April 4, 1961 J. C. HESSON 2,978,187

CARBON DIOXIDE FIRE EXTINGUISHING NOZZLE

Filed Jan. 23, 1959 2 Sheets-Sheet 1

Fig. 1.

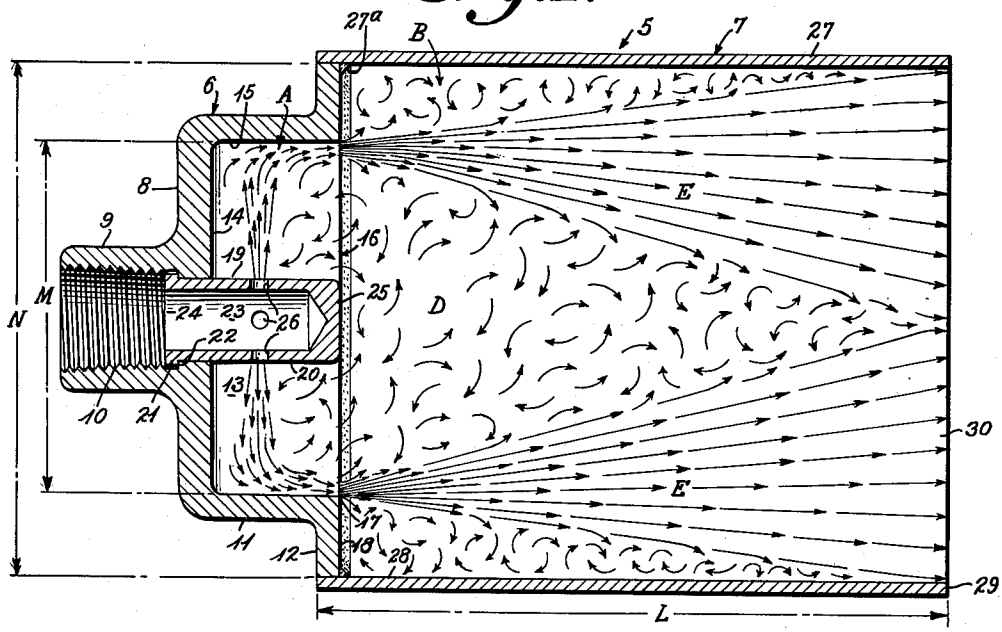
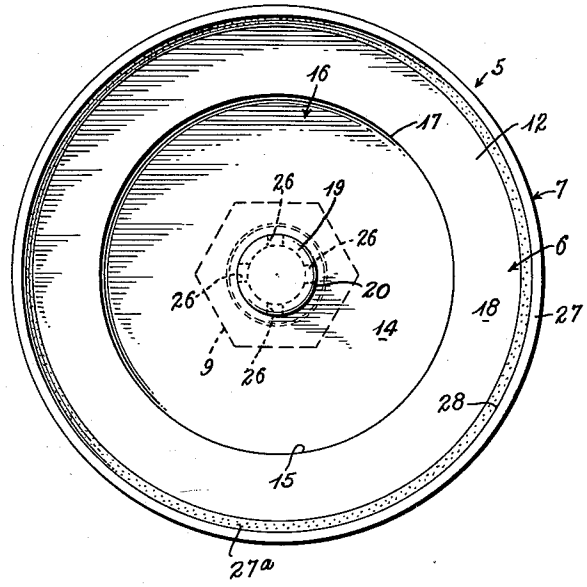


Fig. 2.



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CARBON DIOXIDE FIRE EXTINGUISHING NOZZLE

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Fig. 3.

