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HIGH VACUUM OBSERVATION APPARATUS

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FIG-1

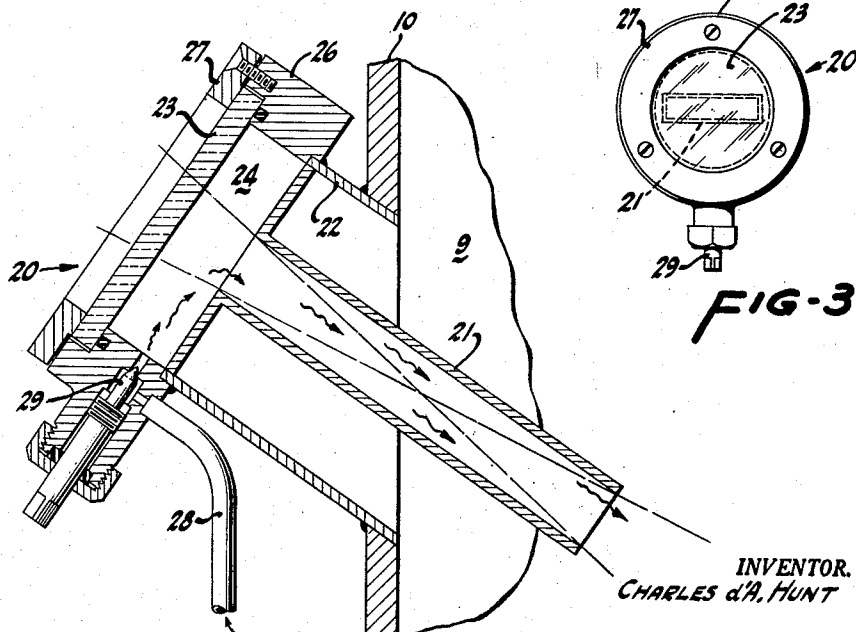
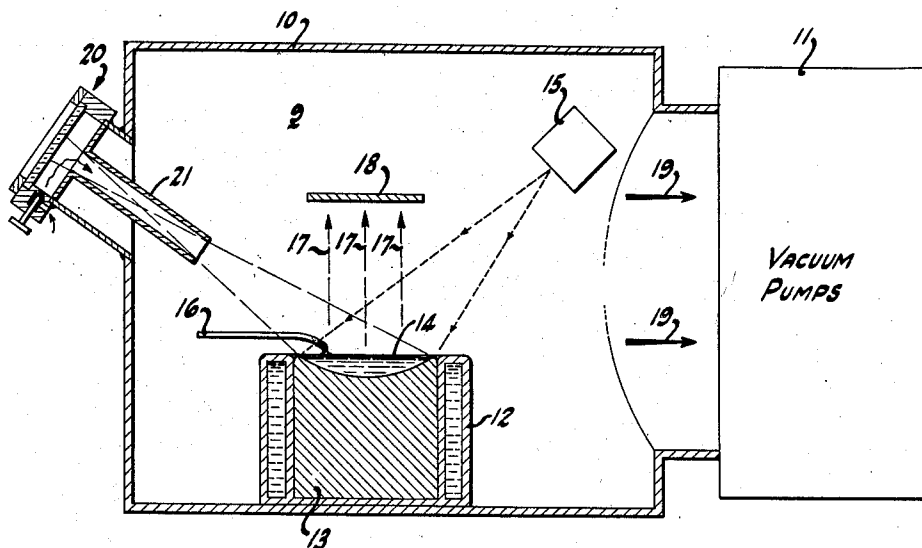


FIG-3

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FIG-2

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HIGH VACUUM OBSERVATION APPARATUS
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3 Claims. (Cl. 98—1)

The present invention relates in general to an improved apparatus for viewing the interior of evacuated chambers wherein substantial quantities of condensable vapor are present, and is particularly directed to the prevention of observation port clouding by vapor deposition thereon.

Difficulties are often encountered in high-temperature furnaces, and the like, through the inability to visually observe operations within same, inasmuch as condensable vapors evolved therein coat the interior of such furnaces and like apparatus and consequently cloud and obscure viewing ports which may be provided therein. Various solutions to this problem have been proposed in the prior art, however, these do not lend themselves to application in the high vacuum field. Thus, for example, in the melting and casting of metals, or the like, under high vacuum and also in the vapor deposition of materials under high vacuum, it has been found that conventional observation means are quite unsuited to the maintenance of a clear field of vision from the exterior of the vacuum apparatus. While it is possible in many casting and vapor processing operations to provide for a heavy flow of gas or air across a desired location whereat viewing ports are disposed, it will be appreciated that this is wholly unacceptable in vacuum conditions. Modern vacuum technology, and in particular, electron beam melting and casting operations and coating operations require the maintenance of very substantial vacuums within reaction volumes. Under these circumstances, it has proven quite difficult and troublesome to insure operators of a clear view of the actual operations within the vacuum chamber.

