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WATER PIERCING MISSILE LAUNCHER

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

1.0 Field of the Invention

The present invention relates to a method for launching missiles and, more particularly, to a method of launching missiles that utilize the missile exhaust gases to simplify the structure of the launcher itself and to enhance the performance of the initial flight as a missile moves away from the launcher.

2.0 Description of the Related Art

Existing launchers, especially those used to launch missiles from submarines, are relatively complex systems having an ejection subsystem and a launch tube. The ejection subsystem pushes the missile through the launch tube against the pressure and a inertia of the ambient water. For such applications, the ejection system generates a gas ejection pressure typically by the use of pyrotechnical devices, which entail a separate firing circuit from a missile and attendant safety and reliability concerns. The gas evolved shoots the missile much as a gun shoots a projectile. The work of the gas is finished for ejection when the base of the missile clears the exit of the launch tube. A large bubble results for such ejection and adds to the acoustic, visual and thermal signatures of the launch. Elaborate pressure balancing systems are commonly used to equilibrate the pressure of the launcher with the pressure of the sea so as to maintain the system in a ready to launch condition as the submarine moves up and down in the seaway. The "huffing and puffing" of the pressure balancing system emits noises that are very undesirable in that they can reveal the presence and location of the submarine. It is desired that a method be provided for launching missiles from beneath the surface of the water that simplifies the launching system.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide a launcher system wherein the number of parts required is reduced relative to existing launcher system.

It is a further object of the present invention to provide a launching system that reduces the complexity of the control systems involved with launching a missile.

It is a further object of the present invention to eliminate the need of pyrotechnical devices to accomplish launching of the missile.

Still further, it is an object of the present invention to provide a method for launching a missile from a submarine that reduces the acoustic, visual and thermal signatures of the launching operation.

SUMMARY OF THE INVENTION

The invention is directed to a method for launching missiles from submarines that reduces the complexity of the launcher itself, while at the same time improving the performance of the initial flight of a missile as it moves away from the launcher of the submarine.

The method comprises the steps of providing a launcher, locating the launcher in a predetermined manner and placing a missile having an igniter in the launcher in a predetermined manner. The provided launcher has top, middle and bottom regions and a central opening at its bottom region that leads to exhaust conduits of the launcher which, in turn, run lengthwise along the launcher from its bottom to its top regions and exit from passageways at the top of the launcher. The step of locating the launcher is to place the launcher into a vessel so that the exit passageways are mated with one of the exterior surfaces of the vessel. The step of placing the missile is to locate the nozzle of the missile in correspondence with the central opening of the launcher. The final step is to activate the igniter of the missile.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention may be realized when considered in view of the following detailed description, taken in conjunction with the accompanying drawings wherein:

Fig. 1 is composed of Figs. 1(A), 1(B), 1(C), 1(D), and 1(E) and illustrates various states of the missile starting at a at-rest condition and sequencing to its launch condition where the missile pierces the surface of the water after it exits from the submarine.

Fig. 2 is composed of Figs. 2(A) and 2(B) both of which illustrate a computer fluid dynamics (CFD) computational domain related to selecting the parameters of the central opening of the launcher of the present invention.

Fig. 3 illustrates a computation domain of the lower portion of the launcher.

Fig. 4 illustrates computational domain at a time 0.301 seconds after rocket launch.

Fig. 5 illustrates the parameters associated with an exhaust bubble at 0.010 seconds after ignition.

Fig. 6 illustrates the exhaust bubble of Fig. 5 in its nearly final state.

Figs. 7 and 8 illustrate some of the parameters associated with the launched missile entering into the water (Fig. 7) and then having lifted out of the water (Fig. 8).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings wherein the same reference number indicates the same element throughout, there is shown in Fig. 1 various states of the missile being launched by a launcher starting from its at-rest state and sequencing to the missile exiting from under the surface of the water, with the sequential states given in Figs. 1(A), 1(B), 1(C), 1(D), and 1(E).

The present invention is associated with launching a missile 12 from a submarine typically traveling under the surface 14 of the water, but is equally applicable to launching from surface vessels. The submarine has exterior surfaces and the missile 12 has an igniter for propellant that produces power in the form of exhaust gases 12A that are delivered to a nozzle 12B of the missile 12.

The launcher 10 may be the launcher described in U.S. Patent 5,837,919, which is herein incorporated by a reference. Although the practice of this invention is particularly suitable for use with launchers used for submarines, the use of launchers for a surface vessel is equally applicable. Furthermore, it is desired that a common launcher be provided so as to reduce associated cost in that logistics of manufacturing, distribution, maintenance, and tactical employment are the same for both surface and submarine missiles and launch tubes.

The launcher 10 of Fig. 1 has top 16, middle 18 and bottom regions 20 and a central opening 22 at its bottom region 20, preferably having a hemispherical shape, that leads into exhaust conduits 24 and 26 of the launcher 10. The central opening 22 is interchangeably referred to herein as port 22. The exhaust conduits 24 and 26 run lengthwise along the launcher 10 from its bottom 20 to its top 16 regions. The exhaust conduits 24 and 26 respectively have exit portions 24A and 26A, interchangeable referred to herein as exit passageways, at the top 16 of the launcher 10.

The launcher 10 preferably cooperates with a hatch 28 of the submarine so as to cover the passageways 24 and 28 before the missile 12 is activated and, conversely, to uncover the passageways 24 and 26 immediately before the missile 12 is to be activated. The activation of the missile is performed by a control mechanism generally shown by reference number 10A. The at-rest state of the missile 12 in the launcher 10 is illustrated in Fig. 1(A). The operative condition of the missile 12 after it has been ignited so that its exhaust gases

12A are delivered to its nozzle 12B may be further described with reference to Fig. 1(B).

Fig. 1(B) illustrates the launcher 10 as having its hatch 28 open so as to expose passageways 24A and 26A thereby allowing the exhaust gases 12A produced by igniting the propellant of missile to enter the water after the exhaust gases 12A have traveled upward within conduits 24 and 26. The continued flow of the exhaust gases 12A may be further described with reference to Fig. 1(C).

