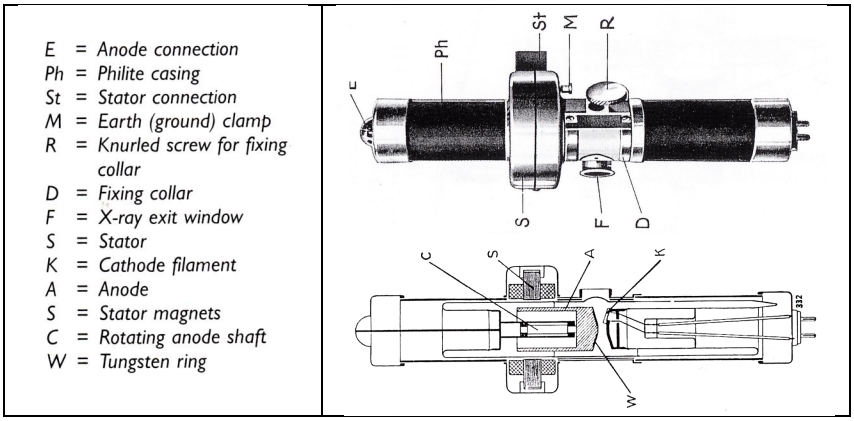
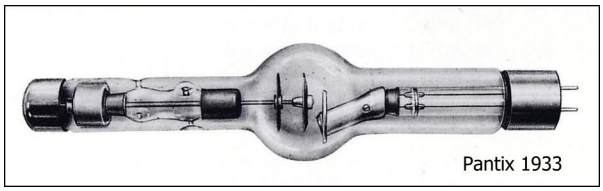
An Introduction to Rotating Anode Tubes

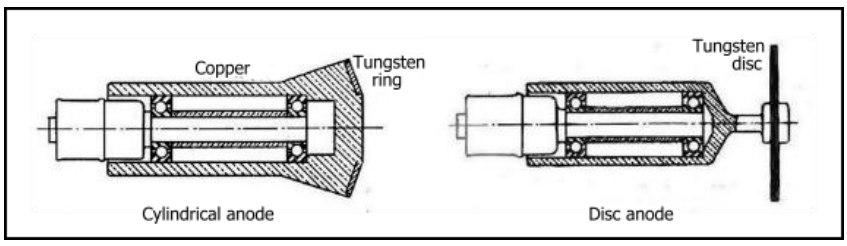
Since the discovery of x-rays by Roentgen on Nov. 8, 1985, and until the late twenties, all x-ray tubes were of the fixed focus type, and all anodes (anti-cathodes) suffered from some overheating, and sometimes total destruction of the target. In an x-ray tube the x-ray photons produced total only some 1% of the energy consumption, while the rest of the energy is converted into heat. There have been many theoretical suggestions for making larger targets and have them rotate during exposure in order to spread the exposed part of the target and avoid overheating, but the first usable rotating anode tube, the "Rotalix", was designed by A.Bouwers, and made by ***Philips*** in 1929, where the anode was a heavy tungsten-tipped copper cylinder acting somewhat as a heat sink. The anode rotated like a rotor in an electric motor, by the action of an external stator around the tube.



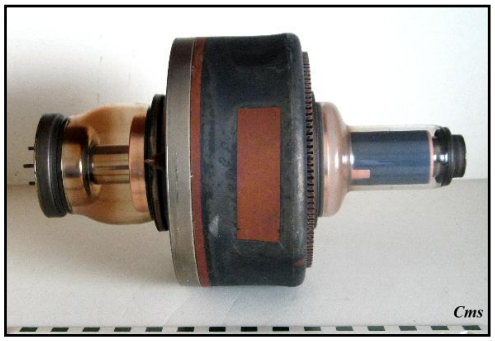
Adopting a similar principle***, Siemens*** introduced in 1933 their first rotating anode tube, the "Pantix" where the cylindrical anode was replaced by a tungsten rotating disc.



On the American continent, the rotating anode tubes were produced by the late thirties by ***General Electric*** and by ***Eureka.*** The anodes were made of heavy tungsten-tipped copper cylinders as inspired by the Philips "Rotalix" but with a somewhat modified shape. These tubes had an externally different shape from European tubes, which became standard in the x-ray tube industry until the present days. Also, the cylindrical anode was soon abandoned and replaced by the tungsten rotating disc, which has equally become the standard in rotating anode tubes all over the world.