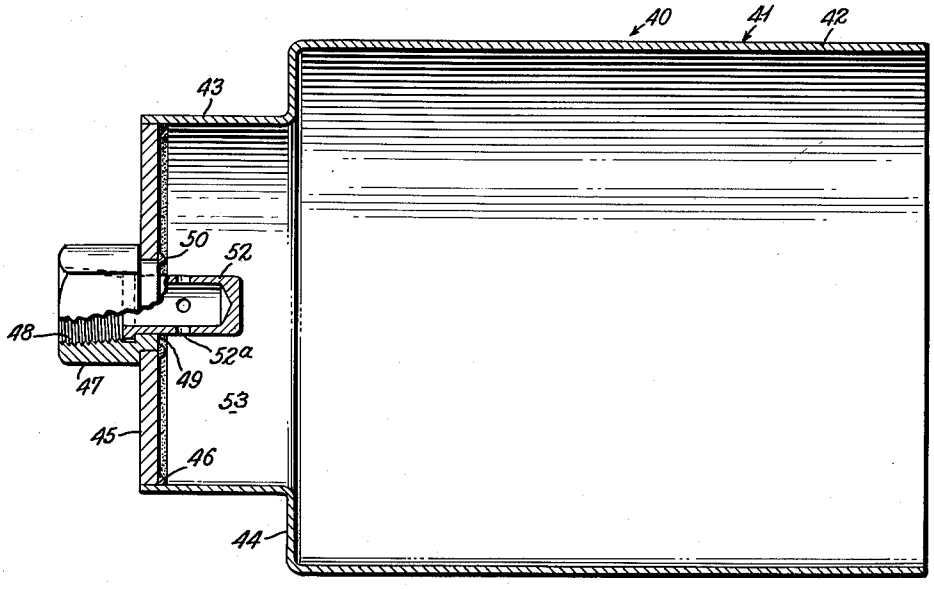
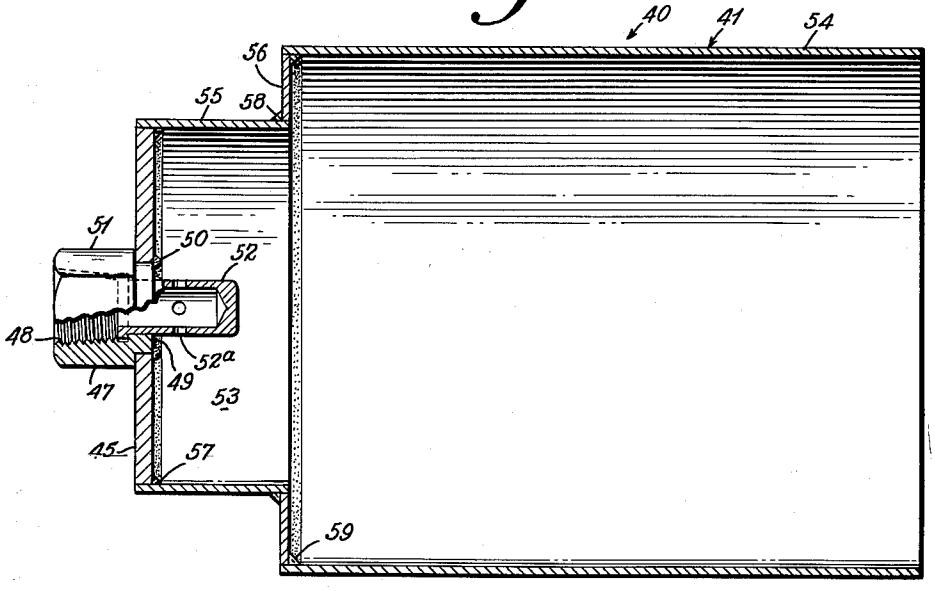


Fig. 4.



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2,978,187

CARBON DIOXIDE FIRE EXTINGUISHING NOZZLE

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3 Claims. (Cl. 239—499)

This invention relates to carbon dioxide fire extinguishing nozzles, and deals more particularly with horn type nozzles of relatively short length for directing and characterizing the flow pattern of carbon dioxide discharged from hand, or portable fire extinguishers.

For quite a number of years, portable or hand carbon dioxide fire extinguishers have employed discharge nozzles of the horn type, as covered by the H. R. Minor patent, No. 1,760,274, issued May 27, 1930, which consisted of a hollow conical horn having a short pipe projecting into its smaller end provided with a single, axially directed, orifice through which liquid carbon dioxide is released and, due to its sudden expansion, is instantly converted into a mixture of snow and vapors for axial travel through the horn. As this mixture moves through the horn, the original single jet form of discharge expands until, if the horn is of proper length, the mixture is delivered to the atmosphere as a stream of uniform velocity throughout its entire cross sectional area. However, to obtain this desired discharge pattern, it was determined that the slope of the conical horn wall should not be more than about 3½° with respect to the axis of the horn, or 7° for the total conical angle, and that the horn should be about eight times as long as the diameter of its outlet end.