As seen in Fig. 1(C), the exhaust gases 12A flow upward and exit passageways 24A and 26A so as to form an atmosphere 30 of water vapor and gas products of a low density as compared to the water itself. The utilization of this atmosphere 30 by the missile 12, may be further described with reference to Fig. 1(D).

As seen in Fig. 1(D), the missile 12, because of its creation of its exhaust gases 12A has already lifted a major portion of itself from launcher 10 and has entered into the atmosphere 30 of water vapor and gas exhaust products. The continuation of the flight of the missile 12 moving through the atmosphere 30 of water, vapor and gas exhaust products is shown in Fig. 1(E).

As seen in Fig. 1(E), the missile 12 has penetrated the surface 14 water and is allowed to go forward in its pre-assigned path to a target of interest.

Because of the creation of the atmosphere 30 of water, vapor and gas exhaust products, the method of the present invention provides for a much higher ejection velocity of the missile 12 and a lower drag in its initial flight as the missile 12 moves away from the launcher 10.

More particularly, as known in the art, the drag pressure is proportional to the density in which an object, such as missile 12, moves. Because of the practice of the present invention, the density of the exhaust gases 12A in which the missile 12 moves within the water is orders of magnitude less than liquid water. Because of this relatively low density created by the exhaust gases 12A, the exit velocity on a missile 12 is greatly increased and more energy is made available for the rocket motor of the missile 12 for its flight to its target of interest. Further, the exhaust gases 12A provide the power to lift the missile 12 out of the launcher 10, unlike prior art launchers requiring gas ejection system to propel the missile 12 from the launcher. Accordingly, the requirements of the gas generator and the elaborate and complex pressure balance systems associated with prior art launchers are eliminated by the present invention.

The method of the present invention allows the firing of surface-to-surface and surface-to-air missiles from submarines without any modification to these missiles. Further, the present invention allows for the acoustic, visual, and thermal signatures to be minimized compared to those signatures yielded by prior art devices. Further, the present invention allows the exhaust gases 12A to do useful work outside the launcher 10 in its maintenance of the low-density column inherit in the atmosphere 30 of water, vapor and gas exhaust products. Moreover, the present invention allows for use of simple geometry to determine the opening 22, sometimes referred to as a port, and may be further described with reference to Figs. 2-8.

With regard to Figs. 2-8, "x" is a vertical coordinate along the centerline of the missile and launch tube. The coordinate "y" is parallel to the longitudinal axis of the submarine or the vessel from which the projectile is being launched. The units of Figs. 2-8 are centimeters and the launch tube is defined as being 671 cm (22 feet) long. The deck of the submarine or the vessel is at x = 671 cm in the computational domains of the present invention to be further discussed hereinafter with regard to Figs. 2-8. The free surface of the water atmosphere interface is 610 cm (20 feet) above the deck of the submarine. The Figs. 2-8 show the flow field established by the exhaust stream of the missile at a very early time. For some of the description related to Figs. 2-8, the exhaust has completely filled exhaust conduits 24 and 26, and just started pushing water away from the exit passageways 24A and 26A. The hatch 28 is not modeled mathematically, but is assumed to be open.

Fig. 2 is composed of Figs. 2(A) and 2(B) each of which illustrates a computer fluid dynamics (CFD) computational domain, wherein both Figs. 2(A) and 2(B) have an x-axis and a y-axis and Fig. 2(B) illustrates the details of Fig.(A). The x-axis of both Figs. 2(A) and 2(B) is along the trajectory of the missile and follows the centerline of the launcher 10. The orientation of this axis is up (vertical) relative to the submarine, but horizontal on the plane of the page of Figs. 2(A) and 2(B). The y-axis of both Figs. 2(A) and 2(B) is internal to the vessel e.g., submarine and is parallel to the longitudinal axis of the vessel. The origin of the coordinates is at the base of the missile launcher, at approximately the central opening or port 22, also shown in Fig. 1. The computational domain is a cross section through the launcher and has cylindrical symmetry. The units of length along the axes are centimeters. A throat 32 and exit plane of the nozzle 12A of the rocket motor are represented in Figs. 2(A) and 2(B). When the rocket motor is fired, the propellant evolves gaseous products of combustion, which pass through the throat 32 of the nozzle 12A and expand through the hemispherical region 20. The exhaust used in the computations of the central opening 22, also shown in Fig. 1, is representative of typical operational missiles. The state of the fluid associated with the atmosphere 30 of the water vapor and gas exhaust products may be further described with reference to Fig. 3.

Fig. 3 illustrates a plot 34 of Mach number contours generally identified by reference designation 34A, which are the result of computations showing details of the region near the origin, that is, near the central opening 22. The contours 34A of the plot 34 are the Mach number (M), ranging from about 0.26 to about 3.96, of the exhaust stream at a time shortly after quasisteady state conditions have been attained. In operation, the motor of the missile 12 evolves exhaust, which passes through the central opening 22 and into the hemispherical bottom region 20, more clearly shown in Fig. 1. The exhaust then enters the exhaust conduits 24 and 26.

Fig. 3 is a detailed view and computational domain of the lower portion of the launcher 10. The geometry related to the lower portion of the launcher 10 is approximately that of the well known US Tomahawk missile. The port 20 at x = 61.5 cm receives the exhaust from the rocket motor nozzle 12A, which is located between x = 61.5 cm and x = 76 cm. The contours 34A in the computational domain are Mach numbers. The Mach numbers represent the quasisteady flow from the rocket motor at the time the exhaust conduits 24 and 26 have filled and the exhaust is beginning to displace water above the exit passageways 24A and 26A. The high supersonic values in the expansion cone of the nozzle 12A and the unit (M = 1) at the throat 32 of the nozzle 12A indicate normal rocket motor performance, even though the outward flow of the exhaust stream through the exhaust conduits 24 and 26 is impeded by the inertial resistance of the ambient water 14 over the launcher 10.

In the practice of this invention a computer method is used to design the port 22 and the free area required for the exhaust conduits 24 and 26. When the port 22 is too small or the launch depth too great, the results show abnormal rocket motor performance, i.e., subsonic flow in the throat and pressure signals propagating from outside the motor into the throat 32 and subsequently into the motor chamber (not shown). When the port 22 is too large, there is less pressure on the base of the missile and the ejection velocity is reduced. The port 22 and conduits 24 and 26 are sized by performing computer studies that systematically vary the port area, the conduit cross sections, and the launch depth. The final design is the one with the highest ejection velocity.

