRAPHY AND IMAGNG TECHNOLOGY

SUBJECT : GENERAL PHYSICS, RADIATION PHYSICS AND PHYSICS OF DIAGNOSTIC RADIOLOGY

PAPER : PAPER II (UNIT 5 – PHYSICS OF DIAGNOSTIC RADIOLOGY : X-ray TUBE)

TOPIC : 1. kV and mA circuit – X-ray Tube

Kilovoltage (kV) CONTROL CIRCUIT

- The kilovoltage applied across an X-ray tube determines maximum energy and hence, the penetrating power of the X-rays.
- To have a wide range of penetrating power of X-rays, the applied kilo voltage must be varied in small steps.
- By using a kilovoltage circuit, the kilovoltage can be varied in steps of say 2 kVp.
- A simplified kilovoltage circuit is shown in Figure.
- The circuit has two transformers, namely, an autotransformer and a step-up transformer The autotransformer is actually the kV_p selector and is located in the control panel.
- The voltage across the primary coil of the step-up transformer can be varied by selecting the suitable number of turns in the auto transformer.

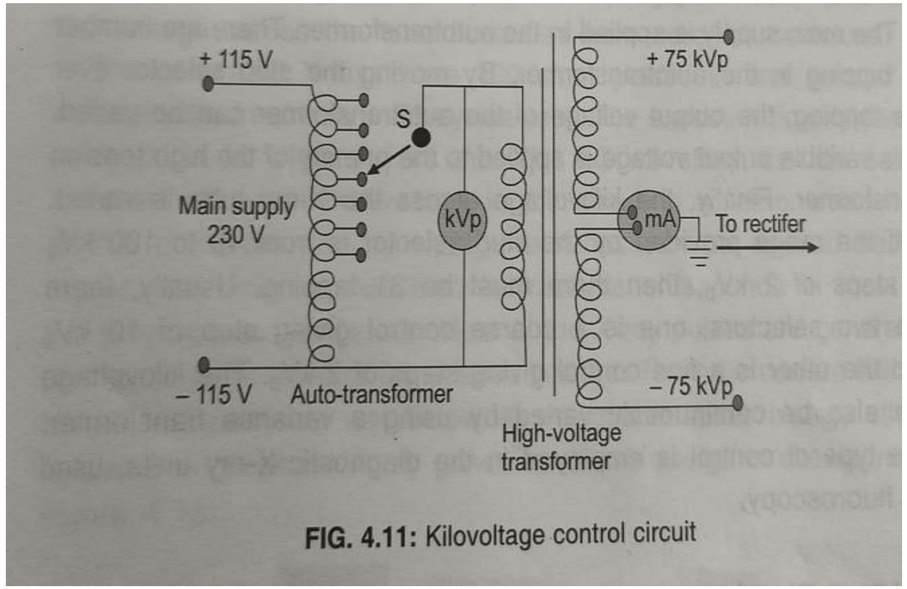
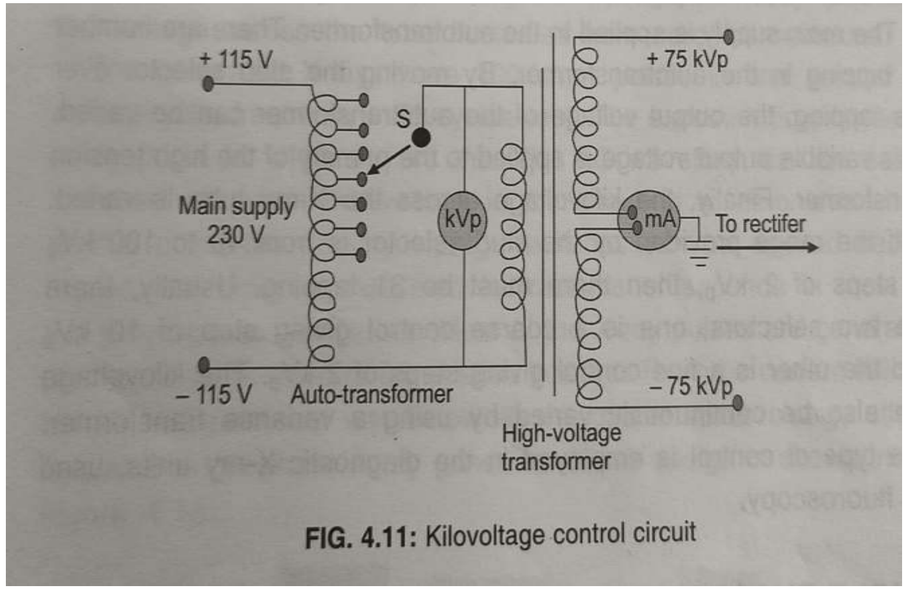


