Sept. 17, 1963 R. S. SYMONS 3,104,338

RIBBED COLLECTOR FOR COOLING KLYSTRONS

Filed July 27, 1960

FIG. 1

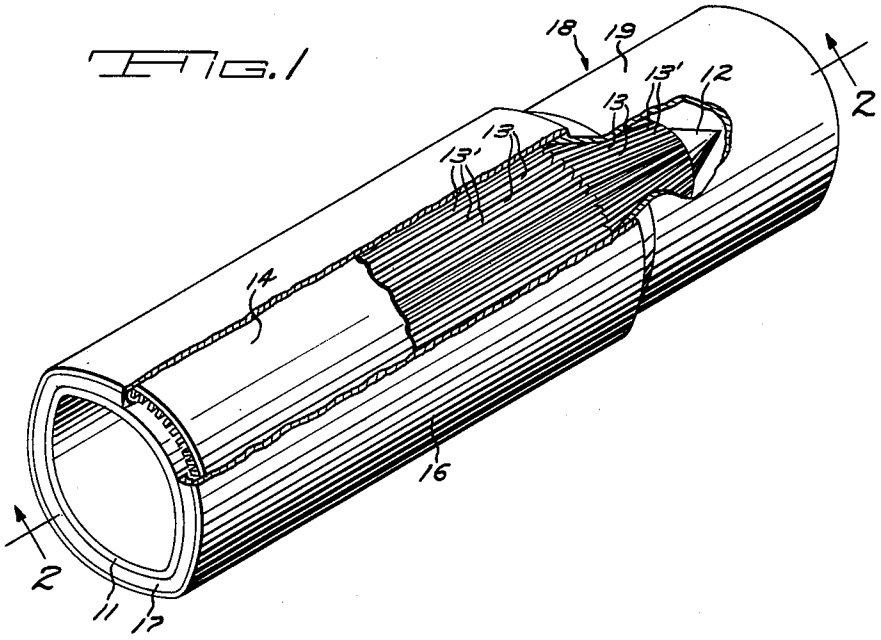


FIG. 2

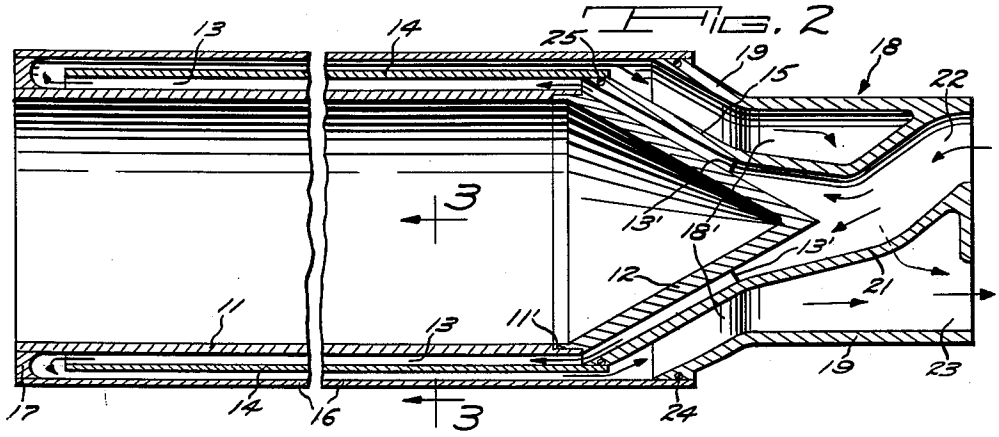
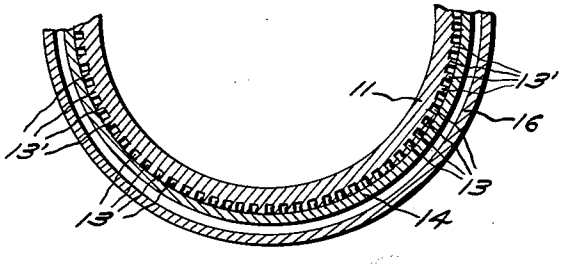


FIG. 3



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RIBBED COLLECTOR FOR COOLING KLYSTRONS

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This invention relates in general to electron tube apparatus and, more particularly, to a novel cooling system of the type employed in cooling the electron collector of electron beam type microwave tubes as, for example, high power klystron tubes or traveling wave tubes.

In the art of high frequency electron beam tubes, extremely high powers are being developed; for example, high power klystron tubes in a range of 0.400 to 0.450 kilomegacycles are now in use which produce peak output powers of 1.25 megawatts and average power outputs of 75 kilowatts. With this great amount of power output it can be readily seen that the amount of heat to be dissipated becomes more than substantial. Cooling systems become increasingly important in order to prevent the electrons which bombard the collector from rapidly burning through the collector and letting the tube down to atmospheric air pressure.

