May 5, 1970 U. LA ROCHE 3,510,193

SUPPRESSION OF SCHLIEREN PHENOMENA

Filed Aug. 15, 1967 2 Sheets-Sheet 1

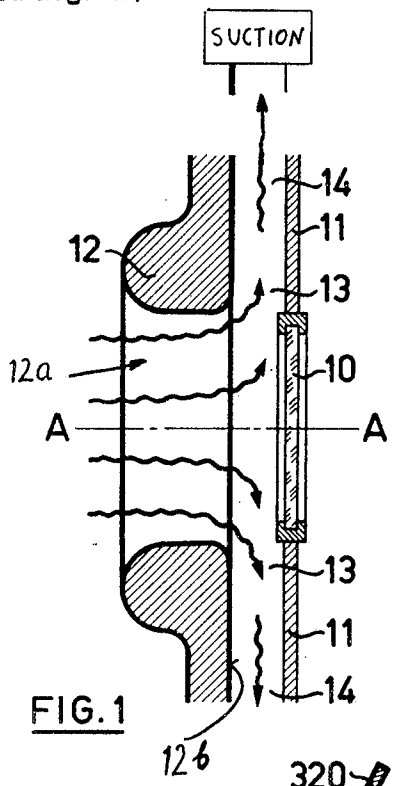

FIG. 1

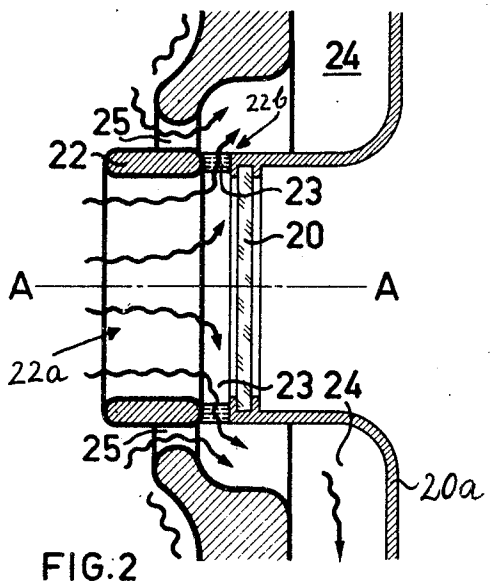

FIG. 2

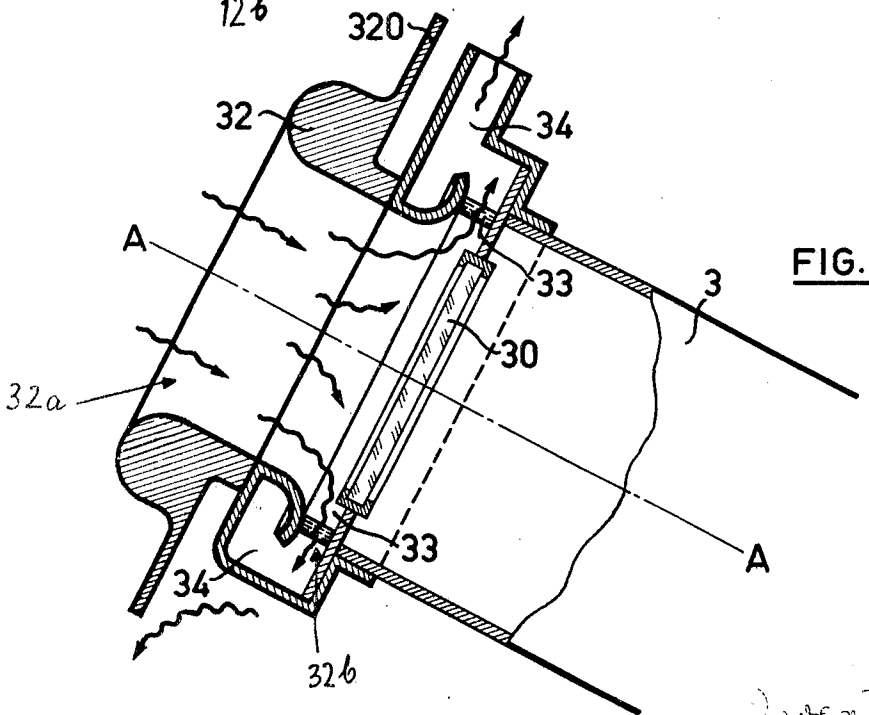

FIG. 3

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SUPPRESSION OF SCHLIEREN PHENOMENA