FIG. 4.11: Kilovoltage control circuit

Kilovoltage (kV) CONTROL CIRCUIT

- The secondary coil of the step-up transformer has more turns than primary, and increases the voltage by a factor of 600.
- The potential difference across the secondary coil may be as high as 150,000 V, so the step-up transformer is immersed in oil for maximum insulation.
- There are two meters in the circuit, one to measure kV_p (voltmeter) and the other to measure mA (ammeter).
- The meters are located on the control panel, but their connections are in the high voltage circuit.
- They indicate the potential across the X-ray tube and the actual current flowing through the tube during exposure.



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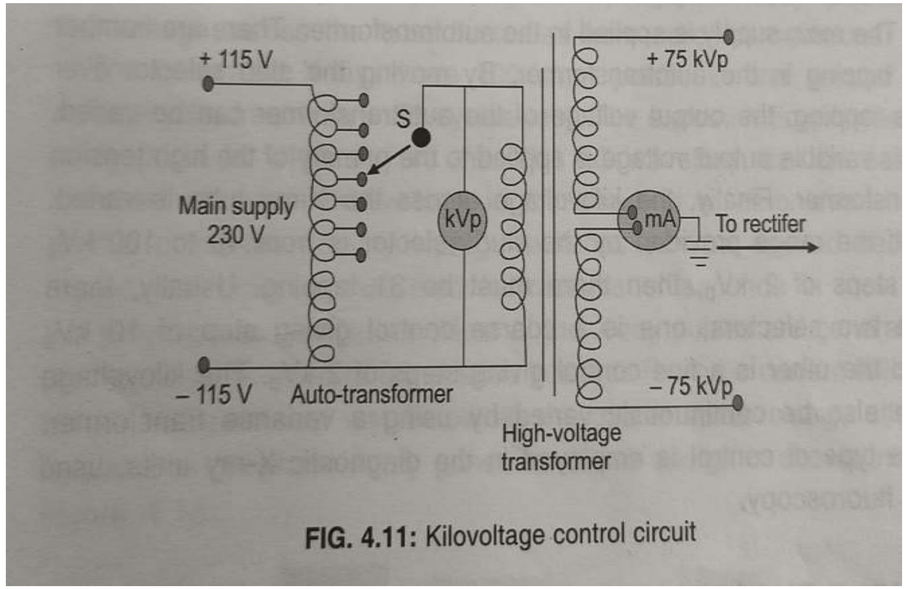
Kilovoltage (kV) CONTROL CIRCUIT

- The potential difference across the X-ray tube can be measured indirectly on the low voltage side of the transformer.
- Therefore, the kV_p meter is placed in the circuit between the autotransformer and step-up transformer Because the kV_p meter records the selected kV_p before the actual exposure begins it is usually termed as pre-reading kV_p If the kV_p meter is properly calibrated, it can directly read the applied voltage across the X-ray tube.
- Since the voltage in the primary circuit is relatively small, the meter can be placed on the control panel. This requires minimum insulation without any risk of electrical shock.



