Aug. 4, 1959 D. B. MILLER 2,898,492

APPARATUS FOR AND METHOD OF COOLING BEAM TRANSMITTING WINDOWS

Filed Dec. 13, 1955

FIG. 1

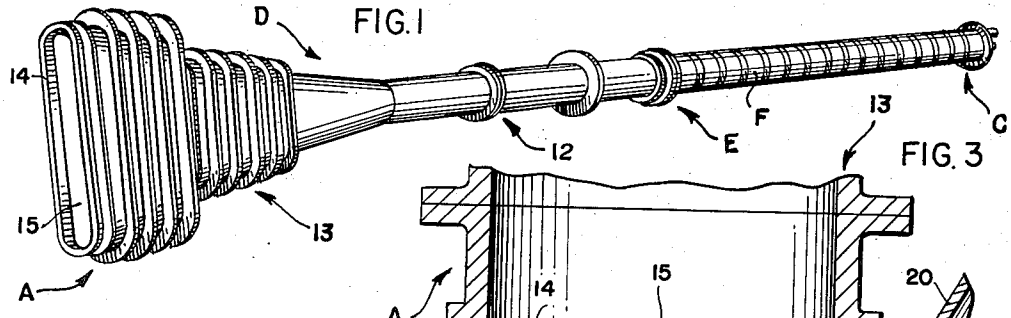


FIG. 3

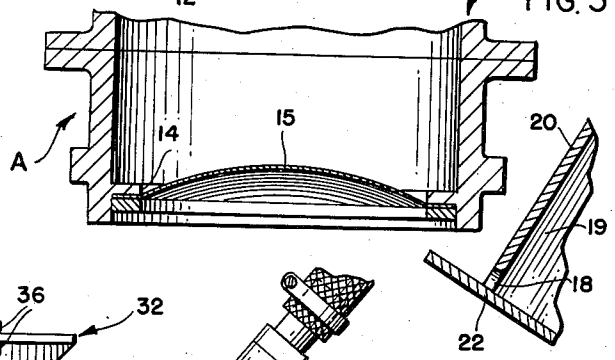


FIG. 2

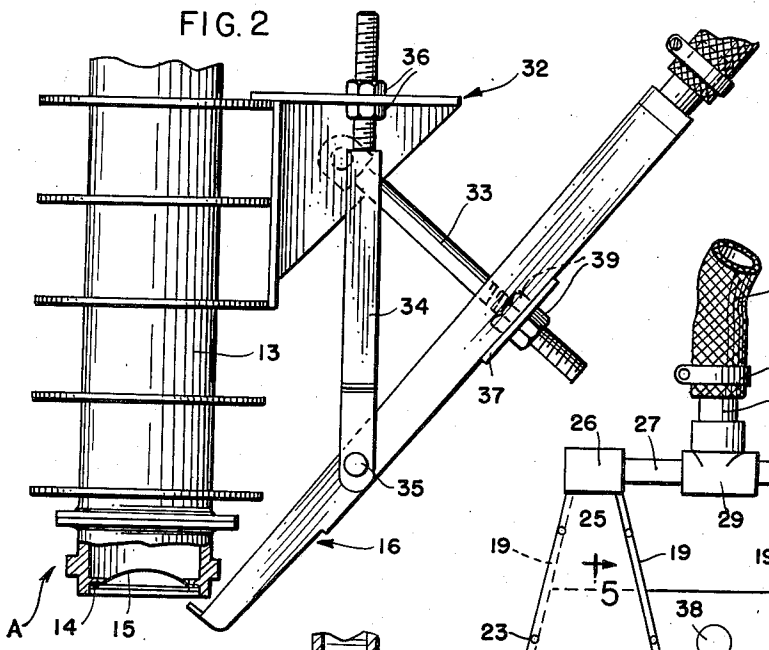


FIG. 4

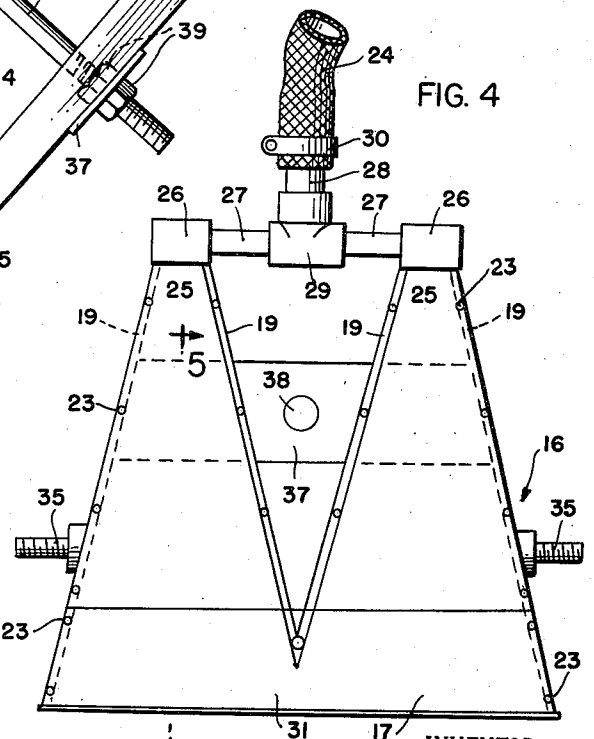
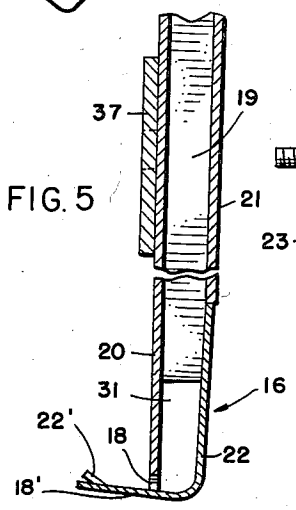


FIG. 5



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APPARATUS FOR AND METHOD OF COOLING BEAM TRANSMITTING WINDOWS

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6 Claims. (Cl. 313—74)

The present invention relates in general to electronics, and has more particular reference to improved means for and method of cooling beam transmitting window structures in which heat may be generated as the result of transmission of penetrating ray beams therethrough.

Penetrating ray beams, such as X-ray beams, electron beams and the like, are commonly produced in ray beam generators comprising electrodes usually mounted in sealed and evacuated envelopes, such envelopes being provided with windows of material that is substantially transparent to ray beams generated through the operation of the device in which the window is incorporated, whereby to allow the substantially unhampered emission of useful ray beams outwardly of the enclosing envelope through such emission windows. Such windows, of course, are not entirely transparent to penetrating rays transmitted therethrough, and consequently will become heated through absorption of a portion of the energy of rays transmitted therethrough. Such heating of the window may damage, destroy or otherwise deleteriously affect the window structure, especially where the transmitted ray beam is of high energy intensity, as in high voltage electron beam generating apparatus.

