

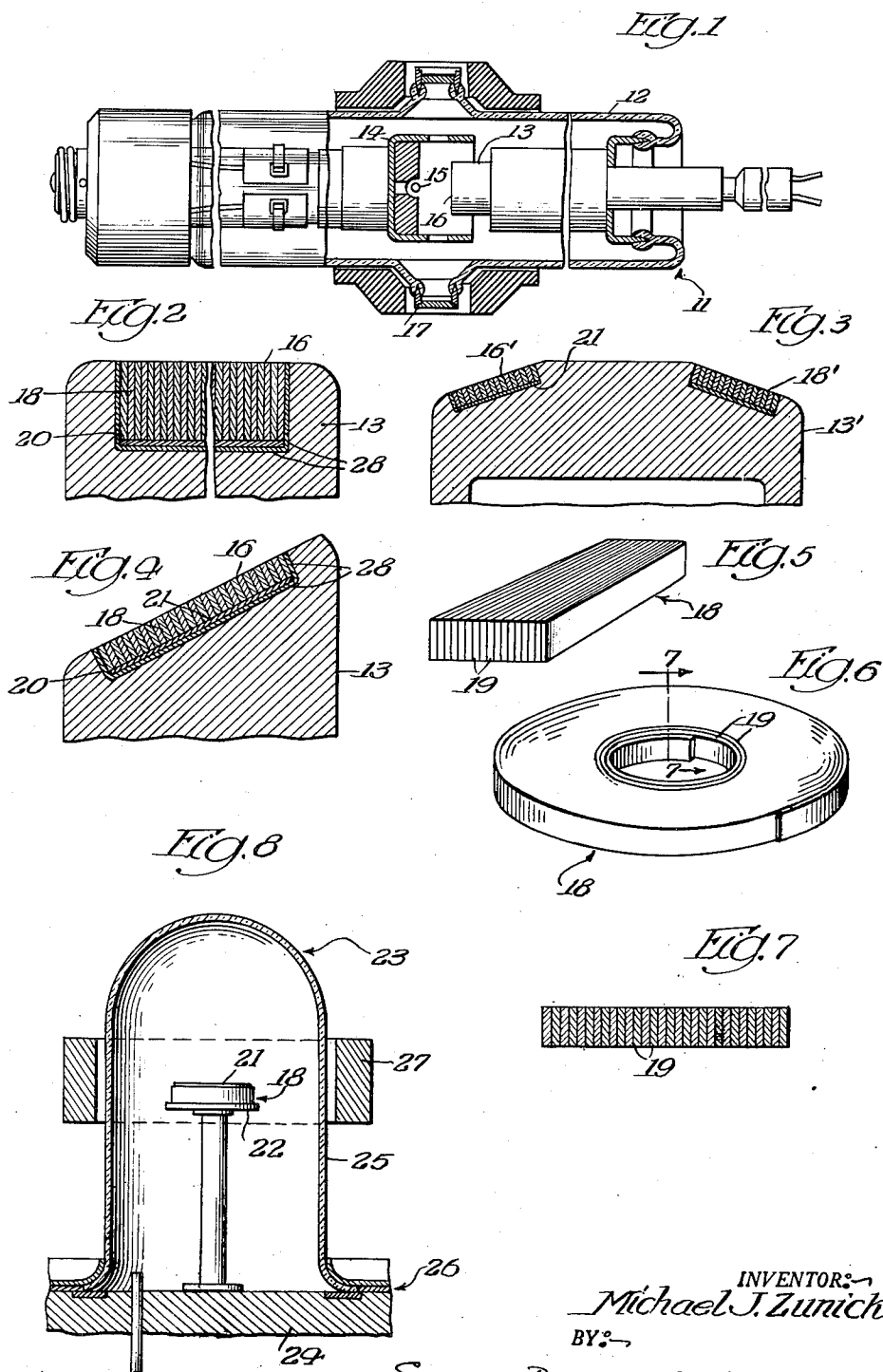
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ANODE CONSTRUCTION

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ANODE CONSTRUCTION

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1

The present invention relates in general to electronics, and has more particular reference to X-rays, the invention relating, in its specific aspects, to an improved electrode construction especially well suited for anti-cathodic service in X-ray generators.

X-rays may be generated by the impingement of electrons, emitted from a suitable cathode, upon an anti-cathode or anode forming an X-ray generating source. Such electron impingement upon a target surface of the anode results in grain growth in the anode material at the target surface due to heat, liberated in the anode as a result of electron impingement thereupon. Such grain growth results in deformation, splitting, cracking and curling of the anode material at the target surface, and consequent reduction of X-ray output, thereby impairing the operation of the generator.

An important object of the present invention is to provide an anode having an improved target highly resistant to deterioration, in service, under the impact of electron impingement thereon.