Accordingly, it is the object of this invention to provide a novel cooling system for the collector of a high power electron beam tube as, for example, a high power klystron.

One feature of the present invention is the use of a large number of coolant channels formed in the exterior of the collector wall and defining therebetween cooling fins of approximately equal height and width, and with coolant being forced through the channels to maintain uniform efficient cooling throughout the entire collector.

Another feature of the present invention is the method of providing the optimum amount of coolant to metal contact around the finned collector by making the coolant channels of a width less than the width of the fins, whereby flow of heat from the collector to the coolant fluid is facilitated.

Another feature of the present invention is the provision of an array of radially directed narrow coolant channels on the end closing wall of the collector for efficient cooling of the collector end wall and to decrease the mass of the end wall of the collector.

Other features and advantages of this invention will become apparent from a perusal of the specification taken in connection with the accompanying drawings wherein:

FIG. 1 is an isometric view partially broken way showing the coolant channels for flowing cooling fluid around the collector,

FIG. 2 is a foreshortened cross-sectional view of the structure of FIG. 1 taken along line 2—2 in the direction of the arrows, and

FIG. 3 is a fragmentary cross-sectional enlarged view of the collector assembly of FIG. 2 taken along line 3—3 in the direction of the arrows.

Referring now to the figures, the collector and novel cooling system of the present invention comprise a hollow open ended cylindrical collector 11 as of, for example, copper closed at one end by collector cone 12 as of, for example, copper which snugly fits as by brazing into a shoulder 11′ cut into the closed end of cylindrical collector 11. Formed as by machining into the exterior of cylindrical collector 11 and cone 12 are a large number of narrow, deep parallel and longitudinally directed channels 13 which form therebetween a number of short, thick fins 13′ of approximate equal depth and width extending most of the length of the collector 11 and cone 12. Closely fitting over the fins 13′, as by a shrink fit for example, is a hollow, open ended cylindrical baffle 14 of

a material having a low thermal conductivity for example, stainless steel which is lower than the thermal conductivity of the collector fins 13′. The baffle 14 is slightly spaced away from the open end of collector 11 and defines a longitudinally partitioned inner coolant annulus formed by the coolant channels 13. Surrounding baffle 14 is an outer wall jacket 16 formed by a hollow, open ended cylinder having an interior diameter slightly larger than the exterior diameter of baffle 14 and forming, with the baffle 14, an annular outer coolant annulus. Closely fitted between outer wall jacket 16 and the open end of collector 11 is a ring 17, which serves to support one end of outer wall jacket 11 and to reverse direction of fluid flow.

Carried at the closed end of jacket 16 is a manifold 18 which is sealed with an O-ring 24 into the inner diameter of housing 16 and with O-ring 25 into the inner diameter of baffle 14. Manifold 18 as of, for example, bronze, distributes and collects fluid for the system and consists of a cast outer cylinder 19 closed off at one end and having two apertures therein. Within outer cylinder 19 is a cast, funnel-like distributor member 15, the tube 21 of the funnel being welded into the entrant aperture 22 of the closed end of outer cylinder 19. The space between distributor member 15 and outer cylinder 19 serves as the fluid collector for the system with the other aperture 23 of the closed end of cylinder 19 providing an exit for the manifold 18. Both apertures 22 and 23 are fitted with quick disconnect adaptors (not shown).

During operation the fluid, normally water, is fed through aperture 22 through tube 21 into the coolant distributor 15. The apex of collector cone 12 acts as a separator for the water which then flows into the channels 13 in the exterior wall of the collector cone and therealong through the channels in the exterior of collector 11. The width and depth of the fins defined by channels 13 are approximately equal in dimension. The maximum water-to-metal surface is utilized so that cooling is evenly distributed over the entire collector. The fluid passes through the channels 13 towards the open end of the collector where the water collector ring 17 directs the water around the end of baffle 14 and back through the outer jacket 16 and baffle 14 and thence into water collector 18′ and out through the exit aperture 23.

It is noted that making the size of the fins deeper will not affect better cooling because of the rapid temperature drop along the length of the fin while making them wider would decrease the fluid to metal surface area. It is clear therefore that an optimum geometry exists when the fins are approximately equal in depth and width.

The radial array of narrow cooling channels on the exterior surface of the conical end closing member or wall 12 of the collector 11 efficiently removes the heat generated on the end wall 12 of the collector permitting the mass of the end wall 12 of the collector to be minimized.