There are practical limits on the design, such imposed by as the increasing strength, weight, and cost of the materials required as the pressures increase, and the potential for erosion of parts in the lower portion of the launcher by the high temperature exhaust stream. The erosion is made worse by confining the exhaust to smaller conduits or causing it to turn sharper corners. Further, the state of the fluid associated with the atmosphere 30 of water vapor and gas exhaust products may be further described with reference to Fig. 4.

Fig. 4 shows a plot 36 and contours generally identified by reference designation 36A related to the opposite end, relative to that of Figs. 2 and 3, of the computational domain at a time 0.301 seconds after rocket motor ignition. The x and y axes of

Fig. 4 represent the dimensions of exhaust conduits 24 and 26. The exhaust conduits 24 and 26 related to Fig. 4 have been filled for some time and the interface between the rocket exhaust and the ambient water 14 is the curved, light-colored region encompassed by the contours 36A of Fig. 4. The light-colored region of contours 36A and points inside the light-colored region are the beginning of a large bubble that is forming over the submarine hatch 28. In Fig. 4, the y-axis region between 28 and 42 is the top of the conduits 24 and 26. The conduit exit plane 24A is at x = 673.

Fig. 4 shows the flow field in the computational domain at a later time, that is 0.301 seconds after rocket ignition. A significant amount of water has been displaced away from the path the missile will follow. The water piercing process has clearly begun. The contours 36A on the plot 34 show "mass fraction," that is the relative amounts of missile exhaust and water at each point of the domain. Near the exit planes 24A and 26A, the material is pure exhaust. Away from the disturbed region near the exit planes 24A and 26A the material is all water. Intermediate regions consist of part water and part exhaust, and are shown as a progressively darkening gray color of contours 36A as the water fraction increases. An object of the invention is to create a path of low density water vapor and exhaust for the missile to fly through. In the practice of the invention, computer simulations show a well defined boundary between the exhaust and the water, which is desirable. The computer simulations can be used to optimize the rocket motor mass flow. Further details of the atmosphere 30 of water vapor and gas exhaust products may be further described with reference to Fig. 5.

Fig. 5 has the x and y axes previously discussed with reference to Figs. 3 and 4 and shows a plot 38 of an exhaust bubble at 0.010 seconds after ignition of a typical submerged missile. Contours of equal volume fractions are shown in Fig. 5 and generally identified by the reference designation 38A. The volume fraction is the volume of exhaust as a fraction of the total volume in a fluid cell of the computational domain shown in Fig. 5. The fluid cells in the black region 40 of Fig. 5 contain pure water. The white region 42 shown in Fig. 5 is pure exhaust gas. The gray regions identified by reference designation 38A associated with the contours are part gas and part water, or vapor. The contour values for the gray scale range from 0.06 to 0.94.

The exhaust bubble of plot 38 of Fig. 5 occurring at 0.010 dissipates itself and is shown in its later, nearly final, state in Fig. 6 at a time of 1.4 seconds at which time the missile 12 has pierced the water 14 as shown in Fig. 1(E). Further, details of the missile exiting the launcher may be further described with reference to Fig. 7.

Fig. 7 generally illustrates a plot 44 showing the position of the missile 12 relative to the conduit 24, exit portion 24A and the top surface of the water 14. Further, Fig. 7 shows contours 44A ranging from 0.06 to 0.94 covering the interface from the exit portion 24A to the top surface of the water 14.

Fig. 8 is interrelated to Fig. 7 and illustrates the parameters after the missile 12 has lifted out of the water 14.

Figs. 7 and 8 show a computer solution with the missile exiting the launcher. In the illustrations of Figs. 7 and 8, the missile 12 was first held by the launcher for 0.5 seconds, then released. The sequence of Fig. 7 (initial) and Fig. 8 (final) shows the missile exiting through the vapor bubble. By holding the missile 0.5 seconds, adequate piercing of the water 14 is assured.

In the practice of the invention, the differential equations of the missile trajectory were integrated numerically.

The motion of the bubble was used to determine the relative velocity between the nose of the missile and the vapor in the bubble. This relative velocity, and the local density, was used to compute the drag on the missile. The drag was very much reduced as compared to calculations for a missile exiting through undisturbed water. The trajectory is very close to the trajectory computed for the same missile being launched into a vacuum.

The results shown in Figs. 7 and 8 were for a current, operational missile, and launcher with a geometry suitable for a surface ship or ground based launcher. The results show that a "common" launcher is possible through extension of the launcher concept, more fully described in U.S. Patent 5,837,919 to submarine applications.

It should now be appreciated that the practice of the present invention provides for a method of utilizing a launcher that diverts the missile exhaust streams before the missile is released from the launcher in such a way that the water above the launcher is pierced and pushed out of the way. The exhaust gas products of the missile are used, rather than gas from a separate device, such as a gas ejection system. The missile 12 is released into an atmosphere 30 of water vapor and gas exhaust products of low density compared to the water allowing the missile to be provided with a higher ejection velocity and a lower drag initial flight as it moves away from the submarine.

ABSTRACT OF THE DISCLOSURE

A method of launching a missile that utilizes the gas exhaust of a missile to create an atmosphere of water vapor and gas exhaust products in which the missile enters. The created atmosphere provides the launched missile with a higher ejection velocity and a lower drag initial flight as it moves away from the submarine.