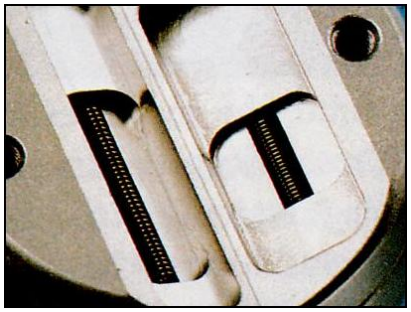


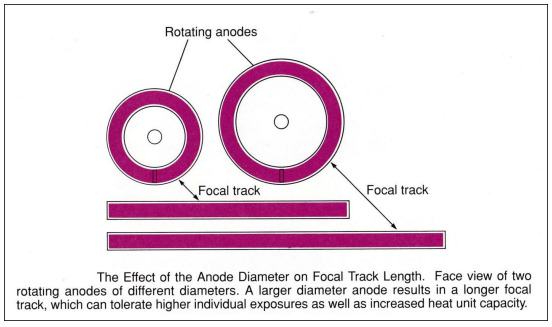
Outer bodies of rotating anode tubes for general use are mostly made of glass but tubes of high output are often made of a combination glass-metal or glass-ceramic. The metal used is most glass metal tubes is often made of a special alloy of iron, nickel and cobalt (usually known as "kovar").



Glass-metal x-ray tube

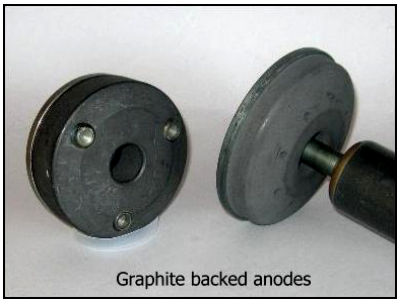
Rotating anode tubes are built with two focal spots, a large spot and a small spot, with an independent focused filament for each spot. The focal spots use either the same track on the tungsten anode disc, or are focused on two independent concentric tracks. The size of the anode disc size depends on the required performance of the tubes. The larger the disc, the longer is the track.



The small and large focus filaments
focused for double or single tracks



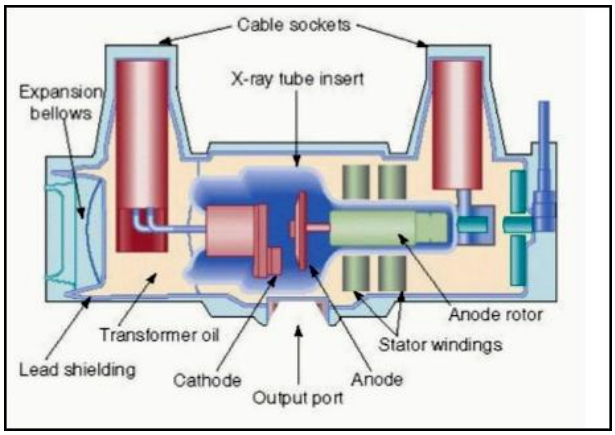
The Effect of the Anode Diameter on Focal Track Length. Face view of two rotating anodes of different diameters. A larger diameter anode results in a longer focal track, which can tolerate higher individual exposures as well as increased heat unit capacity.

In modern high power tubes there are some variations in anode target materials, but they are all tungsten based, some are made of Rhenium-Tungsten, some are Molybdenum backed or graphite backed. Mammography tubes are an exception: they have Molybdenum anodes, but in some tubes there are also Rhodium anodes for use with denser breasts.

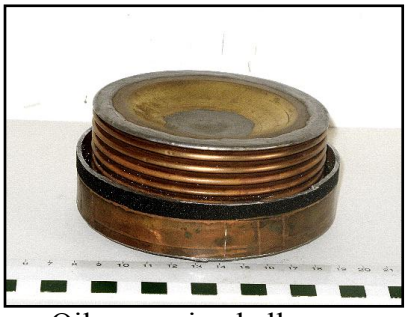
All X-Ray tubes are oil-immersed in a tube-head containing an insulating oil which serves equally as a heat absorber providing some cooling to the tube. The tube-head is lead-lined interiorly to stop any stray radiation into the room, with the exception of the x-ray port where the radiation is controlled by a filter and by an adjustable diaphragm. The tube-head contains also the anode stator controlling the rotation of the anode at speeds between 3000 and 9000 rpm. It contains as well as a special metal bellows device protecting the unit when oil expands with heat.

Typical rotating anode tube-head



Schematic picture of a rotating anode tube-head

Stator windings



Oil expansion bellows