It is further noted that whether the fluid enters into aperture 22 and out aperture 23 as shown with arrows in the drawings is a matter of choice and may be reversed.

Stainless steel is used in the baffle 14 between the inner and outer water annulus because of its poor thermal conductivity. This prevents heating of the incoming fluid by outlet fluid.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A collector for dissipating the energy of a high

velocity beam of charged particles including, a tubular collector electrode for receiving the beam incident thereon, a plurality of cooling fins defined by a plurality of peripherally spaced apart longitudinally directed channels on the exterior surface of said collector, a tubular baffle surrounding said cooling fins whereby said channels, said fins and said baffle define an interior longitudinally partitioned annulus, said tubular baffle being made of a material having a thermal conductivity less than the thermal conductivity of said fins, a tubular outer jacket surrounding said baffle and spaced apart therefrom whereby said baffle and said outer jacket define an exterior annulus and means communicating with said interior and exterior annulus for distributing an input and an output flow of coolant therethrough.

2. A collector for dissipating the energy of a high velocity beam of charged particles including, a tubular collector terminated by an inwardly converging end portion, a plurality of cooling fins of approximately equal width and depth, said cooling fins defined by deep, narrow, longitudinally running channels on the exterior surface of said collector, said tubular baffle being made of a material having a thermal conductivity less than the thermal conductivity of the material of said fins, a tubular baffle surrounding said cooling fins whereby an interior annulus is defined by said channels and baffle, said tubular baffle being made of material having a low thermal conductivity, a tubular outer jacket surrounding said baffle and spaced apart therefrom whereby an exterior annulus is defined by said baffle and said outer jacket, a manifold for distributing an input and output flow of cooling fluid for said interior and exterior annulus, said manifold including a hollow tubular outer distributor closed at one end, said outer distributor being apertured to provide a coolant inlet and outlet, the open end of said outer distributor mating with the outer jacket of said exterior annulus, an inner distributor means communicating with an aperture in said outer jacket at one end and surrounding the converging end portion of said collector and mating with the baffle of said interior annulus at the other end, and means for supplying and receiving coolant through the apertures in said outer distributor.

3. A cooling collector for dissipating energy of a high velocity beam of charged particles including, a tubular collector electrode for receiving the beam incident thereon, a plurality of cooling fins of approximately equal depth and width, said cooling fins defined by a plurality of peripherally spaced apart longitudinally directed channels on the exterior surface of said collector, a tubular baffle surrounding said cooling fins whereby said channels, said fins and said baffle define an interior, longitudinally partitioned annulus, a tubular outer jacket surrounding said baffle and spaced apart therefrom whereby said baffle and said outer jacket define an exterior annulus, said tubular baffle being made of a material having a thermal conductivity less than the thermal conductivity of the material of said fins, and means communicating with said interior and exterior annulus for distributing an input and output flow of coolant therethrough, said baffle of lower thermal conductivity acting to prevent a heat exchange between said output and input flow of coolant.

4. The collector according to claim 1 wherein the width of said longitudinally directed channels is less than the width of said cooling fins.

5. The collector according to claim 3 wherein the width of said longitudinally directed channels is less than the width of said cooling fins.

6. A collector for dissipating the energy of a high velocity beam of charged particles including, a tubular collector member for receiving the beam on the interior surfaces thereof, an array of longitudinally directed peripherally spaced apart cooling fins provided on the exterior surface of said tubular collector member, said fins defining between them an array of peripherally spaced apart longitudinally directed coolant channels extending lengthwise of said tubular collector member in a continuous manner over a preponderance of the length of said tubular collector member, a member surrounding said fins and channels whereby said fins, channels and said member define a first longitudinally partitioned cooling annulus, an end wall closing said tubular collector, an array of peripherally spaced apart elongated cooling channels provided on the exterior surface of said end wall and radiating out from the center of said end wall and defining therebetween a plurality of cooling fins, a member covering over said fins and channels on said end wall and defining a second cooling annulus, said second cooling annulus being in fluid communication with said first cooling annulus, and distributor means communicating with said first and second cooling annuli for distributing input and output flow of fluid coolant to said collector under pressure.

7. The collector according to claim 6 wherein said longitudinally directed fins on said tubular collector member are of approximately equal depth and width.

8. The collector according to claim 6 wherein said coolant channels on said tubular collector member have a width less than the width of said cooling fins on said tubular collector member.

9. The collector according to claim 6 wherein the coolant channels on said tubular collector member and said end closing wall have a width less than the width of said cooling fins on said tubular collector member and said end closing wall.

10. The collector according to claim 6 wherein said end closing wall is a hollow generally cone-like structure.

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