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INVENTOR: JON J YAGLA

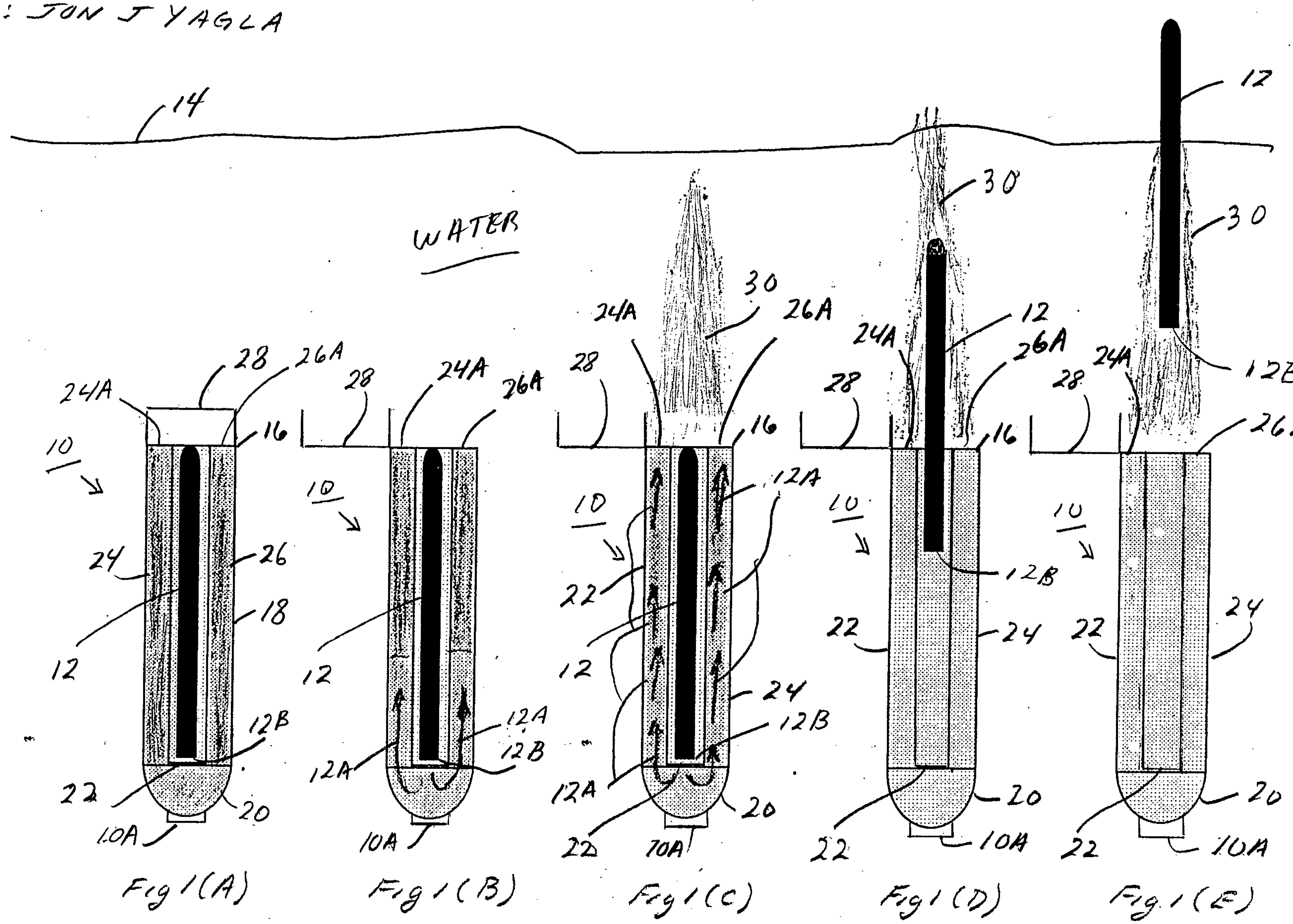

FIG. 1

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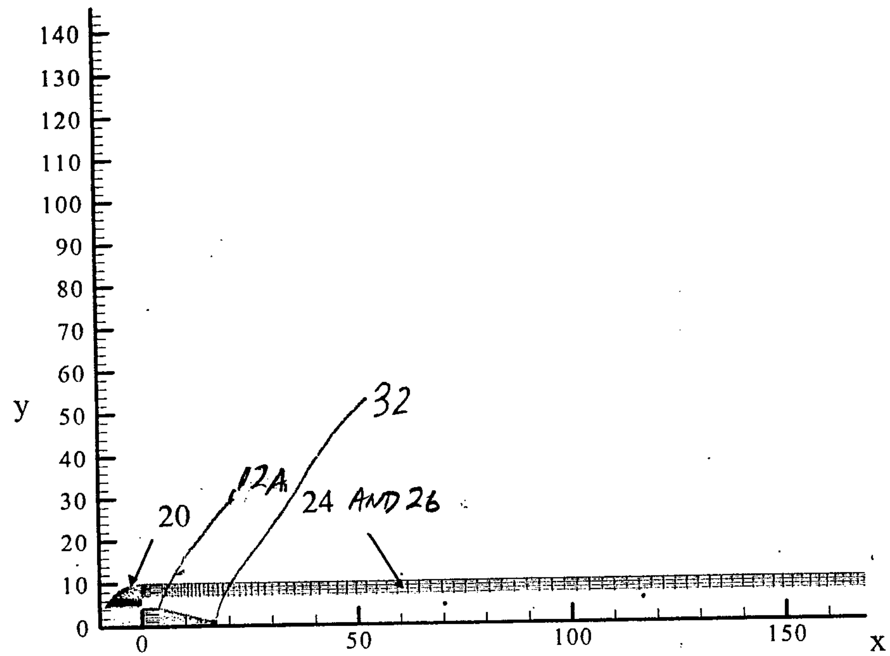

Fig. 2(A)