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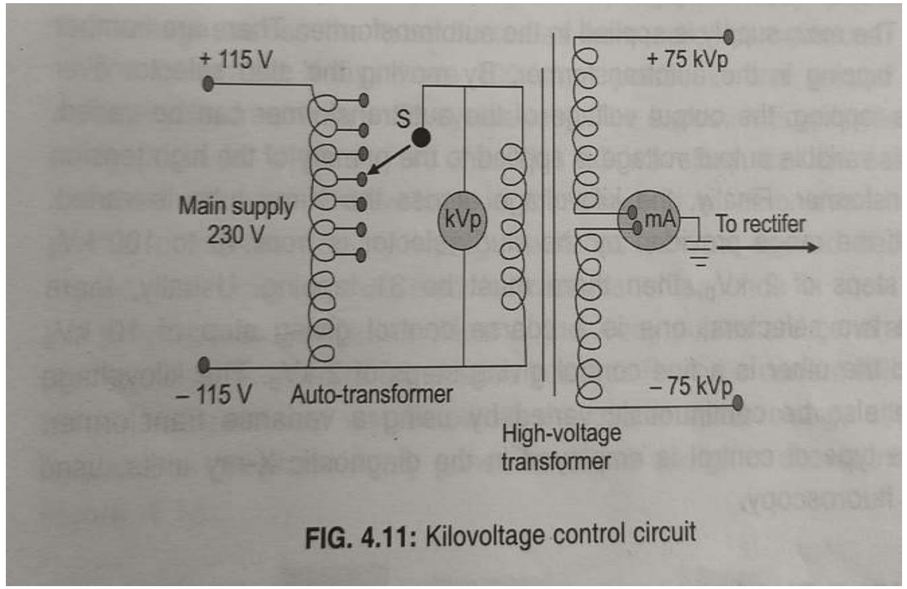
Kilovoltage (kV) CONTROL CIRCUIT

- The connections for the mA meter must be in the secondary winding of the transformer.
- Since the efficiency of the transformer is less than 1, measurement at primary level is not the true representation of the current in the secondary.
- Hence, the mA meter is connected at the center of the secondary coil, at which the transformer is grounded.
- This will minimize the risk of electric shock to the operator, since the center of the coil is at zero potential.
- Though the meter is connected at this point, it may be placed at the control panel.



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Kilovoltage (kV) CONTROL CIRCUIT

- The main supply is applied to the autotransformer. There are number of tapping in the autotransformer.
- By moving the stud selector over the tapping, the output voltage of the autotransformer can be varied.
- This variable output voltage is applied to the primary of the high tension transformer.
- Finally, the kilovoltage across the X-ray tube is varied. If the range provided by the stud selector is from 40 to 100 kVp in steps of 2 kVp, then there must be 31 tapping.
- Usually, there are two selectors, one is a coarse control giving step of 10 kVp and the other is a fine control giving steps of 2 kVp.
- The kilovoltage can also be continuously varied by using a variance transformer.
- This type of control is employed in the diagnostic X-ray units, used for fluoroscopy.

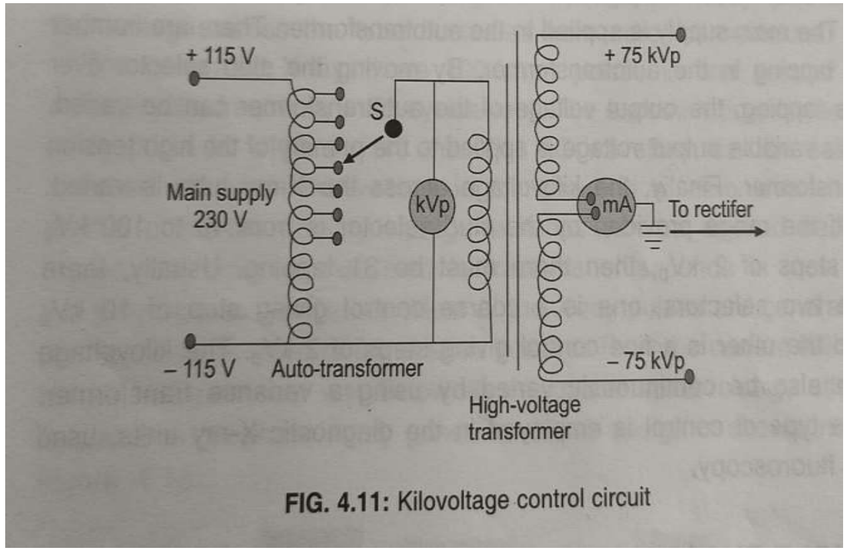


FIG. 4.11: Kilovoltage control circuit

Filament circuit (mA)