An important object of the present invention resides in providing relatively simple yet effective means for maintaining the emission windows of penetrating ray beam generators at safe temperatures while the generator containing the window is in operation; a further object being to provide effective means for cooling the electron emitting window of an electron generator.

Another important object is to provide relatively simple and inexpensive means for continuously applying a fluid cooling medium to a window of the character mentioned, whereby to maintain the same at a desired temperature; a further object being to provide for the continuous delivery of cooling fluid as a relatively thin layer across the surface of the window to be cooled; a still further object being to provide for applying a cooling fluid in gaseous condition across a window element to be cooled.

Another important object is to provide an improved nozzle structure for blasting a relatively thin, wide layer of a gaseous coolant across a window to be cooled; a further object being to apply the layer of coolant at an optimum cooling angle of the order of 45° with respect to the plane of the element, a still further object being to provide for the adjustment of the angle of attack of the coolant blast with respect to the window being cooled.

Another important object is to provide means for delivering a cooling fluid transversely across a window element of elongated configuration.

Another important object is to provide an improved nozzle structure for delivering air or other gaseous cooling medium as a relatively thin, wide jet or blast of cooling fluid across a window to be cooled; a further object being to provide a blast of substantially uniform thickness of the order of one-eighth of an inch or less for window cooling purposes; a still further object being

to form the nozzle in such fashion that the rate of delivery of coolant fluid from the nozzle is substantially uniform throughout the entire extended width of the nozzle.

