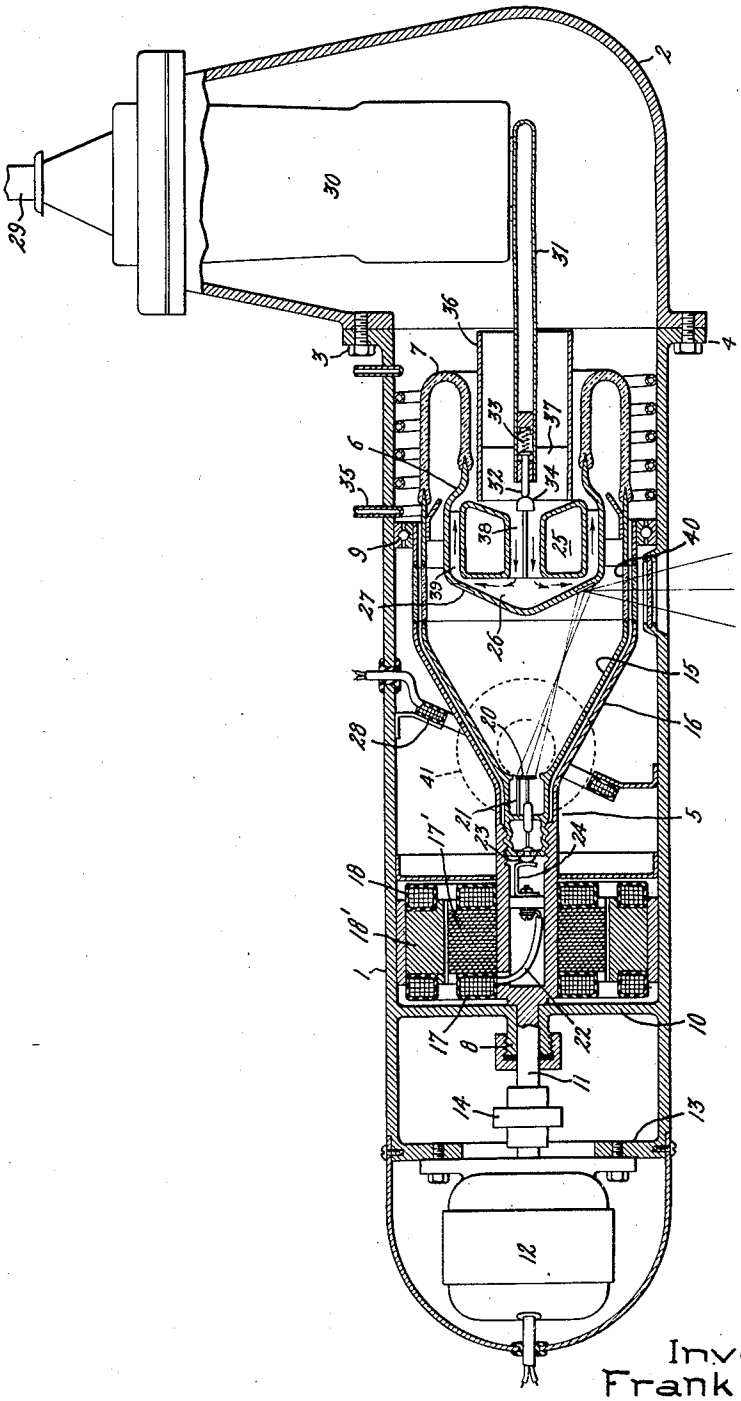
Jan. 3, 1950 F. WATERTON 2,493,606

X-RAY APPARATUS

Filed June 1, 1946



Inventor:
Frank Waterton,
by Harry E. Dunkam
His Attorney.

Patented Jan. 3, 1950 2,493,606

UNITED STATES PATENT OFFICE

2,493,606

X-RAY APPARATUS

Frank Waterton, Manchester, England, assignor, by mesne assignments, to General Electric Company, a corporation of New York

Application June 1, 1946, Serial No. 673,722
In Great Britain June 11, 1945

2 Claims. (Cl. 250—148)

1

The present invention relates to X-ray apparatus which is constructed to be capable of sustained and powerful output of X-rays for diagnostic, crystallographic, industrial or other purposes. In such apparatus it is necessary to provide against excessive heating of the target area which may cause fusion and vaporation of target metal. The object of the invention is to provide an improved apparatus wherein constant shifting of the area of impingement of the cathode rays on the target occurs, thus increasing the area of X-ray generation on the target and consequently of heat dissipation without increasing the size of the focal spot.

The improved X-ray equipment of the present invention is constructed to provide for simultaneous rotation of both the cathode and the anode structures within a stationary sealed housing containing an insulating fluid. My invention also includes improved structural features, such as provision of means within the housing for deflecting the beam of cathode rays out of its normal axial position. When the beam of cathode rays is held stationary in a deflected position and the anode rotates the heating effect of the focal area is dispersed over a relatively large annular area on the target whereby the load capacity of the X-ray apparatus becomes substantially greater than that of an apparatus with a fixed focal area.

Other features of novelty in the improved X-ray apparatus described herein will be pointed out in the appended claims.

As will appear hereinafter one of the novel features of the present device consists in the provision of means for heating the cathode by current generated within the enclosing envelope by a generator which is activated by the rotation of an X-ray generating device. Novelty target cooling constructions also are included.

The accompanying drawing is a longitudinal section of an embodiment of my invention.

