Nov. 17, 1942. H. G. FREEMAN 2,302,021

NOZZLE FOR GENERATING FOG

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Fig.1

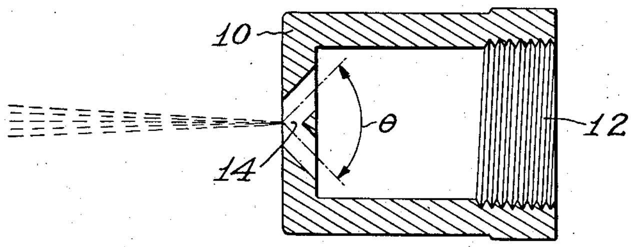

Fig. 2

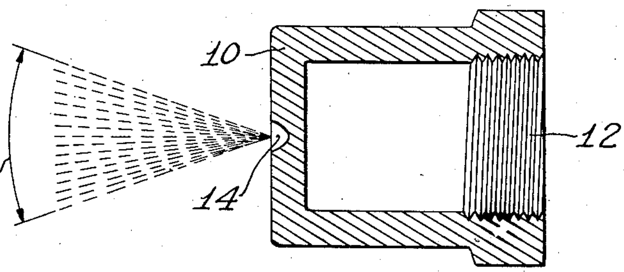

Fig. 3

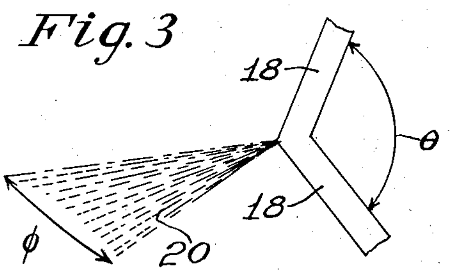

Fig. 4

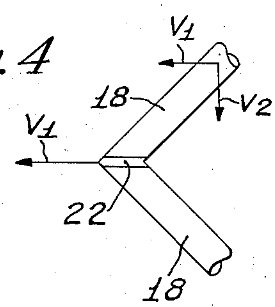

Fig. 5

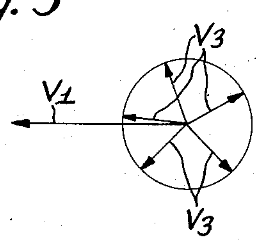

Fig. 6

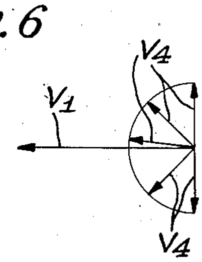

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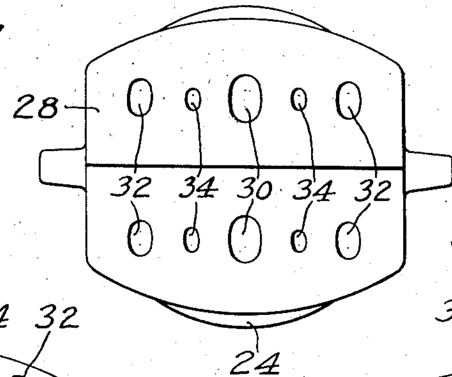
Fig. 7