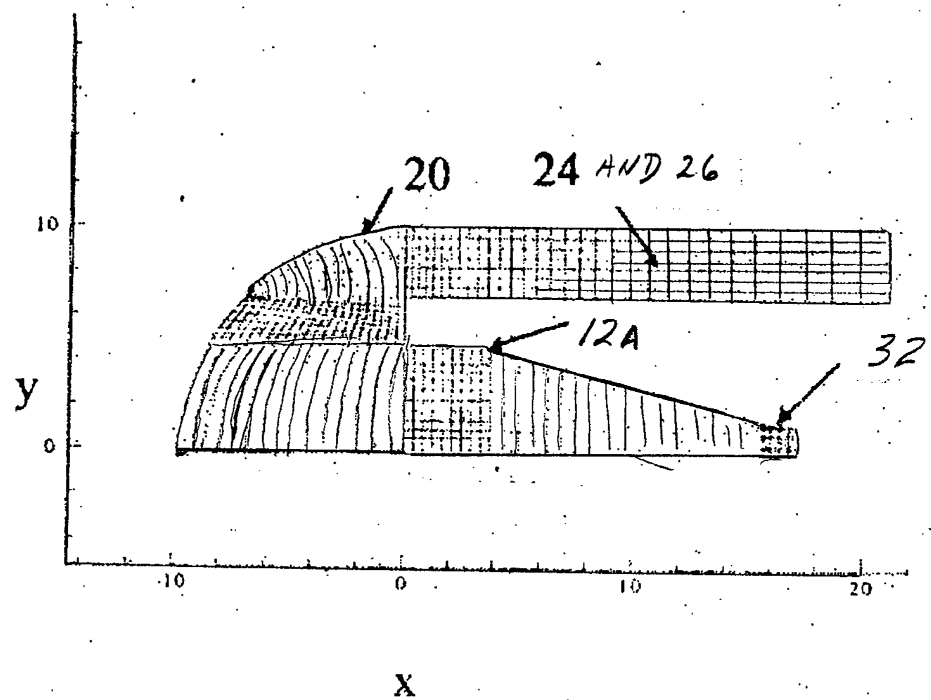

Fig 2 (B)