- The tube current can be altered by altering the number of electrons emitted by the filament.
- The number of electrons can be altered by changing the temperature of the filament. To achieve this, a filament circuit is used, which will regulate current flow through the filament (Fig).
- The power to heat the filament is provided by a small step-down transformer, called the filament transformer.
- In addition, the circuit consists of a variable resister network and a focal spot size selector. This transformer has 10-20 times more turns in primary coil, compared to secondary coil. The filament is connected directly to the secondary coil of a step-down transformer.
- The primary coil of the transformer obtains its voltage from the auto transformer. Usually, the primary voltage will be around 100-200 V, whereas the secondary voltage

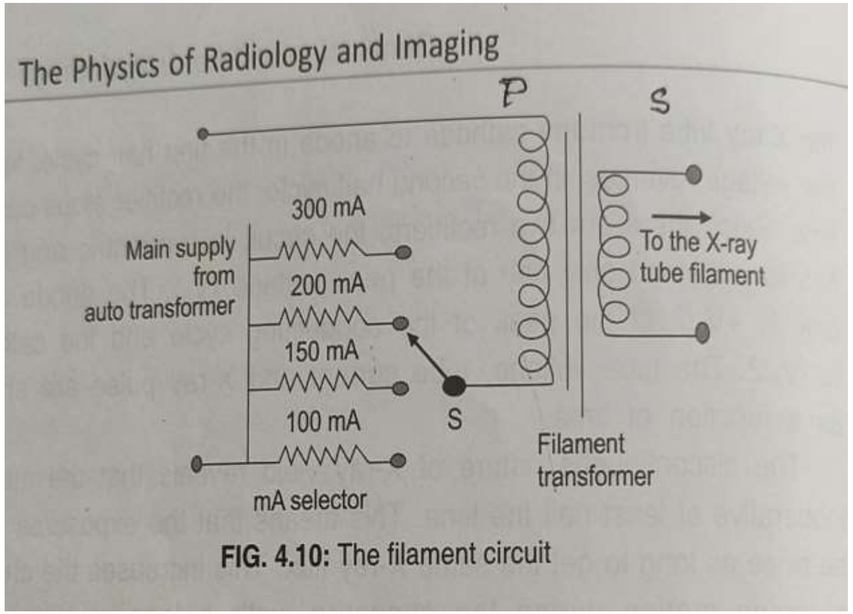
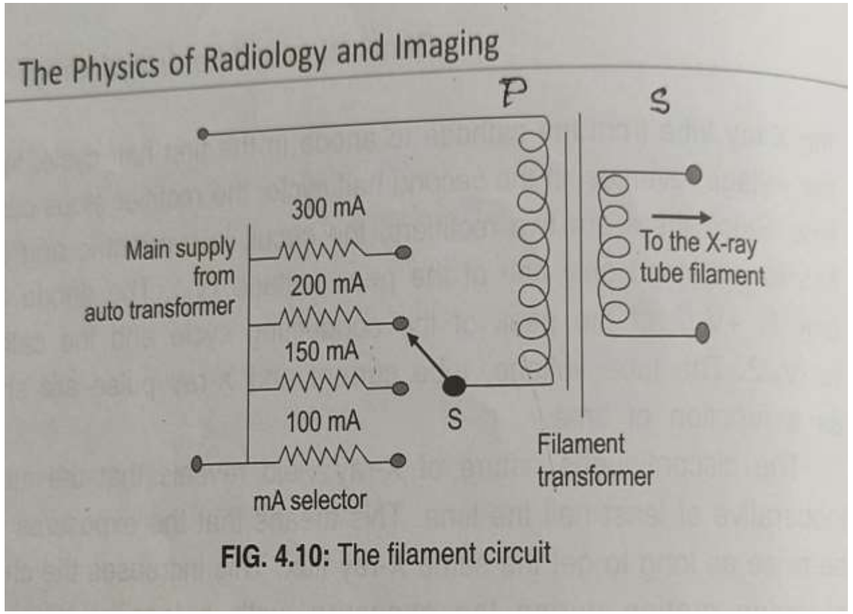