If the total conical angle is increased, the discharge stream will not entirely fill the cross sectional area of the horn and the velocity will not be uniform over such area. If the length-to-outlet diameter ratio is reduced by cutting off the smaller end of the horn and the same total conical angle is maintained, the discharge stream in the horn will not have time to expand sufficiently to entirely fill the outlet end and the discharge velocity of the stream beyond the horn will be so high that it will entrain too much air and thereby reduce the effectiveness of the carbon dioxide as an extinguishing medium. Furthermore, if the fire involves lightweight, loose material the discharge velocity of the stream may scatter the burning material and thereby spread the fire.

The presence of snow in the mixture discharged from a nozzle is very desirable because it enables the stream to be directed more accurately and to be projected a greater distance than would be possible if the discharge consisted solely of vapors. However, after the carbon dioxide reaches the fire area, it is very desirable for the snow to sublime as rapidly as possible so that the entire volume of the discharged medium will be in vapor form to provide a fire smothering, or air diluting, blanket. When the original type of full length horn is employed, the relatively fine or small snow particles that are first formed agglomerate into larger particles, due to the turbulence encountered and the time required to travel the length of the horn. Such larger particles require a greater length of time to sublime. Still more important is the fact that larger snow particles have a tendency to be wet by and sink in some liquid fuels, such as gasoline. The evaporation or sublimation of snow particles below the surface causes a boiling action which releases additional gasoline vapors to the atmosphere above the liquid level.

This makes the extinguishment of a gasoline fire with large snow particles more difficult. Fine snow particles, on the other hand, will sublime at the surface level of the liquid fuel without increasing the evaporation rate of the latter.

Several attempts have been made in the past to develop a horn type of carbon dioxide nozzle which was shorter than the original full length design, and would, therefore, be less awkward to handle and which would provide a satisfactory discharge pattern; that is, a discharge stream which is of uniform velocity and density throughout its entire cross sectional area and in which the snow particles are fine or small.

Apparently the earliest of such shortened horn developments, covered by the S. E. Allen et al. patent, No. 1,993,696, issued March 5, 1935, involved a single, axially directed, short pipe section which discharged the carbon dioxide snow and vapor mixture into the closed inner end of the horn with a concentric deflector member located in the inner end of the horn for spreading the single jet discharge radially in all directions against the wall of the horn. The carbon dioxide was then deflected by the horn wall into a stream of hollow or annular cross section.

This type of stream tended to hug the inner surface of the horn wall and could only spread inwardly away from such wall, or toward the horn axis. Also, because the hollow or annular stream was exposed to turbulence only along its inner surface and was restrained from expanding outwardly by the horn wall, the stream was stabilized and its rate of spread in the only direction possible was reduced. Therefore, the discharge from the outer end of the horn was not of uniform density or velocity throughout its entire cross sectional area.

In one embodiment of this development the horn body was made outwardly convergent; that is, with its outer end of smaller diameter than its inner end, in an attempt to obtain a discharge that was of uniform density and velocity. In other words, it apparently was thought that by squeezing the hollow or annular stream in the horn inwardly toward its axis, the reduced rate of spread inward would be sufficient to provide a discharge from the outer end of the horn that was of more uniform density and velocity throughout its cross sectional area.

The next development in the prior art which attempted to solve the short horn, uniform density and velocity discharge, covered by the C. W. Frese et al. patent, No. 2,545,951, issued March 30, 1951, consisted of a horn with a bowl-shaped or sphere-like chamber at its closed inner end with a short discharge pipe extending axially into such chamber and having a plurality of circumferentially spaced, radial openings that directed jets of carbon dioxide snow and vapors against the curved wall of the chamber. The shape of the curved chamber wall at the locations at which the jet streams contact the same was such that the carbon dioxide was deflected both circumferentially and axially inwardly against the closed inner wall of the bowl-shaped or sphere-like chamber.

These deflections of the discharged carbon dioxide reduce its velocity within the chamber and, due to the agitation that was produced, tended to increase the size of the snow particles. The stream released into the horn must necessarily be of hollow or annular shape in cross section and must spread inwardly toward the axis of the stream, while flowing through the horn, if the ultimate discharge from the outer end of the horn was to be of uniform density and velocity throughout its cross sectional area. Like the concentric deflector member type of development, described above in connection with Patent No. 1,993,696, the rate of spread of the hollow stream toward the axis of the horn was slow because of the absence of any turbulence between the inner surface

of the horn and the outer surface of the flow of carbon dioxide through the horn. This was due to the fact that the flow hugged the surface of the horn.