Briefly stated, in accordance with one of its aspects, the present invention contemplates the cooling of the relatively narrow, elongated emission window of an electron generator, by mounting, adjacent said window, a nozzle structure for the continuous delivery, preferably transversely across said window, of a flowing layer of cooling fluid such as air. The invention also contemplates adjustment of the nozzle toward and away from the window and for angular adjustment to enable the coolant to be delivered at such an angle with respect to the window as to afford an optimum window cooling effect, such optimum effect varying, to some extent, with the spacement of the nozzle from the window, the temperature of the coolant, and the pressure under which it is propelled from the nozzle. The invention furthermore contemplates the provision of a nozzle for emitting a blast of air as a relatively thin sheet of the order of one-eighth of an inch in thickness over an air blast width of the order of several inches, while maintaining coolant delivery at substantially uniform rate throughout the entire width of the nozzle.

The foregoing and numerous other important objects, advantages, and inherent functions of the invention will become apparent as the same is more fully understood from the following description, which, taken in connection with the accompanying drawings, discloses a preferred embodiment of the invention.

Referring to the drawings:

Fig. 1 is a perspective view of the window containing portion of the envelope of an electron beam generator;

Fig. 2 is a partially sectionalized side view of a portion of the envelope structure shown in Fig. 1 to illustrate the application of window cooling means embodying the present invention;

Fig. 3 is an enlarged sectional view showing portions of the apparatus illustrated in Fig. 2;

Fig. 4 is a plan view of a nozzle element forming part of the equipment shown in Fig. 2; and

Fig. 5 is an enlarged sectional view taken substantially along the line 5—5 in Fig. 4.

To illustrate the invention the drawings show an electron flow device D comprising an elongated envelope E embodying an electrical insulating portion F carrying an anode A at one end and an electron emitting cathode C at the other, said cathode being enclosed within the envelope and the anode comprising a hollow envelope extension sealed on the end of the portion F remote from the cathode C. As shown, the device constitutes an electron beam generator, such as is shown in the copending application for United States Letters Patent Serial No. 487,922, filed February 14, 1955, now Patent Number 2,853,622, on the invention of Carl W. Hansen in Electron Discharge Apparatus. In such apparatus the anode A may comprise a tubular portion 12 having one end sealed to the envelope portion F, in coaxial alinement therewith, the opposite end of the portion 12 terminating in a flared portion 13 having one end sealingly connected with the tubular portion and an opposite end defining a relatively narrow, elongated window opening 14. The medial portions of the opening 14 may be disposed in alinement with the tubular envelope portion 12, and said window opening 14 may be sealingly closed, as by means of a window pane element 15 of material substantially transparent to the penetrating ray beam produced by operation of the generator.

The present invention, of course, is not necessarily limited to the precise shape and configuration of the window element 15, or of the flared window containing

portions 13 of the envelope. The flared envelope portion 13 and the relatively narrow, elongated window structure shown, however, are particularly well suited for incorporation in electron beam generators. In such devices, the envelope portion F, at the end of the portion 12 remote from the window, may contain electron accelerating electrodes for the transmission of cathode emitted electrons, at high velocity, through the tubular and flared envelope portions 12 and 13, and thence outwardly of the envelope through the window element 15.

The window element 15 of a beam generating tube preferably comprises a relatively thin, foil-like panel of aluminum, nickel or other suitable or preferred material, which is relatively transparent to the passage of the penetrating beam therethrough. Windows of the character mentioned of necessity absorb a part of the energy of the transmitted beam, with the result that heat is produced in the window element. Such heat should be dissipated as rapidly as possible in order that the window element be maintained at a temperature below that at which the relatively thin, foil-like element may warp, creep or otherwise become distorted or ruptured.

The present invention provides relatively simple and inexpensive yet reliable means for and method of effectively cooling windows of the character mentioned without interference with the window transmitted beam. To this end, the present invention contemplates the provision of means for continuously flowing a preferably relatively thin layer of cooling fluid transversely across the window element 15, such means being supported on one side of the window in position to direct the stream of cooling fluid upon the window at an angle such as to accomplish an optimum cooling effect, the cooling effect varying with the temperature of the cooling fluid and the pressure at which it is applied to the window, as well as the angle of incidence, with respect to the plane of the window, at which the cooling fluid is applied thereto.