FIG. 4.10: The filament circuit

Filament circuit (mA)

- The power to heat the filament is provided by a small step-down transformer, called the filament transformer.
- In addition, the circuit consists of a variable resister network and a focal spot size selector.
- This transformer has 10-20 times more turns in primary coil, compared to secondary coil. The filament is connected directly to the secondary coil of a step-down transformer.
- The primary coil of the transformer obtains its voltage from the auto transformer. Usually, the primary voltage will be around 100-200 V, whereas the secondary voltage is around 10 V and current up to 7A.
- This makes it necessary to provide high voltage insulation between primary and secondary coils. Hence, the filament transformer is placed in the same oil-filled grounded metal tank as the high voltage transformer.



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Filament circuit (mA)

- Precise control of filament heating is very essential. A small variation in the filament current results in a large variation in X-ray tube current.
- A 5% change in filament voltage may bring a change of 20-30% in X-ray tube current. The filament current may be controlled, by altering the voltage to the primary of the step-down transformer, by addition of resisters connected in series.
- The resisters may be a number of separate resisters or a single variable resister. As the resistance increases, the voltage to the filament decreases. For example, a current of 4 A and a resistance of 1.5 ohms will reduce voltage by 6 V.
- When the selector S moves over the resisters, the primary voltage of the transformer is altered. As a result, different values of tube current (mA) are obtained. The selector is either a rotary switch or a push button located on the control panel. The circuit also has other components to stabilize the voltage to the filament transformer that includes a voltage stabilizer and a frequency stabilizer. There is also a circuit that automatically compensates for the space charge effect.

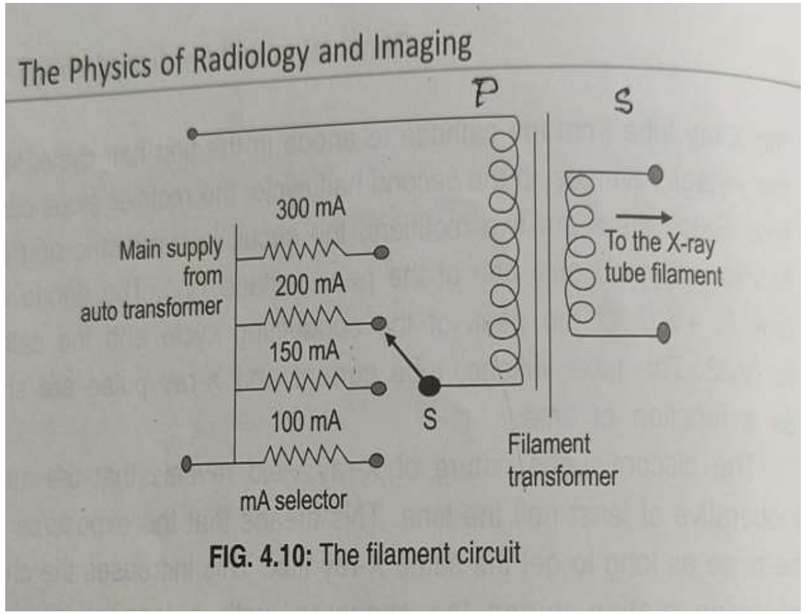

FIG. 4.10: The filament circuit

INTERROGATIONS

1. The difference between kV and mA circuit in X-ray tube
2. What dose the kVp and mA control in the X-ray tube ?
3. How dose kV and mAs effect image quality ?

INTERROGATIONS

1. What is Attenuation ?
2. What is Absorption ?
3. What is Scattering ?

REFERENCES

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THANK YOU