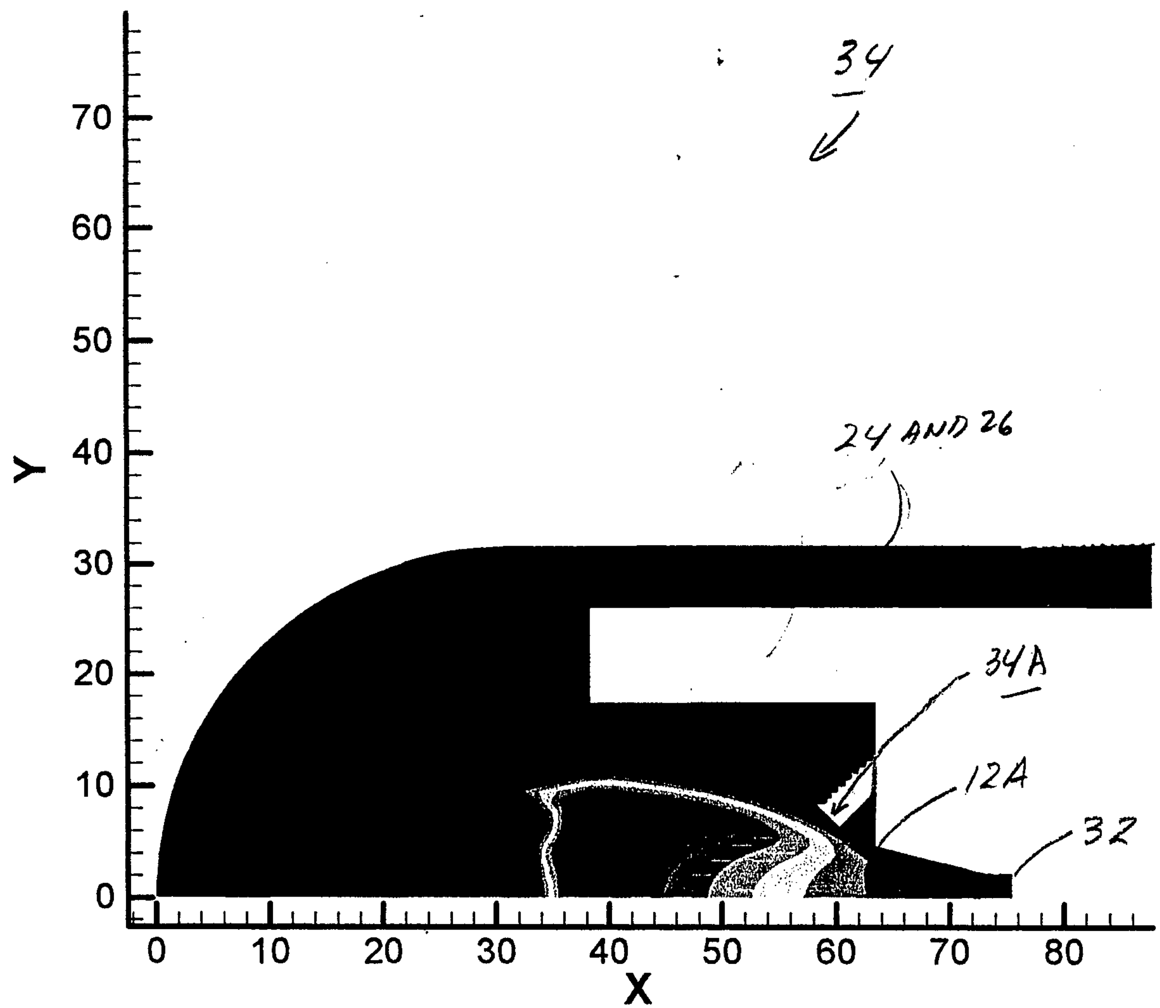

FIG 3

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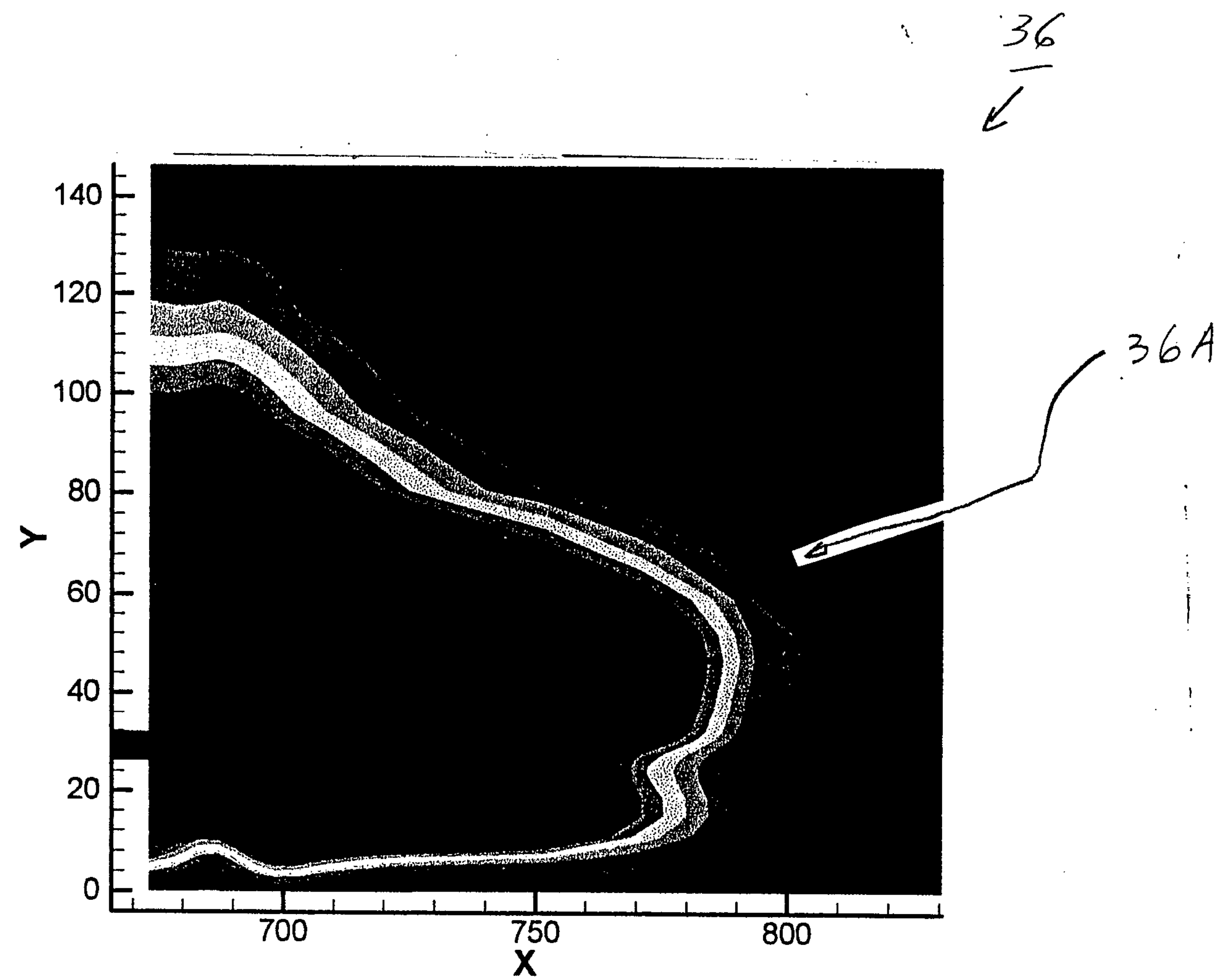

FIG 4

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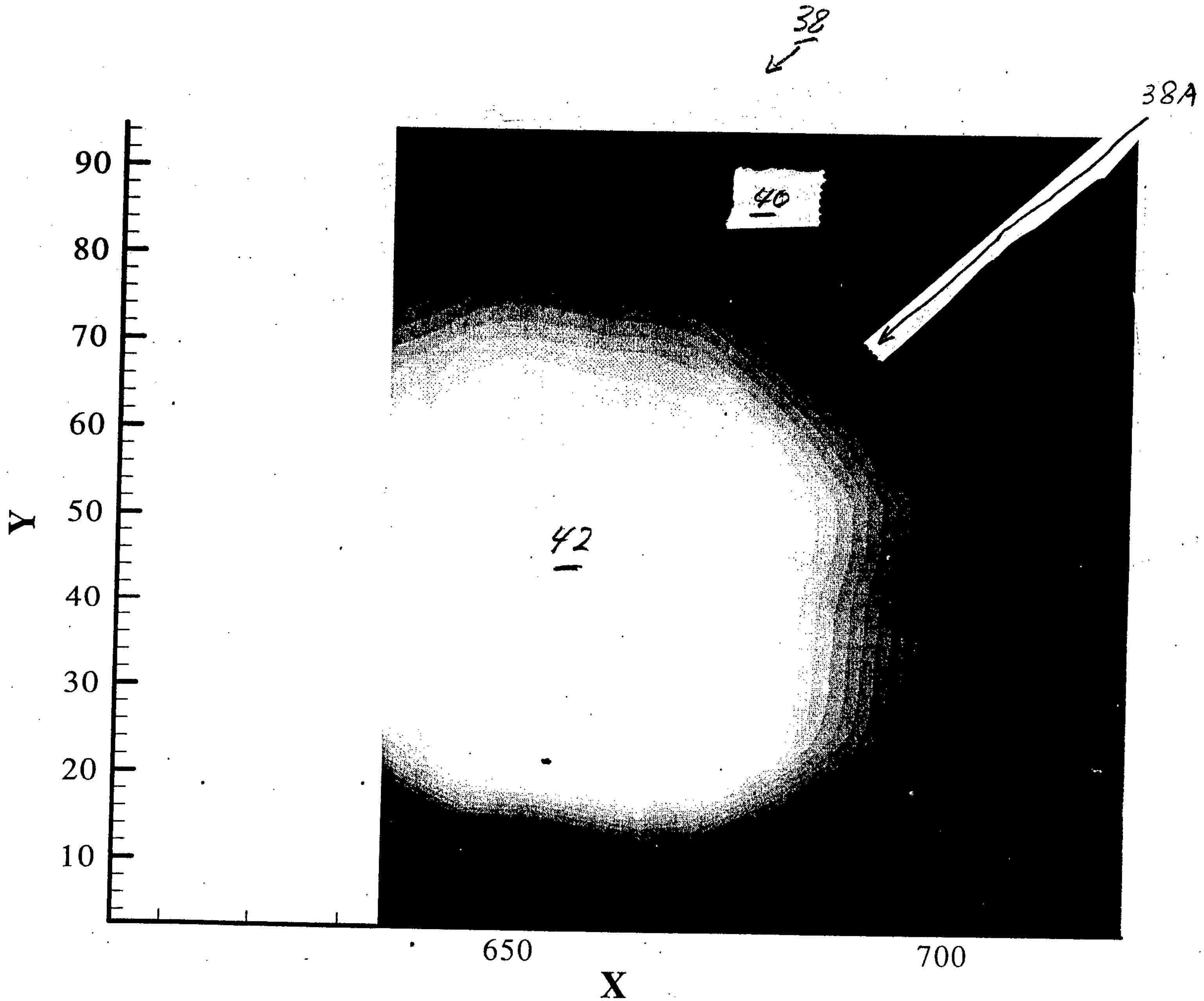