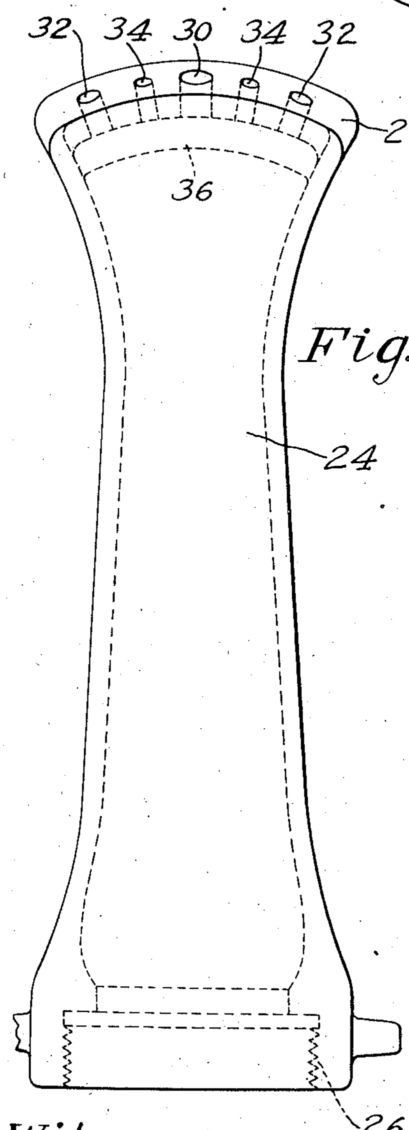
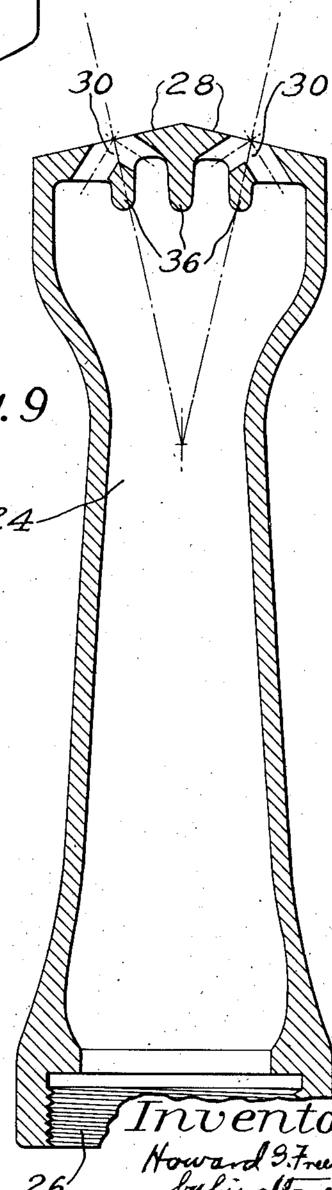


Fig. 8

Fig. 9



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2,302,021

NOZZLE FOR GENERATING FOG

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Application November 6, 1941, Serial No. 418,003

5 Claims. (Cl. 299—143)

The present invention relates to nozzles for generating a fine mist or fog, especially suitable for use in extinguishing fires.

Artificial fogs have been generated by the impingement of streams of water under such conditions that the streams break up into droplets. In general, it has been supposed that the impingement must be external of the body of metal forming the nozzle, and accordingly such nozzles have been made with orifices or passages arranged to project streams of water which impact at a substantial distance from the surface. This external impingement, as it may be called, has some disadvantages, particularly in that the passages must be formed with extreme precision in order that the streams may impinge accurately; otherwise, the device will not form a proper fog or will fail to give the desired pattern.

I have discovered that superior results are attained by using properly formed passages which allow an impact of streams primarily within the confines of the body of the nozzle. The fog produced by my improved nozzle is more satisfactory, in that it consists of smaller and more uniform particles and may be projected farther for any given angle of impingement.

It has been supposed that the initiation of a spray immediately adjacent to the surface of the nozzle will result in collection of large drops. This I have found to be true in some instances, but if the nozzles are properly constructed according to the present invention, as will hereinafter be described, there is substantially no tendency for large drops to form either in the process of break up or by coalescence on the surface.

In the accompanying drawings, Fig. 1 is a side elevation in section, and Fig. 2 is a plan view in section of a nozzle according to the present invention; Figs. 3, 4, 5 and 6 are diagrams illustrating the theory of operation; Fig. 7 is an end view of a multiple-nozzle head according to the present invention; Fig. 8 is a side elevation of the nozzle shown in Fig. 7; and Fig. 9 is a section on line 9—9 of Fig. 7.

The apparatus shown in Fig. 1 comprises a nozzle head, consisting of a hollow metal body 10, formed at the base 12 with threads for attaching to a pipe or hose. In the end face, the body is provided with two drilled passages 14, arranged at an angle with respect to each other, here illustrated as an angle of approximately 90°. The two passages 14 are accurately drilled so that their centerlines intersect substantially at the surface of the metal body. Sufficient space is provided within the nozzle to allow the water to approach the passages 14 without introducing an excessive turbulence. The impingement of the streams causes a break-up of the water into relatively small particles which are projected substantially in a plane, as indicated in Fig. 1.