In a closely allied development, covered by the C. W. Frese patent, No. 2,566,324, issued September 4, 1951, the plurality of circumferentially spaced openings formed in the short discharge pipe extending into the closed inner end of the horn were arranged to face rearwardly at an acute angle to the axis of the pipe to direct the jets of snow and vapor mixture toward the bowl-shaped inner end wall of the horn. This structure produced the same type of discharge from the outer end of the horn as the structure described above.

The next developments in the short horn nozzle art consisted of three closely related devices, covered by the H. Ensminger patent, No. 2,655,219, issued October 13, 1953; the F. B. Allen patent, No. 2,736,388, issued February 28, 1956; and the F. B. Allen patent, No. 2,737,251, issued March 6, 1956, which were described as being simplified structural improvements over the above referred to concentric deflector member nozzle, Patent No. 1,993,696. In other words, by discharging the carbon dioxide from a plurality of circumferentially spaced radial openings formed in a short discharge pipe extending axially into the closed, semi-spherical end of a horn, the resulting jets of mixed snow and vapors were directed against the outwardly curved end wall of the horn and merged into a hollow or annular stream that hugged the inner surface of the horn in flowing toward the open, outer end of the latter. As has been pointed out above, with such a shaped stream the rate of spread toward the axis of the horn was slow because now turbulence occurs between the inner surface of the horn and the stream. Therefore, the resulting discharge from the horn was not of uniform density and velocity throughout its cross sectional area.

With the above analysis of the modes of operation of the prior nozzles to start with, tests were made in an endeavor to develop a short horn nozzle structure which would produce a discharge of a mixture of carbon dioxide snow and vapors with the snow particles small or fine enough to quickly sublime when applied to a fire area; with the velocity of the stream as it leaves the horn low enough so as not to entrain sufficient air to materially lessen the effectiveness of the carbon dioxide as a fire extinguishing medium and so as not to scatter burning lightweight, loose material; and with the discharge from the open end of the horn being of uniform velocity and density throughout its cross sectional area.

It was determined that a discharge stream of mixed carbon dioxide snow and vapors could be formed that possessed all of the above mentioned desirable characteristics if a horn of the desired short length were so shaped and its various portions so proportioned that it would subject the outer surface as well as the inner surface of a hollow or annular stream, shortly after it was formed at the closed inner end of the horn, to a substantial amount of turbulence with the result that the stream would spread rapidly both inwardly and outwardly relative to the axis of the horn.

The primary object of this invention is, therefore, to provide a carbon dioxide discharge nozzle of the shortened horn type having a performance at least equal to that of a full length horn discharge nozzle of similar capacity.

Another object of the invention is to provide a carbon dioxide discharge nozzle of relatively short length that is capable of producing a discharge of uniform density and velocity throughout the entire cross sectional area of the stream.

A still further object of the invention is the provision of a nozzle having a short horn type of shield that is so shaped, and portions of the same are so proportioned, that a hollow or annular discharge of mixed carbon dioxide snow and vapors produced at the closed inner end portion of the horn will be changed, during its travel through the horn, to a single stream of uniform density and velocity through its entire cross sectional area as a result of spreading both inwardly and outwardly relative to the axis of the horn, and in which the stream will be discharged at the outer end of the horn at a velocity which will be too low to entrain sufficient air to materially lessen the effectiveness of the carbon dioxide as a fire extinguishing medium.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawings forming a part of this specification and in which like numerals are employed to designate like parts throughout the same,

Figure 1 is a longitudinal sectional view of a carbon dioxide fire extinguishing nozzle embodying the present invention,

Figure 2 is an end elevational view of the nozzle shown in Fig. 1,

Figure 3 is a longitudinal sectional view of a carbon dioxide discharge nozzle comprising another embodiment of the invention, and

Figure 4 is a longitudinal sectional view of a carbon dioxide discharge nozzle comprising still another embodiment of the invention.