Fig. 5

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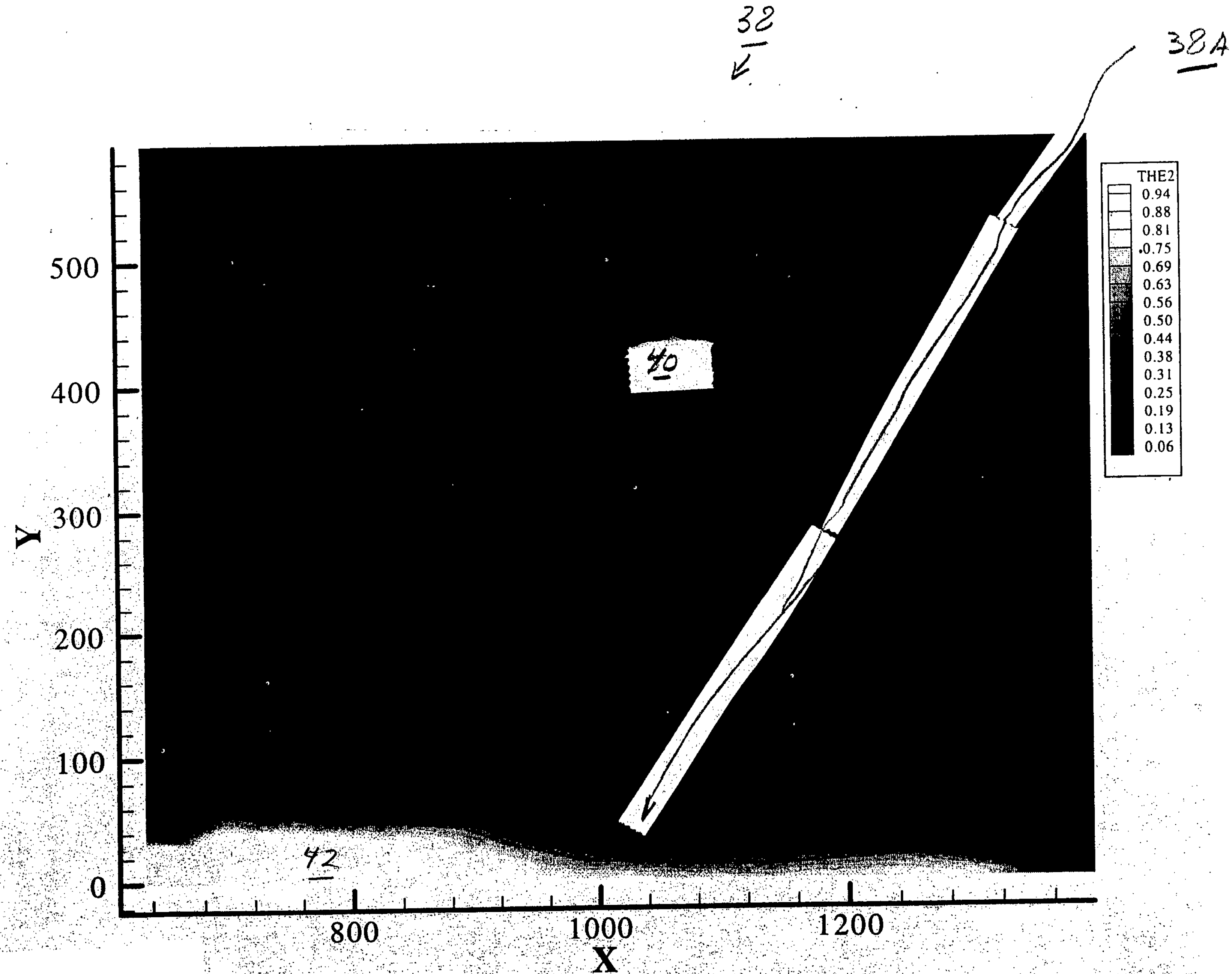