This drawing shows a sealed housing consisting of a tubular main portion 1 and an end cap 2 which is bolted to the portion 1 as indicated at 3 and 4. The housing may consist of metal or other suitable material. In the tubular portion 1 is mounted a rotatable X-ray structure consisting of a cathode assembly 5 and an anode assembly 6. The assemblies are mounted on a shaft and are connected to one another at the anode end by a reentrant insulator 7 which ordinarily consists of glass, thereby forming a sealed envelope. This rotatable X-ray device is supported on bearings 8 and 9. The sleeve bearing 8 is supported on a diaphragm 10 extending from the walls of the

2

housing 1 and the fixed member of a roller bearing 9 is mounted directly on the wall of the housing 1. The cathode and anode assemblies are mounted on a driving shaft 11 which is connected for rotation to an electric motor 12, the latter being supported as indicated on wall extensions 13 of the enclosing housing. The motor is insulated from the X-ray cathode by an insulated coupling 14. The space surrounding the motor 12 and the coupling 14 may or may not be filled with insulating liquid.

The cathode assembly comprises a funnel-shaped envelope 15 which is supported within a cradle 16 of similar shape. The outer thin rim of the flared end of the metal envelope 15 is sealed to the glass insulator 7. On the small bore tubular end of the rotating cradle 16 are mounted the electric rotor coils 17 and the magnetic core 17' of an electric generator. The stator coils 18 and the annular fixed magnetic core 18' of the generator are mounted on the wall of the envelope 1, the core having inwardly directed salient field poles carrying the exciting windings. An electric current of suitable voltage for heating the cathode filament 20 to electron emitting temperature is furnished by the generator during rotation. The generator is connected to the cathode by conductors 21 and 22, the former being shown only in part as the circuit is completed through the metallic cradle 16.

Advantageously the X-ray tube is releasably secured in its cradle 16, for example, by screwing the cathode end of the cathode assembly into a correspondingly screw-threaded portion of the cradle 16. One end of the filament is connected with said screw-threaded part of the envelope, which in turn is earthed. The other end of the filament is connected to a terminal clip 23 adapted to be engaged by a spring-pressed contact 24 which is connected to one lead of the rotor winding, the other lead of the latter being earthed.

The anode may be constructed as shown of an inwardly directed substantially cup-shaped member, which consists partly of a shell 6 of copper, or other metal of good heat conductivity surrounding circulating vanes 26 and a cathode-ray receiving layer 27 of tungsten, or other suitable refractory metal. It is also contemplated to supplement the tungsten ring, by other metal targets, for example chromium, a ferrous alloy, or even a copper surface, and to arrange for the electron beam to be moved to a desired target surface by altering the orientation of a magnetic coil 28 whereby the electron beam is focussed and de-

flected or by altering the excitation of the coil 28.

The anode 6 is electrically connected to the external terminal 29 by a conductor (not shown) passing through an insulator 30 which is sealed into the housing member 2 and is electrically connected to a tubular conductor 31. The electrical butt contact 32 is urged by the spring 33 into frictional engagement with the rotating contact 34 which is mounted on the baffle 25. The circuit is completed through the grounded casing 1.

The space within the external casing is filled with mineral oil or other suitable insulating liquid which envelops the rotating X-ray device. Heat is abstracted by circulation of a cooling medium through the cooling coil 35 which is immersed in the cooling medium. Attached to the anode 6 and thus rotating with it are disposed radial vanes 26 forming an impeller adapted to enforce circulation of oil through the tubular baffle 36 against the back of the anode. The oil may be arranged to pass into the interior of the hollow baffle 25 by openings 38 and from thence out through opening 39 into the narrow space between the baffle 36 and the reentrant tubular attachment which supports the anode. Baffle 36 is supported from conductor 31 by radial vanes 37.

Advantageously the X-ray transmitting windows 40 in the envelope 15, the cradle 16 and the housing 1 are disposed to be substantially parallel with the axis of rotation of the co-operating electrodes. Preferably the surface of the target is acutely inclined with respect to the tube axis through an angle approaching 90°. Although the focal spot is attenuated by the angle at which the electron beam strikes the target so as to be relatively long in a radial direction, nevertheless it subtends a relatively small angle when viewed from the X-ray window to give the effect of a focal spot small in all directions. The result is that the penumbra at the edges of the shadows cast by the X-ray beam will be small.

Various changes may be made in the described apparatus without departing from my invention. For example, instead of a single magnetic coil 28 which combines the functions of focussing and directing the beam of cathode rays, two coils 41 may be used which respectively perform these functions. Instead of encircling the beam of electrons the coils may be disposed with their axes inclined substantially at right angles to its general direction. It is also feasible to utilize well known electrostatic means for focussing the electron beam and electromagnetic means for directing the beam.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. An X-ray apparatus comprising the combination of a sealed housing, a thermionic X-ray device rotatably mounted therein, a liquid insulating medium in said housing enveloping said X-ray device, a motor within said housing arranged to rotate said device, and a generator located within said housing and having a rotor mechanically connected to said motor and electrical connections for furnishing current from said generator to a cathode of said X-ray device.

2. An X-ray apparatus comprising the combination of a sealed housing, an X-ray device rotatably mounted therein having co-operating electrodes having respectively a cathode and target functions, a liquid insulating medium surrounding said device, a motor also contained within said housing mechanically connected to said X-ray device for rotation thereof, means contained in said housing for deflecting from a normal path an electron discharge in said X-ray device whereby X-rays are generated from successive areas of said target electrode and an electric generator also located in said housing and being operatively disposed and connected to furnish current for heating the cathode of said X-ray device.

FRANK WATERTON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,040,156	Slack et al.	May 12, 1936
2,090,582	Mesick	Aug. 17, 1937
2,121,630	Gross et al.	June 21, 1938
2,222,549	Verhoeff	Nov. 19, 1940
2,261,215	Bird	Nov. 4, 1941

FOREIGN PATENTS

Number	Country	Date
365,432	Great Britain	Jan. 21, 1932