The present invention is particularly directed to those vacuum applications wherein it is required and necessary for the internal atmosphere to be maintained at a very low pressure as, for example, of the order of one micron of mercury or less. In particular, the present invention is advantageous in vacuum deposition operations, wherein rather copious quantities of vapor may be evolved, and this is exemplified in the coating of strip iron with a light metal such as aluminum, for example. Despite precautions normally taken to direct the vapor upon the substrate to be coated, it will be appreciated that a certain amount of the vapor unavoidably escapes the desired vapor path, and does then coat the interior of the vacuum apparatus. Even a relatively small amount of vapor deposition upon the interior viewing ports or windows is sufficient to cloud same and prevent adequate observation therethrough.

The present invention, in brief, provides for the establishment of an elongated viewing member or tube extending through the wall of a vacuum chamber and directed toward an area or volume to be viewed by an operator exteriorly of the apparatus. This elongated viewing tube is closed at the outer end by a window or port formed of a transparent material, and is opened at the inner end. It will be appreciated that vapor evolved or otherwise present in the apparatus would normally in part traverse such a viewing tube. However, in accordance herewith, one cross-sectional dimension of the tube is maintained quite small, particularly as regards the ratio of same with respect to the overall tube length. Inasmuch as the apparatus of the present invention is directed to the viewing of operations wherein condensable vapor is involved, it will thus be seen that a substantial portion of vapor entering the open end of the viewing tube with random directions of motion will impinge upon and condense upon the

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tube walls. This alone has been found to be insufficient to prevent undue clouding of the observation port or window. Consequently, the apparatus hereof further provides for the maintenance of an increased pressure within the tube, varying from a maximum at the inside of the viewing port to a minimum at the open end of the tube. Such a pressure gradient is afforded hereby through the introduction of relatively minute quantities of gas immediately adjacent the inner surface of the viewing window. With regard to the particular effects involved herein in the prevention of vapor deposition upon the window by the foregoing briefly noted steps of this invention, reference is made to the following detailed description of the present invention.

The present invention is herein illustrated as to applicability with a vacuum furnace and as to possible, actual, physical structure of apparatus capable of carrying out the method in the accompanying drawings, wherein:

FIGURE 1, is a sectional view of a vacuum plating apparatus embodying the viewing apparatus of the present invention as illustrated at the left of such figure.

FIGURE 2, is an enlarged sectional view of viewing apparatus of the present invention, and

FIGURE 3, is an end view of such apparatus as may be visually observed by an operator exteriorly of a vacuum furnace or the like.

In order to afford an appropriate setting for the present invention and to specifically identify one particular and highly advantageous application thereof, reference is made to FIGURE 1 showing a vacuum chamber 9 defined by a vacuum enclosure 10 communicating with high speed vacuum pumps 11. Within this chamber there may be disposed a vapor source formed, for example, of a crucible 12 having therein an ingot of material 13. The upper surface of this ingot 13 is heated as by means of electron bombardment from an electron gun 15, likewise disposed within the chamber. This heating may be employed to directly vaporize the material of the ingot 13, or in the alternative there may be applied to the top of such ingot a further material 16, as by the feeding of a wire or the like thereon, so that vapor is evolved from the vapor source and rises as indicated by arrows 17. Although not germane to the present invention, it is noted that under certain circumstances advantage lies in the feeding of a second material 16 onto the top of a block of higher melting point material retained within a cool crucible. This is particularly true, for example, in the vapor deposition of aluminum and like metals. The disposition of a substrate or a strip 18 above the crucible will be seen to result in the deposition of vapor thereon, so as to provide a coating upon such substrate.

Continuous evacuation of the chamber 9 is accomplished by the vacuum pumps 11, and such is indicated by the heavy arrows 19, it being contemplated that the chamber shall be maintained at a pressure of the order of one tenth micron of mercury. In a wide variety of applications, including the one identified above and illustrated in FIGURE 1, it is highly desirable to carry out operations in such high vacuum, and it is with respect to these applications that the present invention is particularly directed.

Despite the indication in FIGURE 1 of the direct rise of vapor from the crucible, as indicated by arrows 17, it will be appreciated that there is unavoidably included a certain random vapor motion whereby a vapor deposition actually occurs upon other portions of the apparatus. Normally this is not particularly undesirable, and in the instance indicated herein, such may be very materially minimized through the superheating of the vapor and the maintenance of the high vacuum within the chamber. Despite this minimization of random vapor motion, there yet occurs a sufficient dispersion of the vapor to cloud ob-

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servation ports which might otherwise be positioned in exterior walls of the enclosure 10. It will be further appreciated, that a direct viewing of operations within the vacuum apparatus of the type hereinabove described is highly desirable and is in fact necessary for many applications. Direct viewing of any desired portion of the interior of a vacuum chamber, wherein condensable vapor may be evolved, is afforded by the present invention, and there is generally indicated at 20 of FIGURE 1 apparatus suitable to carry out the method hereof.