Another important object is to provide an anode structure presenting a target surface comprising anode material in dense condition having a particular grained structure and arrangement, and other characteristics whereby the anode is highly resistant to deterioration through target deformation, curling or cracking.

Another important object is to form a target as a laminated button or plate, in which the laminations are presented edgewise toward electrons impinging thereon.

Another important object is to utilize equiaxed material for the purpose of providing an electron target, such material comprising metal in completely recrystallized condition; a further object being to utilize material having crystalline structure wherein the constituent grains of the material are disposed in substantially parallel relationship, thereby presenting an "end grain" structure at the target surface to receive electron impingement.

Another important object is to provide an anode comprising a target button or plate mounted at the target carrying end of a support member of iron, nickel or copper, the target material being of heat resisting character, having a high melting point and being mounted on the support base which is preferably of copper, having high thermal conductivity; a further object being to utilize target material in substantially pure condition and to prevent seepage of the

2

material of the support member into and through the target member, during the service life of the anode, by coating the back of the laminated target member, which is secured to the support member, with a coating of material such as platinum, to isolate the end grain structure of the target member from the material of the support base.

The foregoing and numerous other important objects, advantages, and inherent functions of the invention will become fully understood from the following description which, taken in connection with the accompanying drawing, discloses preferred embodiments of the invention.

Referring to the drawing:

Fig. 1 is a sectional view taken through an X-ray generator fitted with an anode embodying the present invention;

Fig. 2 is an enlarged sectional view through an anode of the type embodied in the generator in Fig. 1;

Fig. 3 is a sectional view through an anode of the rotary type, embodying the present invention;

Fig. 4 is a sectional view through an anode of the stationary type embodying the present invention;

Fig. 5 is a perspective view of a rectangular laminated target button embodying the present invention;

Fig. 6 is a perspective view of a target disk embodying the present invention;

Fig. 7 is a sectional view taken substantially along the lines 7—7 in Figs. 5 and 6; and

Fig. 8 is a sectional view taken through an evacuated chamber in which target buttons are conditioned for mounting in anodes, in accordance with the present invention.

To illustrate the invention the drawings show an X-ray generator 11 comprising a sealed envelope 12 containing an anode 13 and a cathode 14 in facing relationship within the envelope. The cathode embodies an electron emitting filament 15 and is adapted to direct electrons emitted from said filament upon the facing target surface 16 of the anode for the generation of X-rays at said surface. Suitable conductors for energizing the filament 15 and for applying operating potential between the filament and the anode from an electrical power source, outwardly of the envelope, are, of course, provided.

The generator operates to produce X-rays at the target surface 16 as a result of the impingement, on said surface, of electrons emitted by and at the filament 15, said emitted electrons

being impelled toward and caused to impinge upon the target surface under the influence of operating electrical potential applied between the filament and the anode. The target surface may, as indicated in Figs. 1 and 2, be disposed in a plane normal to the path of electrons, or, as shown in Figs. 3 and 4, the target surface may be disposed at an inclination to such path, it being usual to dispose the target at an inclination in generators for producing X-ray for radiographic and diagnostic purposes. For other purposes, as in generators for X-ray diffraction analysis, the target is preferably disposed in a plane normal to the path of impinging electrons.

X-rays generated as a result of electron impingement on the target surface 16 may pass outwardly of the envelope in a radial direction through one or more transmitting windows 17 formed in the envelope walls opposite the target end of the anode. If desired, the entire generator may be enclosed in a casing of X-ray opaque material, provided with an opening or openings forming X-ray transmitting window means opposite the window or windows 17.

When the generator is in operation for the production of X-rays, a considerable amount of heat is developed at the target surface 16 as a result of electron impingement, such heat being dissipated through the body of the anode and thence outwardly of the envelope, the anode having an end extending outwardly of the envelope and provided, if desired, for the circulation of a cooling fluid through the anode which, in such case, may be hollow, or the outwardly extending anode portions may be provided with heat radiating fins for dissipation of heat to atmosphere outwardly of the envelope. The temperature at the target surface of the anode, however, may be of the order of the melting temperature of the target material, it being usual in the interests of operating efficiency, to operate the generator so that its anode, at the target surface thereof, functions at a temperature just short of the softening temperature of the anode material. When operated at such relatively high temperature there is a tendency for grain growth to occur in the anode material, such growth being evidenced by the peeling or curling of the anode material at the target surface, and consequent deformation of said surface from a desirable flat condition.