While the invention is not necessarily restricted to the employment of a specific cooling medium, it is preferable that a gaseous coolant, such as air, be employed to maintain the window temperature within the desired limits. Accordingly, the window 15 is cooled by providing for flowing a stream of air across the element 15, air being delivered to the window under pressure through a suitable nozzle structure 16. As shown, the nozzle structure 16 comprises a chamber forming casing 17 providing a relatively narrow, substantially elongated orifice 18 at one end of the casing, means being provided for delivering cooling fluid into orifice remote portions of the casing under pressure, so that the cooling fluid may traverse the casing and be expelled therefrom through the orifice at substantially uniform pressure in all portions of the elongated orifice.

The casing 17 may have any suitable, preferred or convenient configuration for the accomplishment of its intended purpose. As shown more particularly in Figs. 4 and 5 of the drawing, the casing may be formed of metal, such as copper or brass, and may comprise side wall portions 19, as of cast metal, upon which may be secured a bottom panel 20, a cover panel 21, and an orifice defining panel 22. The panels 20, 21 and 22 may be secured at their edges to the side wall portions 19 by any suitable or preferred fastening means, such as headed screws 23 penetrating the edges of the panels and taking into the side wall portions 19.

The housing 17, at the end thereof remote from the orifice 18, may be formed for connection with suitable conduit means, such as a flexible hose 24, for the delivery of the cooling medium, from a suitable source, into the housing, at desired pressure. When air is delivered under pressure through a narrow elongated orifice, in the manner here contemplated, various circumstances may operate to impair the uniformity of the desired thin layer of coolant emitted at said orifice. Frictional engagement of the coolant stream with the more or less stagnant circumambient atmosphere at the nozzle will tend to peel off portions of the moving coolant layer, commencing as soon as it shall have passed outwardly of the nozzle, thus forming eddies of such peeled off portions which dissipate the coolant into the circumambient atmosphere outwardly of the orifice emitted layer. Any air movement or draft, which may occur in the surrounding atmosphere in a direction transversely of the orifice, will of course, tend to impair or destroy the uniformity of the orifice emitted layer of coolant fluid, and hence to reduce its window cooling efficiency.

In order to maintain the configuration of the thin orifice emitted layer of cooling fluid against layer distorting influences of the character mentioned, the nozzle forming housing element 22 may be provided with a flange portion 18' forming a lip extending across and in spaced relationship with respect to the end edge of the panel member 20 to define the orifice 18 between said end edge and the flange portion 18', the lip formed by said flange portion projecting outwardly of and forming an extended side for the elongated orifice 18. Coolant fluid, after passing through the orifice 18, will flow across the lip formed by the flange portion and will tend to hug the same, thereby minimizing lateral dispersion or eddying of the coolant laterally outwardly of the moving coolant stream. Since the nozzle is preferably located in position to deliver the coolant upon the window element to be cooled, as soon as said coolant shall have passed outwardly of the orifice remote edge of the flange portion 18', the present invention provides for the application of the coolant to the window element being cooled with a minimum of coolant loss through lateral eddying thereof into circumambient atmosphere. In that connection, it may be mentioned that in flowing across the window element to be cooled, the coolant fluid tends to cling to the surface of the window element across which it is traveling in the same way as it tends to cling to the flange portion 18' in traversing the same, thereby minimizing laterally eddying of coolant fluid into the surrounding atmosphere. If desired, the flange 18', at its orifice remote edge, may be bent inwardly, as at 22', to deflect the coolant layer upon the window pane element to be cooled.

Although the invention is not necessarily restricted to any particular configuration of the housing 17, the same preferably tapers or flares outwardly from the end at which the fluid supply hose 24 is connected toward the end at which the orifice 18 is located. Furthermore, the housing, if desired, may comprise a pair of flaring arms 25 having ends of restricted area secured to hollow inlet fittings 26, as of brass, said fittings in turn being connected with the fluid supply hose 24, as by means of coupling pipes or conduits 27 and 28 and a common coupling, such as a T fitting 29, suitable hose clamping means 30 being provided for attaching the hose 24 on the pipe 28. The ends of the arms 25 remote from the inlet fittings 26 may be laterally interconnected, whereby said arms merge together to form a delivery chamber 31 at and inwardly of the orifice 18.