Fig. 2 illustrates the same nozzle turned through an angle of 90° so that the fog pattern is indicated in plan. The angle between the edges of the pattern may be called the angle of dispersion and is designated by ϕ. This angle depends on the angle of impingement, which is designated as θ in Fig. 1. In general, the larger the angle of impingement the larger will be the angle of dispersion. It has been found that a definite relation exists between these two angles, regardless of the size of the passages.

It will be observed that the two passages 14 intersect in an ellipse; as viewed in Fig. 2, the intersection of the pasages is shown as an ellipse, or rather, a half ellipse included within the body of the nozzle head. Likewise, the intersection of each passage with the surface of the body is an ellipse; that is, the head when viewed from the end exhibits an opening of true elliptical shape.

The operation of the nozzle above described is not easily explainable. It is, however, possible to develop a theory that satisfactorily explains most of the phenomena of the present invention. This theory is illustrated in Figs. 3 to 6, and is described below.

In Fig. 3 are shown two impinging streams 18 and a fog pattern 20 produced thereby. For the immediate purpose of this theory, the streams are shown as existing in space, without regard to the means for producing them. In Fig. 4 the streams are indicated in side view. Each particle of water has a horizontal component of velocity V_1 and a vertical component V_2. The component V_1 may be termed the velocity of projection, for reasons that will presently appear. When the streams impinge, the kinetic energy represented by the velocity V_2 is converted into pressure energy. A thin lamina 22 of water at the intersection of the streams may be considered to exist with an internal pressure determined from the previously existing velocity V_2. This lamina is of elliptical form, since it is at the intersection of two cylindrical surfaces. The lamina has the forward component V_1, which is unaffected by the impact.

Since the lamina is not confined, the pressure energy above mentioned is immediately reconverted into kinetic energy. This kinetic energy is manifested as a change in velocity of the water particles, represented at V_3 in Fig. 5. By reason of symmetry, the velocities V_3 are in the plane 20. The plane is viewed from above in Fig. 5, where the forward component V_1 is retained and the velocity vectors V_3 are shown with their ends lying on a circle. The lamina cannot maintain itself against the effects of the radial velocities V_3 and must therefore break up into small particles. Or the lamina may be considered to break up under the disruptive internal pressure, which pressure was generated by conversion of the kinetic energy represented by V_2. In general, the greater the component V_2, that is, the greater the energy, the finer will be the break-up.

The foregoing theory also accounts for the fan-shaped dispersion pattern. All of the particles have the velocity component V_1, and the various velocities V_3 around the circle may be considered as being uniformly distributed among the various particles. There will be all possible combinations of velocities resulting from the summation of the vector V_1 and the several V_3's. It will be obvious that such summations result in a fairly uniform distribution of velocities in a sectorial pattern.

In the foregoing analysis, the velocity V_1 has been indicated as greater than the magnitude of the velocities V_3, whereby the net movement of any particle is forward. For large angles of impingement, however, the converted velocities V_3 may exceed the forward velocity V_1 in magnitude, whereby some of the particles tend to be projected backward.

With nozzles working on the external impingement principle, where the impact of the streams is at a distance from the surface of the nozzle head, there may therefore be an actual backward projection which will carry some particles against the metal surface. As a consequence, large drops tend to form and drop from the nozzle. Such drops are undesirable in fire fighting, not only because they indicate inefficient conversion of water into fog, but also because in the case of oil fires, the falling of drops on the surface of the oil causes splashes which tend to reignite easily.

In the present invention, wherein the nozzle operates under what may be called internal impingement, the lamina is confined around the rear half of its periphery by an elliptical web which is formed at the intersection of the passages 14 as illustrated in Fig. 2. The disruptive velocities cannot act over the whole circle, as in Fig. 5, but are restricted to a smaller angle, somewhat as indicated by the velocity vectors V_4 in Fig. 6. These vectors V_4 represent the velocities due to conversion of the internal pressure of the lamina. It is not certain that the vectors are uniformly distributed and are of equal magnitude, and Fig. 6 is not intended to represent the conditions accurately. However, it is clear from this diagram that for any value of internal pressure, the disruptive velocities V_4 will be greater than the velocities V_3 of Fig. 5, because the same amount of energy spreads the particles in a narrower angular pattern.