Various metals may be employed as electron targets, tungsten being commonly employed in diagnostic and radiographic generators, while copper and other metals may be used in generators for diffraction analysis. Certain of the novel features of the present invention have application regardless of the target material employed, and in this respect the invention is not necessarily limited to any particular target material and applies to inclined targets as well as targets that are disposed at right angles to the path of impinging electrons. A specific aspect of the invention, however, contemplates the utilization of platinum, columbium, tantalum, or molybdenum as target materials; and the invention, regardless of the target material employed, teaches a novel laminated target structure which, for optimum performance, comprises end grained material, and includes the structure and arrangement whereby the preferably high thermal conductive material of a support base structure is isolated and prevented from generating into and thus contaminating the material of the target element.

According to the present invention, the tendency

of the target surface to curl and peel in service is minimized by forming the anode, more particularly at the target areas thereof, to provide dense, uniform and chemically pure metal, preferably having a grain structure characterized in that the grains of the material extend parallel with respect to each other and in the direction of electron impingement upon the surface thereof. In such end grain structure the individual grains of the target material, at the target surface 16, are presented endwise toward the electron source 15. Electrons impinging upon an end grained surface strike the ends of the crystals of material forming the anode target, such end grain structure, because of the compact, dense character of the material, tending to prevent peeling and splitting along grain boundaries.

The target material, also, is equiaxed, that is to say, the material is in completely recrystallized condition as by heating the same for one hour at a temperature of the order of 1600° C.

As shown in Figs. 2, 4, and 5, the target comprises a block 18 of the selected target material, the block comprising strips of material forming laminations 19. The material of each strip is transversely grained whereby the constituent grain crystals are in parallel relationship extending in a direction transversely of the strip to provide an end grain structure at and along the longer edges of the strips. The strips are arranged in side-by-side stacked relationship, as shown more particularly in Fig. 5 of the drawings to comprise the block 18. The strips are secured together in any suitable fashion, more particularly as hereinafter described; and the block 18 may be mounted at the target end of the anode 13 as by forming a cavity 20 in said end and by securing the block 18 in the cavity, with an end grained block surface facing outwardly of the anode to provide the target surface 16.

As shown more particularly in Fig. 3 of the drawings, the target may comprise an annular member 18' formed by spirally winding upon itself a strip of preferably transversely equiaxed material, whereby the body of the member 18' may comprise side-by-side strip sections 19'. The member 18' thus comprises an annular flat ring, the convolutions of its constituent spirally wound strip being secured together in any preferred fashion and more particularly as hereinafter described. The flat disk 18' may be mounted in an annular cavity 20' formed in the target end of the anode which, as shown, comprises an anode 13' of the rotating type, the member 18' being secured in the cavity 20' in any suitable or preferred fashion.

The anodes 13 and 13' preferably comprise castings of any suitable material, such as copper, iron, nickel, and the like, copper being preferred because of its heat conducting characteristics; and the blocks 18 and 18' may be mounted by casting the supporting anode portions 13 and 13' upon and around said blocks in a suitable casting mold.

In order to maintain the constituent material of the target blocks 18 and 18' in pure uncontaminated condition after the same have been mounted in the supporting members 13 and 13', it is preferable to apply a protective coating of material, such as platinum, as a thin layer 21, at least upon the back end grained surfaces of the blocks 18 and 18', in order to prevent seepage, through such end grained surfaces, of the material of the support members 13 and 13'.

The protective layer 21 may be applied by

mounting the block 18 or 18' upon a suitable support plate 22 within a sealed compartment 23. This compartment may conveniently comprise a support 24 and a removable, preferably glass, bell jar 25 inverted upon the support 24 and having edge sealing means 26 to seal the jar 25 to the support to form the hermetic enclosure 23, which may be evacuated by a suitable connection preferably through the support 24 to an exhaust pump. A button or wire of platinum may be laid upon the surface of the member to be coated within the enclosure 23 and melted in place to flow upon and cover the surface to be treated by the action of an induction heating coil 27, which may encircle the jar 25 opposite the target block being coated. By melting the platinum button or wire, the melted platinum will flow upon and cover the end grained surface of the target member and may be allowed to harden in place.

Alternately, the layer 21 may be applied by vaporizing the metal and applying same, in vaporized condition to, and condensing it upon the surface to be coated; or the layer may be applied by spraying or sputtering the metal upon the surface. The surface also may be coated by electrodeposition in a suitable aqueous or fused plating bath.

After being coated, the target member may be mounted in position in the anode by casting the member 13, or 13', about the target button in a suitable casting mold. Alternately, as indicated in Figs. 2 and 4, the coated member 18, or 18', may be secured in the cavity 20, or 20', by means of a suitable attaching alloy 28 interposed between the surfaces of the cavity 20, or 20', and the cavity enclosed surfaces of the coated member 18, or 18', said attaching alloy forming a thin mounting layer integrating the target member with the anode base on which it is mounted.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the forms herein disclosed being preferred embodiments for the purpose of demonstrating the invention.