Any suitable or preferred means may be provided for mounting and supporting the nozzle structure 16 on one side of the window 15 and at any selected inclination with respect to the plane of its edges, in position to direct a stream of cooling fluid continuously across and in heat exchange relation with the window pane element 15. To this end, mounting bracket means 32 may be firmly secured, as upon the flared envelope portion 13, adjacent the window to be cooled, said bracket means providing pivotal support for a nozzle mounting stem 33 and vertically adjustable support for a pair of nozzle suspension links 34 adapted rockably to support axle pins 35 which may be brazed or otherwise secured, preferably in coaxial alinement, on the opposite side members 19 of the nozzle structure in position extending outwardly

thereof. The ends of the links **34** remote from the axle pins **35** may be threaded for the reception of adjustable clamping nuts **36**, whereby to secure said threaded ends in the bracket means **32** at any desired elevation. The nozzle structure may also include a mounting plate **37** secured on the housing **17** and formed with an opening **38** sized to slidingly receive the mounting stem **33**. The mounting stem, in turn, may be provided with screw threads for receiving clamping nuts **39** in position to engage opposite sides of the mounting plate **37**.

Any other suitable or preferred suspension means may be provided for supporting the nozzle structure **16** at a desired elevation and at selected angularity such that the stream of cooling fluid emitted from the nozzle through the orifice **18** may be applied to the window pane element **15** in a manner providing an optimum window cooling effect.

As shown more particularly in Figs. 2 and 3 of the drawings, the window element **15** may assume an inwardly curved or concave configuration. This will be the case where the element is of thin, foil-like character and where the envelope of the ray beam generator is maintained under reduced pressure conditions. The edges of the element **15**, however, extend in the plane of the opening **14**, which may be regarded as the plane of the window element. For optimum cooling effect, it is desirable that the nozzle structure be disposed at an inclination such that the stream of cooling fluid, as emitted through the orifice **18**, will be applied to the window pane element in a direction making an angle of the order of 45° with respect to the plane containing the marginal edges of the window element.

The orifice **18** preferably has width of the order of one-eighth inch or less in order that the stream of cooling fluid delivered across the window pane element may be relatively thin, to thereby minimize turbulence in the immediate vicinity of the element **15**. Indeed, exceedingly effective results are obtained with orifices of the order of one-sixteenth inch in width. The length of the orifice **18** is preferably substantially equal to or slightly greater than the longitudinal dimension of the window element **15**.

It has been found that the foregoing arrangement may be adjusted to obtain adequate and efficient window cooling effects; that the pressure at which the cooling fluid is delivered into the nozzle structure should be adjusted to obtain maximum cooling effect throughout the width of the window element, since air velocity across the window and consequent cooling effect varies somewhat parabolically along the short window dimension. As a consequence, adjustment of the angle at which the stream is directed toward the window may be accomplished in the interests of promoting a uniform cooling effect throughout the width of the window. The maximum window heating effect takes place in the mid portions of the window along its major dimensional axis. As a consequence, adjustment of pressure and velocity of the cooling fluid, in conjunction with adjustment of the elevation and angularity at which the nozzle structure is supported, may be made to obtain optimum cooling effects.

The velocity of the air stream, as it passes across the window, should everywhere exceed a minimum velocity determined by the intensity and size of the electron beam transmitted through the window. In this connection, the air velocity across the window element to be cooled should desirably be of the order of 250 feet per second. Accordingly, the nozzle structure which creates the air stream should not only be capable of delivering air velocities of the character mentioned, but should also be able to produce substantially uniform velocity distribution across the entire width of the coolant screen. The provision of uniform velocity in all portions of the stream makes for optimum cooling efficiency.

The nozzle structure of the present invention and its

mounting system not only provides for the delivery of coolant air at required uniform velocity throughout the thin, wide stream, but also affords means whereby the nozzle structure may be positioned with respect to the window element **15** for maximum cooling effect. In this connection, the air delivery conduit **24** is of sufficient size to delivery air at a rate required to produce the desired velocity across the entire orifice **18**. The cross sectional area of the air path in the housing **17** from the inlet conduit to the exit orifice increases gradually enough so that air flow does not separate from the walls of the nozzle and thereby prevent air from flowing through the entire length of the delivery orifice. The gradual increase in area of the air flow channel in the housing **17** also eliminates the possibility of pressure losses due to sudden expansion of the flowing air.