Fig. 6

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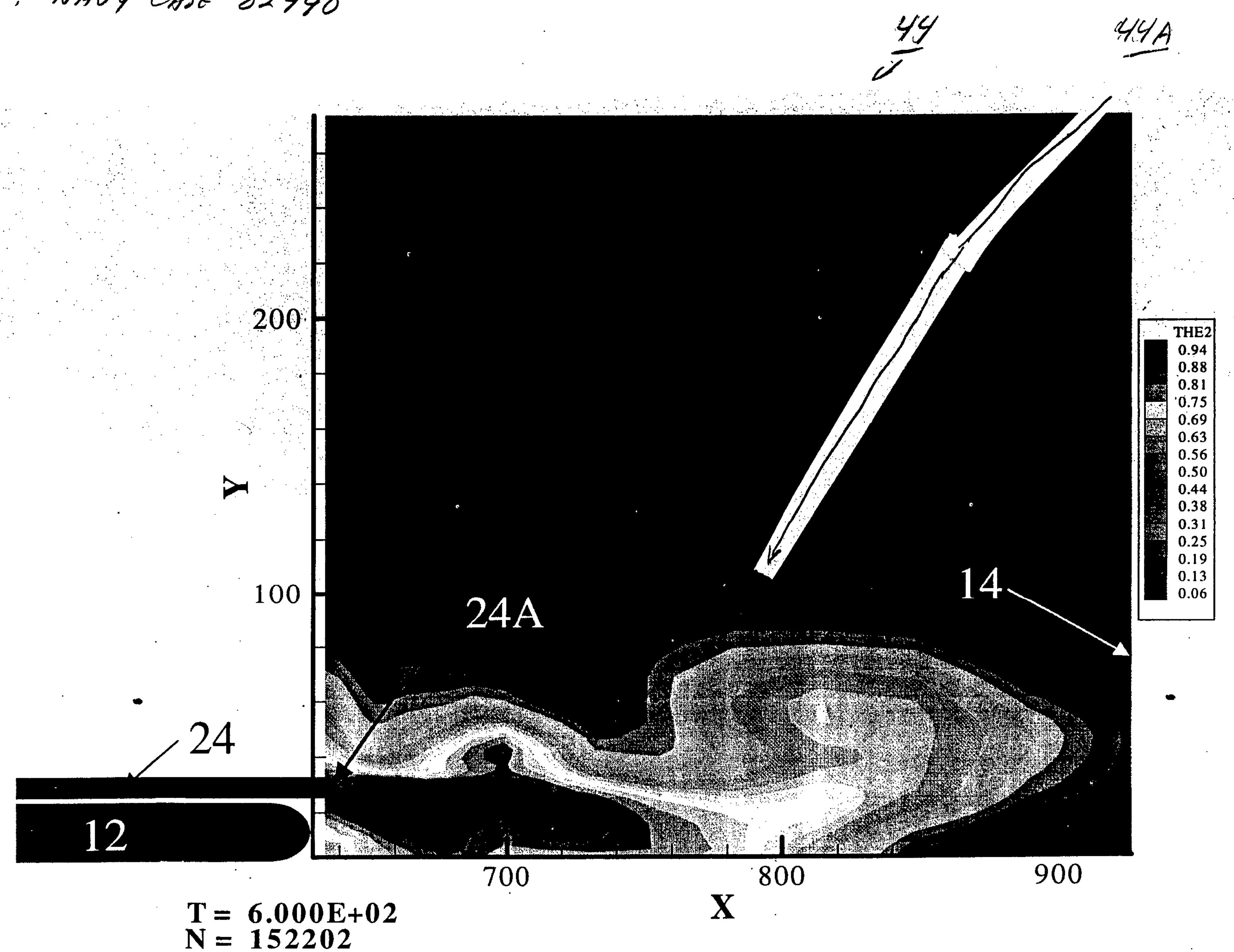

Fig. 7

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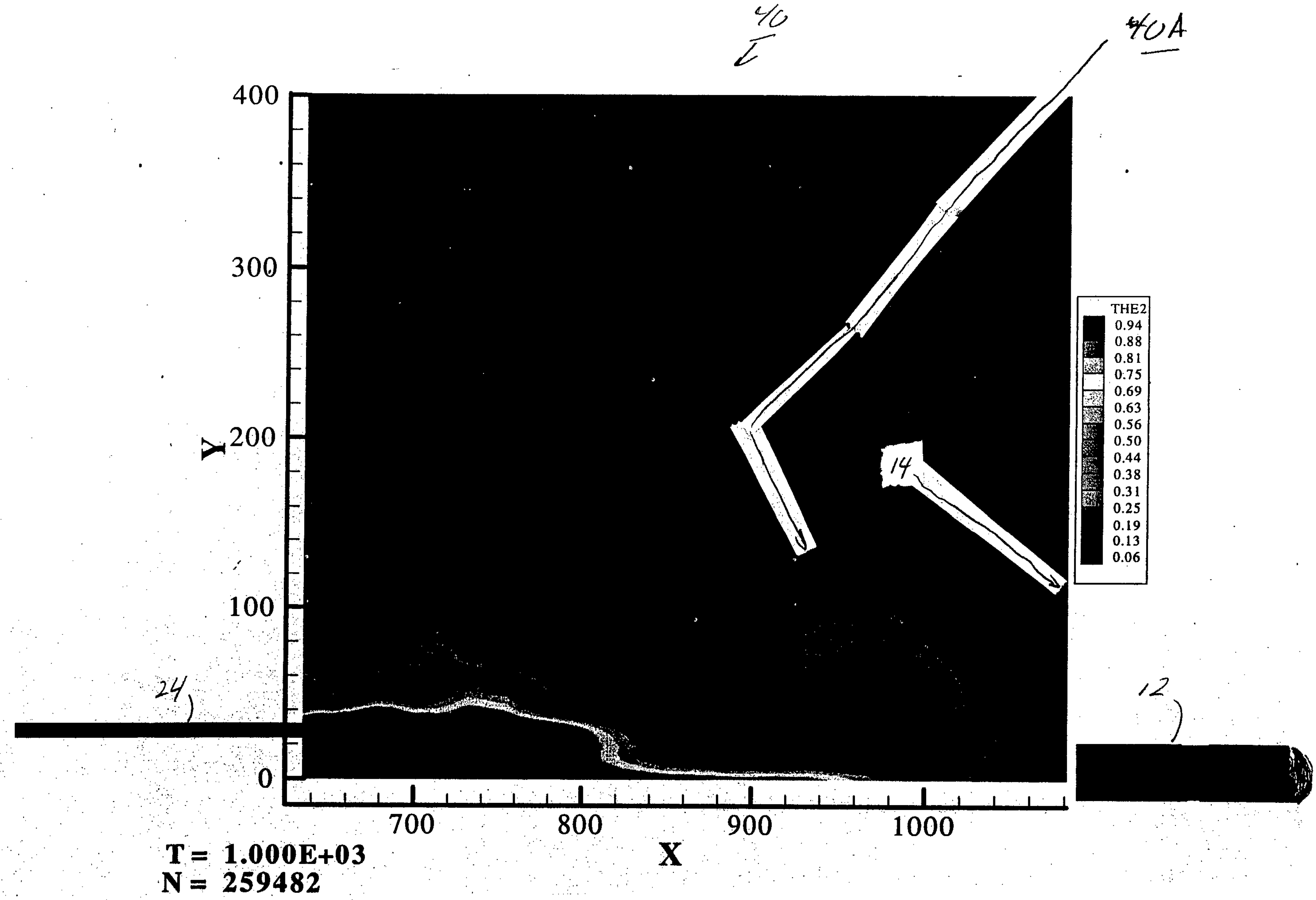

Fig 8