A specific embodiment of this invention is generally indicated at FIGURE 2 of the drawing, and with reference thereto it will be seen that there is provided an elongated viewing tube 21 extending through a wall of the enclosure 10 into the evacuated chamber 9. This viewing tube, which is open at both ends, may have a flange about the outer end thereof, engaging a cylinder 22 which is in turn physically connected to the enclosure wall, as indicated. Viewing is accomplished through a port or window 23, disposed outwardly of the viewing tube and in spaced relation from the outer end thereof. This then defines an enlarged chamber 24 between the window 23 and the outer end of the viewing tube 21, and such may be enclosed by an annular member 26 secured, for example, to the outer end of the cylinder 22. The window 23 is mounted upon this ring 26 as by means of a clamping ring 27 with screws or the like extending into the ring 26, and confining the window within a recess in the latter ring 26. Suitable sealing means, as indicated, may be provided to insure vacuum integrity within the chamber 24 as regards possible leakage of air about the viewing window 23.

In accordance with the present invention, there is provided a gas which is introduced into the chamber 24 immediately adjacent the window 23 at a low pressure which is, however, greater than the pressure within the vacuum chamber 9 to be viewed. As illustrated, this gas may be supplied through an external tube 28 from a gas source, not shown, and metered into the chamber 24 by a valve 29. Inasmuch as the high vacuum within the chamber 9 is maintained despite the evolution of vapors or gases therein, it will be appreciated that the viewing method hereof cannot introduce a sufficient quantity of gas into such chamber as to materially affect the pressure thereof. Prevention of vapor deposition upon the viewing port 23 is accomplished herein by the direction of vapor molecules onto the walls of the viewing tube for condensation of such vapor thereon, so that same cannot reach the window and condense upon the window to coat same. To this end at least one cross sectional dimension of the viewing tube is made quite small. It will be seen that in this manner vapor molecules entering the inner end of the viewing tube with random directions of motion will in most part naturally impinge upon the closely spaced walls of the tube, and consequently, will condense thereon. There is, however, some proportion of the entering vapor molecules which will have a direction sufficiently axially of the tube to normally traverse same, and consequently, to impinge upon the inner surface of the viewing port. These vapor molecules are redirected in accordance herewith by collisions with gas molecules provided within the tube. Rather than attempt, as in prior art approaches, to provide a blast of air or gas across a viewing port, inasmuch as such would obviously be impossible in high vacuum apparatus of the type herein contemplated, the present invention provides for the presence of sufficient gas molecules in the path of vapor molecules so as to produce deflecting collisions, whereby the vapor molecules are redirected toward walls of the viewing tube.

Although it is possible to provide for this gas concentration and consequent vapor molecule collision by the introduction of gas at any point along the viewing tube, it is highly preferable for the gas to be introduced immediately adjacent the viewing port. Certain specific advantages result from this location of gas introduction. In the first place, it will be appreciated that the limited dimen-

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sions of the viewing tube provide a substantial impedance to the flow of gas along the length thereof, so that with the introduction of gas at the outer end of the tube there may then be obtained a desired and sufficient gas density adjacent the inner end of the tube and viewing port to prevent the vapor penetration thereof, while at the same time limiting the actual volumetric flow of gas into the vacuum chamber 9. This then provides a material assistance in the limiting of gas flow, so that the vacuum system associated with the vacuum chamber 9 is not unduly affected by the viewing method hereof. It is furthermore noted that with the introduction of gas adjacent the viewing port, the highest gas pressure, and consequently the highest collision probability, will exist adjacent the outer end of the viewing tube. Inasmuch as vapor molecules entering the tube will have not only random directions of travel but also a wide variety of velocities, it will be appreciated that the slower moving vapor molecules will be normally deflected by collision in the first portion of the tube and those yet traveling axially of the tube toward the outer end thereof will have the highest velocity. It is determined that vapor molecules at the outer end of the tube which have a suitable velocity for hitting the window have exponentially decreased in quantity along the length of the tube, while at the same time the collision probabilities for vapor molecules with permanent gas molecules increases in approximately a linear fashion along the tube. This will be seen to present an optimum situation for intercepting vapor molecules with a flow of gas through the tube. It is furthermore noted with regard to the redirection of vapor molecules by collision with permanent gas molecules, that the gas introduction at the outer end of the tube then results in a flow of gas inwardly of the tube. Although this flow is of a relatively low order, it will be seen that the gas molecules are then directed inwardly of the tube, so that rather than a random distribution of molecular velocity there will result an average component of gas molecule velocities down the tube toward the vapor molecules. Consequently, collisions between vapor molecules and gas molecules will provide a net change in momentum with the movement in a direction away from the window, consequently increasing the efficiency of the collision process hereof which forms the barrier to vapor deposition upon the viewing window. This is furthermore advantageous in lowering the required gas pressure to accomplish the same amount of barrier action.