The nozzle is also provided with a smooth exit plate, which may be flat or slightly curved and extending from the lower edge of the exit orifice **18** in the direction desired for the air stream to follow, such exit plate aiding in directing the cooling stream upon the curved path which it must follow in traversing the concave window element **15**. The exit plate thus aids in preventing diffusion of the stream before it makes contact with the window.

It will be seen also that the apparatus of the present invention is of simple character affording ease of manufacture and assembly.

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 form herein disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. In apparatus of the character described having a beam emitting window comprising an elongated, relatively narrow pane element, the combination, with said apparatus, of nozzle means for delivering a stream of cooling fluid upon and across the pane element, said nozzle means comprising a housing providing a chamber of substantial capacity and formed with an elongated, relatively narrow, slit-like fluid delivery orifice along a side of said chamber, and means for supplying cooling fluid under pressure in said housing to thereby maintain a substantial quantity of fluid therein, immediately behind said orifice, and thus obtain turbulence-free emission of fluid, at a substantially uniform delivery rate, throughout the length of the orifice.

2. In apparatus of the character described having a beam emitting window comprising an elongated, relatively narrow pane element, the combination, with said apparatus, of nozzle means for delivering a stream of cooling fluid upon and across the pane element, said nozzle means comprising a housing formed at one end with an elongated, relatively narrow, slit-like fluid delivery orifice, and conduit means for connecting said housing with a source of cooling fluid under pressure, said housing forming a chamber of substantial sectional area extending between said conduit means and said orifice to thereby maintain a substantial quantity of fluid therein, immediately behind said orifice, and thus obtain turbulence-free emission of fluid, at a substantially uniform delivery rate, throughout the length of the orifice.

3. In apparatus of the character described having a beam emitting window comprising an elongated, relatively narrow pane element, the combination, with said apparatus, of nozzle means for delivering a stream of cooling fluid upon and across the pane element, said nozzle means comprising a housing providing a chamber of substantial capacity and formed with a fluid delivery orifice along a side of said chamber, conduit means for connect-

ing the housing with an elongated, relatively narrow, slit-like source of cooling fluid under pressure to thereby maintain a substantial quantity of fluid therein, immediately behind said orifice, and thus obtain turbulence-free emission of fluid, at a substantially uniform delivery rate, throughout the length of the orifice, and adjustable means for supporting said nozzle means in position to apply the stream of cooling fluid at desired directional angularity upon the window pane element.

4. In apparatus of the character described having a beam emitting window comprising an elongated, relatively narrow pane element, the combination, with said apparatus, of nozzle means for delivering a stream of cooling fluid upon and transversely across the pane element from one side thereof toward the other, throughout the length thereof, said nozzle means comprising a housing providing a chamber of substantial capacity and formed with a slit-like fluid delivery orifice of length substantially equal to the length of the window element, and a stream guiding flange forming a vane extending outwardly of said orifice and along a side thereof to guide the cooling fluid upon said pane element.

5. In apparatus of the character described having a beam emitting window comprising an elongated, relatively narrow pane element, the combination, with said apparatus, of nozzle means for delivering a stream of cooling fluid upon and across the pane element, said nozzle means comprising a housing providing a chamber of substantial capacity and formed with an elongated, relatively narrow, slit-like fluid delivery orifice along a side of said chamber and conduit means, joined to said housing, remote from said orifice, and adapted for connection with a source of cooling fluid under pressure to thereby maintain a substantial quantity of fluid therein, immediately behind said orifice, and thus obtain turbulence-free emission of fluid, at a substantially uniform delivery rate,

throughout the length of the orifice, said housing forming a plurality of ducts, of progressively increasing sectional area, extending between said conduit means and said orifice and merging together to form a common fluid delivery chamber at said orifice.

6. In apparatus of the character described having a beam emitting window comprising an elongated, relatively narrow pane element, the combination, with said apparatus, of nozzle means for delivering a stream of cooling fluid upon and across the pane element, said nozzle means comprising a housing providing a chamber of substantial capacity and formed with an elongated, relatively narrow, slit-like fluid delivery orifice along a side of said chamber, and conduit means joined with said housing remote from said orifice and adapted for connection with a source of cooling fluid under pressure, said housing forming channel means of progressively increasing sectional area from said conduit means toward said orifice, to thereby maintain a substantial quantity of fluid therein, immediately behind said orifice, and thus obtain turbulence-free emission of fluid at a substantially uniform delivery rate throughout the length of the orifice.

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