When the forward velocity component V_1 is added to the various radial components V_4, the resulting pattern will show a greater average forward velocity than in the case of impingement in space. Taking all the factors into consideration, therefore, it has been found that for a given angle of impingement, the particles will be finer and will be projected at higher forward velocity and in a narrower sector than in the case of external impingement. It will be understood that a high forward velocity of projection of the entire pattern is not always desired, but the forward component V_1 can always be reduced by increasing the impingement angle, and this will result in an even finer break-up of the particles.

The same theoretical considerations indicate the practical necessity of forming the nozzle substantially as indicated in Figs. 1 and 2; namely, with the center lines of the passages intersecting substantially in the surface of the nozzle head. If the intersection is back of the surface, the web formed at the intersection of the passages will not present a true half-elliptical shape but will include more than half an ellipse. The result will be that the sides of the pattern will be constricted. This constriction, if appreciable, tends to cause the formation of relatively large drops at the sides of the pattern.

If the intersection of the passages is ahead of the surface, the web presents less than a half ellipse, and therefore the velocity diagram of Fig. 6 is not realized. The conditions then theoretically approach those for external impingement, in that there will be some backward projection components in proximity to the metal surface. Since the surface is so close to the point of formation of the fog, the tendency for large drops to form may be actually greater than in the case of true external impingement; moreover, the pattern, instead of exhibiting clear edges, may become somewhat indefinite in shape.

Definiteness of pattern is one of the characteristics of the present nozzle, and is highly advantageous, in that it permits design and use of several sprays to cover any desired angular spread, with reasonably uniform distribution of water. In considering definiteness, it will be understood that no spray can maintain clear edges for large distances from the nozzle. Owing to friction between the fog particles and the atmosphere, the edges tend to diffuse at some distance from the nozzle, which distance is less, the smaller the particles. But in any case, with proper construction according to the present invention, the pattern maintains clear edges for a substantial distance, far enough to permit accurate design and predictable performance. An example of a head with multiple nozzle is shown in Figs. 7 to 9, to be described later.

While the intersection of the passages does not have to lie exactly in the surface formed by the head of the nozzle, and some deviation therefrom may be permitted, it has been found that the tolerable deviation is not great and should preferably not exceed 5% of the diameter of the drilled holes.

With respect to the size of the particles, it will be understood that no method of fog generation will produce particles of exactly uniform size. In general, the fog pattern will contain particles of a wide range of sizes, which sizes may be considered as being distributed according to the "normal law." Definition of size therefore requires, in any case, consideration of average or mean size. In general, the average particle size depends on the diameter of the passage, and on the water pressure, as well as on the angle of impingement. The greater the size of the passage, the larger will be the particles. For any given passage, the greater the pressure (that is, the higher the velocity of the streams), the smaller the particles will be. Also, all other factors being equal, increasing the angle of impingement will make the particles finer. All of these considerations follow from the fact that the degree of break-up depends on the internal energy which momentarily appears in the form of pressure in the lamina at the intersection of the streams.

The velocity of projection and the angle of dispersion likewise depend on the foregoing factors. Thus, the velocity of projection and the mean particle size may be made substantially as desired, for any available water pressure, by proper choice of passage diameter and angle of impingement. The pattern may then be designed for any desired spread by combining any number of nozzles. Actually passages of different sizes may be used in combination, as in the construction shown in Figs. 7 to 9, now to be described.

The head comprises a body 24, having threads 26 for attachment to a hose. The body is formed at its end with surfaces 28 which, as viewed in Fig. 9, diverge from each other at an angle of about 25°. As viewed in Fig. 8, each face 28 is curved. A set of nozzles is formed in each of the faces 28. In end view, as indicated in Fig. 7, each face is provided with a large central nozzle 30 formed by intersecting passages ¼ inch in diameter, two end nozzles 32 formed by intersecting passages 3/16 inch in diameter, and intermediate nozzles 34 formed by intersecting passages ⅛ inch in diameter. As shown in Fig. 9, the nozzles are as previously described, with the center lines of their passages intersecting accurately at a point in the surface 28. Ridges 36 are formed in the body in back of the end faces to lead the water smoothly to the passages.