In further explanation of the method hereof, it is particularly noted that there is herein provided a directed mass flow of permanent gas molecules away from a viewing port through a constricted tube or the like to insure collisions between such permanent gas molecules and vapor molecules tending to migrate along such tube. A relatively insignificant flow of gas is employed herein, and it will be appreciated that such is indeed necessary in order to preserve the vacuum within the chamber being viewed. In one specific example of the viewing method of the present invention there may be employed a gas feed to establish a pressure of the order of five microns of mercury in the chamber 24 with the tube establishing a pressure differential of about 50 to 1 along the length thereof, so as to accommodate viewing of a vacuum chamber normally maintained at a pressure of the order of 0.1 micron of mercury. Maintenance of a limited cross-sectional dimension of the viewing tube together with a sufficient length thereof provides for only a limited flow of gas into the vacuum chamber, and with a substantial pumping speed associated with such chamber, as for example, of the order of 20,000 litres per second, it is almost impossible to detect any rise in vacuum chamber pressure through the utilization of the method of the present invention.

The present invention is not to be limited by the above description of a particular application thereof, as it will readily be appreciated that the viewing method hereof

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is equally applicable to a wide variety of different circumstances, wherein exterior observation of occurrences within a highly evacuated chamber is desired. Also it will be seen that various alternative structures may be employed in carrying out the present method. Reference is thus made to the appended claims for a precise delineation of the true scope of this invention.

What is claimed is:

1. An apparatus for viewing the interior of an evacuated chamber having condensable vapor therein comprising an elongated viewing tube open at both ends adapted to be supported in a wall of an evacuated chamber so as to extend therethrough toward an area to be viewed, said tube terminating at an end exterior to an evacuated chamber in an enlarged chamber having walls and having a cross-sectional area substantially greater than the cross-sectional area of the interior of said tube, and being in communication with the interior of said tube, a viewing window supported in one of said walls of said enlarged chamber opposite said exterior end of said tube for allowing viewing of the interior of an evacuated chamber through said tube from said window, and means for introducing a gas into said enlarged chamber to raise the pressure therein above the pressure in said tube to insure flow of the gas from said enlarged chamber through said tube for maximizing deflecting collisions of gas molecules and condensable vapor traveling along the tube, whereby the deflected vapor impinges upon the tube walls and condenses before reaching said window.

2. An apparatus for viewing the interior of an evacuated chamber having condensable vapor therein comprising an elongated viewing tube open at both ends adapted to be supported in a wall of an evacuated chamber so as to extend therethrough toward an area to be viewed, said tube having at least two closely-spaced parallel walls to maximize collisions of vapor entering the tube with the interior thereof, said tube terminating at an end exterior to an evacuated chamber in an enlarged chamber having walls and having a cross-sectional area substantially greater than the cross-sectional area of the interior of said tube, and being in communication with the interior of said tube, a viewing window supported in one of said walls of said enlarged chamber opposite said exterior end

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of said tube for allowing viewing of the interior of an evacuated chamber through said tube from said window, and means for introducing a gas into said enlarged chamber to raise the pressure therein above the pressure in said tube to insure flow of the gas from said enlarged chamber through said tube for maximizing deflecting collisions of gas molecules and condensable vapor traveling along the tube, whereby the deflected vapor impinges upon the tube walls and condenses before reaching said window.

3. An apparatus for viewing the interior of an evacuated chamber having condensable vapor therein comprising an elongated viewing tube open at both ends adapted to be supported in a wall of an evacuated chamber so as to extend therethrough toward an area to be viewed, said tube having a rectangular cross-section and a very small ratio of tube height to tube length to maximize collisions of vapor entering the tube with the interior thereof, said tube terminating at an end exterior to an evacuated chamber in an enlarged chamber having walls and having a cross-sectional area substantially greater than the cross-sectional area of the interior of said tube, and being in communication with the interior of said tube, a viewing window supported in one of said walls of said enlarged chamber opposite said exterior end of said tube for allowing viewing of the interior of an evacuated chamber through said tube from said window, and means for introducing a gas into said enlarged chamber to raise the pressure therein above the pressure in said tube to insure flow of the gas from said enlarged chamber through said tube for maximizing deflecting collisions of gas molecules and condensable vapor traveling along the tube, whereby the deflected vapor impinges upon the tube walls and condenses before reaching said window.

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