In the drawings, wherein for the purpose of illustration are shown the preferred embodiments of this invention, and first particularly referring to Figs. 1 and 2, there is shown a discharge nozzle **5** having a head **6** at the inlet end of the nozzle and a horn or shield **7** extending from the head **6** to the outlet end of the nozzle, as viewed in Fig. 1. The head **6** includes a generally circular end wall **8** having a central boss **9** extending outwardly from the end wall and adapted for connection, by means of a threaded bore **10**, to a conduit (not shown) for supplying liquid carbon dioxide to the nozzle. A cylindrical wall **11** extends forwardly for some distance from the margin of the circular end wall **8**, and a radial wall **12** extends radially outwardly from the forward end of the cylindrical wall **11**. Preferably, the head **6** is made as a single casting, with the walls **8**, **11** and **12** and the boss **9** being integral with one another.

The interior of the head **6** provides an inlet chamber **13** which is closed at one end by the inner surface **14** of the circular wall **8** and which is defined in the radial direction by the inner surface **15** of the cylindrical wall **11**. At its forward end, the inlet chamber **13** has a circular opening **16**, and the inner surface **15** of the wall **11**, which extends rearwardly from the edge **17**, of the opening **16**, is cylindrical in shape. From the edge **17**, the radial wall **12** provides a shoulder **18** which extends outwardly normal to the cylindrical surface **15**.

To provide for the admission of carbon dioxide to the inlet chamber **13**, the head **6** is provided with a short pipe section or tip **19** having a main body **20**. The pipe section or tip **19** is seated in the base of the bore **10** of the boss **9** and extends through the rear wall **8** of the head **6** into the inlet chamber **13**. At its inner end, the body **20** has a radially extending flange **21** which engages a seat **22** formed in the base of the bore **10** and which is held in place against the seat by means of a coupling member (not shown) threaded into the bore **10** when the head **6** is attached to a supply conduit. The pipe section or tip **19** has an axial bore **23** which extends from its inner end **24** to the closed outer end **25**. A plurality of circumferentially spaced, radially directed orifices **26** are formed in the body **20** of the tip **19** in communication with the axial bore **23**.

The horn or shield **7** comprises a hollow cylindrical tube **27** welded at **27***a* to the outer edge of the radial wall **12**. From the radial wall **12**, the tube **27** extends forwardly for some distance and defines at its forward end **29** an outlet **30** of circular cross-section.

In operation, liquid carbon dioxide under relatively high pressure, usually obtained from a portable cylinder,

is supplied to the axial bore 23 of the tip 19 by any suitable means, which is usually a flexible tube, not shown, connected to the boss 9. The carbon dioxide leaves the tip 19 through the radially directed orifices 26 in the form of high velocity jets of mixed snow and vapors traveling toward the cylindrical surface 15 of the inlet chamber 13. The jets of snow and vapors impinge against the surface 15, and are deflected thereby. Due to this deflection, the mixture forming the jet streams spread circumferentially until a single hollow or annular stream is formed which hugs the inner surface 15 of the cylindrical wall 11 and flows therealong until it passes through the opening 16. This flow pattern is clearly illustrated in Fig. 1 by the closely grouped arrow lines A. Just as soon as the hollow or annular stream A of carbon dioxide snow and vapors passes the edge 17, it is subjected to turbulent forces, represented by the curved arrow lines B, acting on its outer surface and turbulent forces, represented by the curved arrow lines D, acting on its inner surface. These inner and outer turbulent forces cause the hollow or annular stream A to spread both inwardly and outwardly, as represented by the straight arrow lines E, at a sufficiently rapid rate to cause the flowing material, as it reaches the open outlet 30 of the horn or shield, to merge as a single stream of uniform density and velocity throughout its entire cross sectional area. Due to the deflection of the jet streams that occurs in the head 6 and the turbulent forces in the horn 7, the velocity of the discharge from the horn is sufficiently low so as not to entrain an amount of air from the surrounding atmosphere which will materially affect the efficiency of the carbon dioxide as a fire extinguishing medium.