At the impingement angle indicated in Fig. 9, the several nozzles produce sprays with a spread of approximately 10°, whereby each set of five nozzles produces a sectorial pattern of about 50° spread. The arrangement of nozzles as herein shown is illustrative only. In this particular construction the purpose of the large nozzles 30 is to obtain a high projection velocity at a considerable distance from the nozzle. The small nozzles 34 produce a fine fog. Nozzles 32 produce droplets of intermediate size, which serve to maintain definite edges of the pattern at a considerable distance from the nozzle. Under a water pressure in excess of 30 pounds per square inch, a true fog will be generated by each of the nozzles, although the mean size of the droplets will vary for the different nozzles.

This type of nozzle is useful as a general purpose portable nozzle for fire fighting. The droplets of the several sizes contribute to produce the desired results. For example, with closely spaced nozzles, the larger droplets from the nozzles 30 will tend to carry along the smaller fog particles which are emitted from the nozzles 34.

In other cases, different nozzle combinations may be used. For example, in stationary installations for protecting against oil fires, small nozzles of uniform size may be preferred, in order to obtain a fog composed of fine particles with a low projection velocity.

In any case, the present invention affords decided advantages over external impingement. In addition to the advantages previously mentioned, there are a number of practical considerations in favor of nozzles of the type described herein.

In external impingement, extreme care must be used to drill the holes, since even a slight deviation may cause partial or total failure of impact, whereas in the present case, ordinary precision is sufficient for practical purposes. The nozzles may be conveniently made by the method described in the co-pending application of Freeman and Hencinski, Serial No. 418,004, filed of even date herewith.

It has also been found that holes of the same diameter will pass about 20% less water for the same pressure than external impingement nozzles. This means that for the same volume, the holes may be measurably increased in diameter, which is an important consideration where any clogging difficulties are likely to be encountered.

Although the invention has been described as embodied in apparatus for generating a fog of water particles, it will be understood that it may be applied to any liquid, particularly a liquid useful for extinguishing fires.

Having thus described my invention, I claim:

1. A nozzle for fog generation comprising a hollow body having circular passages inclined from the surface of the body with their center lines intersecting substantially in said surface to cause streams of liquid to impinge and thereby to break up into fine particles projected forwardly in a definite pattern, the body of the nozzle having an internal confining web defined by the intersection of the cylindrical walls of said passages.

2. A nozzle head for fog generation comprising a hollow body having a plurality of nozzles, each nozzle consisting of drilled circular passages inclined from the surface of the body with their center lines intersecting substantially in said surface to cause streams of liquid to impinge and thereby to break up into fine particles projected forwardly in a definite pattern, the body of the nozzle having an internal confining web defined by the intersection of the cylindrical walls of said passages.

3. A nozzle for fog generation comprising a hollow body having drilled circular passages inclined from the surface of the body with their center lines intersecting substantially in said surface, said passages intersecting substantially in a half-ellipse included within the body of the nozzle, to cause streams of liquid to impinge and thereby to break up into fine particles projected forwardly in a definite pattern.

4. A nozzle for fog generation comprising a hollow body having drilled circular passages inclined from the surface of the body with their center lines intersecting substantially in said surface, with a tolerable deviation not exceeding 5% of the diameter of the passages, to cause streams of liquid to impinge and thereby to break up into fine particles projected forwardly in a definite pattern, the body of the nozzle having an internal confining web defined by the intersection of the cylindrical walls of said passages.

5. A nozzle head for fog generation comprising a hollow body having a plurality of nozzles, each nozzle consisting of two drilled circular passages with their center lines intersecting substantially in said surface, with a tolerable deviation not exceeding 5% of the diameter of the passages, to cause streams of liquid to impinge and thereby to break up into fine particles projected forwardly in a definite pattern, the body of the nozzle having an internal confining web defined by the intersection of the cylindrical walls of said passages.

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