The invention is hereby claimed as follows:

1. An electron target comprising a laminated block of target material presenting laminations edgewise to form a target surface.
2. An electron target comprising a laminated block of equiaxed target material presenting laminations edgewise to form a target surface.
3. An electron target comprising a laminated block of target material presenting end grained laminations edgewise to form a target surface.
4. An electron target comprising a laminated block of target material presenting the laminations edgewise to form a target surface, the material of the laminations comprising a metal selected from the class group consisting of platinum, columbium, tantalum, and molybdenum.
5. An electron target comprising a laminated block of target material presenting the laminations edgewise to form a target surface, the material of the laminations comprising equiaxed metal selected from the class group consisting of platinum, columbium, tantalum, and molybdenum.
6. An electron target comprising a laminated block of target material comprising a metal se-

lected from the class group consisting of platinum, columbium, tantalum, and molybdenum, the material of said block having a grain structure providing an end grained target surface.

7. An anode for an X-ray generator comprising a laminated block of target material presenting laminations edgewise to form an electron target surface, said laminations having end grained structure at the electron receiving edges thereof.

8. An anode for an X-ray generator comprising a laminated block of target material selected from the group of metals consisting of platinum, columbium, tantalum, and molybdenum, said block presenting laminations edgewise to form an electron target surface, said laminations having end grained structure at the electron receiving edges thereof.

9. An anode for an X-ray generator comprising a laminated block of target material presenting laminations edgewise to form an electron target surface and an oppositely facing mounting surface, a support base to which said mounting surface is secured, and a layer of protective material covering said mounting surface in position interposed between said block and said base.

10. An anode for an X-ray generator comprising a block of target material forming a target surface and an oppositely facing mounting surface, said block having end grain structure at said surfaces, a support base to which said mounting surface is secured, and a layer of platinum coated on said mounting surface in position extending between said block and said base.

11. An X-ray generator embodying an anode comprising a laminated block of target material presenting laminations edgewise to form an electron target surface.

12. An X-ray generator embodying an anode comprising a laminated block of target material presenting laminations edgewise to form an electron target surface, said laminations having end grain structure at the electron receiving edges thereof.

13. An X-ray generator embodying an anode comprising a laminated block of target material presenting laminations edgewise to form a target surface, a support base on which said block is mounted in integral fashion, and a layer of protective material coating a base attached surface of said block in position interposed between the base and the block.

14. An X-ray generator embodying an anode comprising a laminated block of metal presenting laminations edgewise to form a target surface, a support base on which said block is mounted in integral fashion, and a layer of platinum coating a base attached surface of said block in position interposed between the base and the block.

15. An X-ray generator embodying an anode comprising metal strip material disposed spirally to provide an annular laminated block of metal presenting the laminations thereof edgewise at the face of the block to form a target surface, a support base on which said block is mounted in integral fashion, and a layer of platinum coating a base attached surface of said block in position interposed between the base and the block, said strip material being equiaxed and having its constituent grain crystals in parallel relationship and extending transversely thereof to provide end grain structure at the target surface forming edge portions of said strip material.

16. An X-ray generator embodying an anode comprising metal strip material disposed spirally

7

to provide an annular laminated block of metal presenting the laminations thereof edgewise at the face of the block to form a target surface, a support base on which said block is mounted in integral fashion, and a protective layer of metal coating a base attached surface of said block in position interposed between the base and the block, said strip material providing end grain structure at the target surface forming edge portions thereof.

17. An anode comprising metal strip material disposed spirally to provide a laminated block presenting the laminations thereof edgewise to form a target surface at a face of the block, a support base on which said block is mounted in integral fashion, and a protective layer of metal coating a base attached surface of said block, said strip material providing end grain structure at the target surface forming edges thereof.

18. An electron target comprising metal strip material disposed spirally to provide a laminated block of metal presenting the laminations thereof edgewise to form a target surface at a face of the block, said strip material being equiaxed and having its constituent grain crystals in parallel relationship and extending transversely thereof to provide end grain structure at the target surface forming edge portions of said strip material.

19. An electron target comprising metal strip material disposed spirally to provide a laminated block of metal presenting the laminations thereof edgewise to form a target surface at a face of the

8

block, said strip material providing end grain structure at the target surface forming edges thereof.

20. An electron target comprising metal strip material forming a laminated block having laminations providing edges disposed in a common plane to form a target surface, said strip material being equiaxed and having constituent grain crystals in parallel relationship and extending transversely thereof to provide end grain structure at the target surface forming edges of said strip material.

21. An electron target comprising metal strip material forming a laminated block having laminations providing edges disposed in a common plane to form a target surface, said strip material providing end grain structure at the target surface forming edges thereof.

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