To obtain this desired discharge from the outlet end of the horn or shield, it has been determined that the outward cross sectional area of spread or expansion in the horn beyond the edge 17 of the deflector surface 15 should be equal to the inward cross sectional area of spread or expansion in the bore of the hollow or annular stream A. These areas are graphically illustrated in Fig. 2 in which the outward cross sectional area of spread is the annular area between inner surface 15 and the inside wall of the horn or shield 7, and the inward cross sectional area of spread is the area of the open end 16 of the inner deflector surface 15. In other words, for optimum performance the cross sectional area of the open end 16 of the inner deflector surface 15 shall be substantially one-half the total cross sectional area enclosed by the inner end of the horn or shield 7. This cross sectional area relationship may advantageously be illustrated in connection with Fig. 1 of the drawings by converting it to the ratio of the diameters M to N, where M is the diameter of the open end 16 of the inner deflector surface 15 and N is the diameter of the inner end of the horn or shield 7. For said optimum performance, this ratio should be about 0.7 but it has been determined that any ratio between 0.6 and 0.8 can be advantageously employed.

If the ratio is too large; that is, if M is greater than 0.8 N, the stream at E will spread or expand outwardly to the wall 27 of the horn 7 before it will spread or expand inwardly to the horn axis. On the other hand, if M is less than 0.6 N, the stream at E will spread or expand inwardly toward the axis of the horn, and fill the bore of the originally formed hollow or annular stream, before it spreads or expands outwardly to the wall 27 of the horn 7. In either case, it would be necessary to lengthen the horn dimension L beyond that required if the ratio of the diameters M to N is held within the range given above.

If the optimum ratio of the diameters M to N is employed; that is, 0.7 N, the optimum ratio of the length L to the diameter N should be about 1.25 (L should be 1.25 N) to provide entirely uniform velocity and density of the stream discharged from the outlet end 36 of the horn 7.

If the ratio of the diameters M to N is varied from 0.7 through the permissible range mentioned above, the ratio of the length L to the diameter N can still be maintained at about 1.25.

It has been determined that the size of the snow particles in the stream discharged from the nozzle structure of Fig. 1 is substantially less than that of the snow particles in the stream discharged from a long horn of standard length. This undoubtedly is due to the fact that the jet streams of snow and vapors are only subjected to the single impingement against the wall 15 and the short time required for the mixture to flow through the horn 7.

In Fig. 3 is shown another embodiment of the invention comprising a discharge nozzle 40 which includes a horn 41 having a cylindrical portion 42 at the forward end thereof and a cylindrical inlet portion 43 at the rearward end thereof connected to the portion 42 by a radial wall portion 44 which is integral with both the cylindrical portions 42 and 43. The rear end of the inlet portion 43 is closed by a circular end piece 45, which may be cut from flat stock, and welded to the inlet portion as at 46. At its center, the end piece 45 is provided with a connector 47 which is provided with a threaded bore 48 for connection to a flexible tube, or the like, from which the nozzle receives its supply of liquid carbon dioxide. At its forward end the connector 47 has a cylindrical portion 49 which fits through a corresponding opening in the end piece 45 and is welded to the latter as at 50. A short pipe section or tip 52, identical to the tip 19 of Fig. 1, is seated in the base of the bore 48 and extends forwardly through the end piece 45 into an inlet chamber 53 defined by the inlet portion 43 of the horn and the end piece 45. This tip 52 is provided with a plurality of circumferentially spaced orifices 52*a* which are directed radially.

In respect to its size, shape and mode of operation, the discharge nozzle 40 is the same as the nozzle 5 described in connection with Fig. 1.

The embodiment of Fig. 4 is in many respects similar to the embodiment illustrated in Fig. 3, and like reference numerals have been applied to like parts which need not be further described. In Fig. 4, the nozzle 41 instead of being formed as an integral unit, as in Fig. 3, is comprised of several pieces welded together. These pieces include a cylindrical horn 54, a cylindrical inlet member 55, and an annular wall member 56 connected between the inlet member 55 and the horn 54. The inlet member 55 is welded to the end piece 45 as at 57, and the annular wall member 56 is welded to the inlet member 55 and the horn 54 as at 58 and 59, respectively. The nozzle structure will function in exactly the same manner as the nozzle of Fig. 1.

It is to be understood that the forms of this invention herewith shown and described are to be taken as preferred examples of the same, and that various changes in the shape, size, and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

Having thus described the invention, I claim:

1. A carbon dioxide fire extinguishing nozzle having a large discharge capacity in relation to its overall length comprising a head member forming an inlet chamber closed at one end and open at the other end with an imperforate wall extending between said ends, a tip extending into said inlet chamber through said closed end and having a plurality of orifices positioned to discharge mixed carbon dioxide snow and vapors substantially radially of said inlet chamber toward said imperforate wall for deflection by the latter into a hollow stream discharging through the open chamber end, means for establishing a turbulence zone adapted to subject the outer surface of the carbon dioxide stream to a substantial amount of turbulence, said means including a shoulder extending radially outwardly from said imperforate cham-

ber wall around the periphery of the open end of the chamber, said shoulder being adapted for connection to a horn and having an area approximately equal to the area of the open end of said inlet chamber so that the outward cross-sectional area of spread of the carbon dioxide stream is approximately equal to its inward cross-sectional area of spread, and a horn connected to said shoulder around its outer periphery, said horn being in axial alignment with said inlet chamber to provide a shielded flow path for the carbon dioxide stream discharging from the open end of said chamber, said shielded flow path having zones of turbulence adapted to subject both the inner and outer surfaces of the carbon dioxide stream to substantial amounts of turbulence ensuring that the discharge stream at the outer end of the horn is of uniform density and velocity throughout its entire cross-sectional area.

2. A carbon dioxide fire extinguishing nozzle having a large discharge capacity in relation to its overall length comprising a head member forming an inlet chamber closed at one end and open at the other end with a cylindrical imperforate wall extending between said ends, a tip extending into said inlet chamber through said closed end and having a plurality of orifices positioned to discharge mixed carbon dioxide snow and vapors substantially radially of said inlet chamber toward said imperforate wall for deflection by the latter into a hollow stream discharging through the open chamber end, means for establishing a turbulence zone adapted to subject the outer surface of the carbon dioxide stream to a substantial amount of turbulence, said means including a shoulder adapted for connection to a horn extending outwardly from said imperforate chamber wall and normal thereto around the periphery of the open end of the chamber, whereby the carbon dioxide discharge leaves the inlet chamber over the relatively sharp edge provided by the intersection of the chamber wall and the shoulder so as to produce a clean cut hollow discharge pattern, and a cylindrical horn connected to the outer periphery of said shoulder in axial alignment with said inlet chamber to provide a shielded flow path for the carbon dioxide stream discharging from the open end of said chamber, the ratio of the diameter of said inlet chamber to the diameter of said horn being between 0.6 and 0.8, whereby the area of the shoulder is approximately equal to its inward cross-sectional area of spread, said shielded flow path having zones of turbulence adapted to subject both the inner and outer surfaces of the carbon dioxide stream to substantial amounts of turbulence ensuring that the discharge stream at the outer end of the horn is of uniform density and velocity throughout its entire cross-sectional area.

3. A carbon dioxide fire extinguishing nozzle having a large discharge capacity in relation to its overall length comprising a head member forming an inlet chamber closed at one end and open at the other end with a cylindrical imperforate wall extending between said ends, a tip extending into said inlet chamber through said closed end and having a plurality of orifices positioned to discharge mixed carbon dioxide snow and vapors substantially radially of said inlet chamber toward said imperforate wall for deflection by the latter into a hollow stream discharging through the open chamber end, means for establishing a turbulence zone adapted to subject the outer surface of the carbon dioxide stream to a substantial amount of turbulence, said means including a shoulder adapted for connection to a horn extending outwardly from said imperforae chamber wall and normal thereto around the periphery of the open end of the chamber whereby the carbon dioxide discharge leaves the inlet chamber over the relatively sharp edge of said shoulder so as to produce a clean cut hollow discharge pattern, and a cylindrical horn connected to the outer periphery of said shoulder in axial alignment with said inlet chamber to provide a shielded flow path for the carbon dioxide stream discharging from the open end of said chamber, the ratio of the diameter of said inlet chamber to the inside diameter of the inner end of said horn being 0.7 and the length of the horn being about one and one-quarter times its inside diameter, whereby the area of the shoulder is substantially equal to the area of the open end of the said inlet chamber and the outward cross-sectional area of spread of the carbon dioxide stream is substantially equal to its inward cross-sectional area of spread, said shielded flow path having zones of turbulence adapted to subject both the inner and outer surfaces of the carbon dioxide stream to substantial amounts of turbulence ensuring that the discharge stream at the outer end of the horn is of uniform density and velocity throughout its entire cross-sectional area even though the length of the horn may be only about one and one-quarter times its inside diameter.

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