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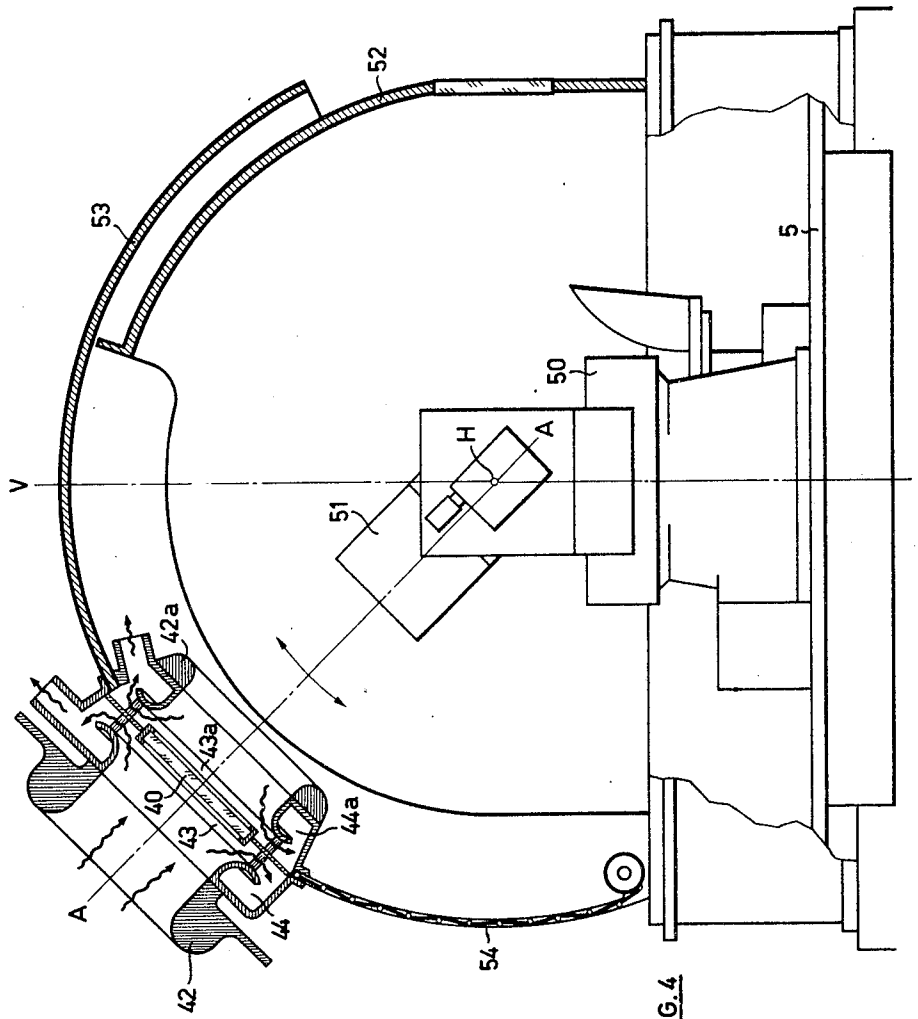

FIG.4

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United States Patent Office 3,510,193
Patented May 5, 1970

3,510,193

SUPPRESSION OF SCHLIEREN PHENOMENA

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Filed Aug. 15, 1967, Ser. No. 661,173
Claims priority, application Switzerland, June 23, 1967, 11,758/66
Int. Cl. G02b
U.S. Cl. 350—63 8 Claims

ABSTRACT OF THE DISCLOSURE

Wall means defines an enclosed space which has a predetermined inner temperature. An observation window is mounted in the wall means exposed to this inner temperature and has a surface which is located outside the space and is exposed to a body of fluid having a different temperature. A nozzle structure is arranged adjacent the exposed surface and defines a fluid channel extending normal to the exposed surface and having an inner end adjacent to the exposed surface, and an annular gap communicating with the fluid channel so that, when suction is applied to the annular gap, fluid will be drawn through the channel in the direction against the exposed surface of the observation window and will thereupon be caused to flow across the observation window in radial direction and toward the marginal zones of the exposed surface.

BACKGROUND OF THE INVENTION

It is well known that density variations occur at the interface between a body of fluid and an exposed surface if a temperature differential exists between the two. This leads to the formation of schlieren, a term which has become accepted for describing a phenomenon in which the density variations in the fluid adjacent the surface appears to be developing oscillating streaks.

This phenomenon can be very undesirable under certain circumstances, for instance if it is necessary to conduct observations through that zone of the fluid in which the phenomenon has developed. Particularly in cases where relatively small objects are to be observed, tracked or located, for instance observation and location of flying bodies at great distances by means of optical observation and/or tracking devices, the results obtained can be significantly affected in an adverse manner if such observation must be made through a schlieren-containing zone or region of fluid. It is of course known that there are differences in the size of schlieren, some of which are relatively small while others are much larger. It is particularly the relatively large schlieren which have been found objectionable under the circumstances just discussed because they decrease the contrast in the observation of relatively small objects or of objects which move rapidly with respect to their size.

The present invention overcomes the aforementioned problems. More particularly, the present invention inhibits the development of schlieren, and particularly of the relatively large schlieren, which, as mentioned before, have been found objectionable in optical observations.

In accordance with one feature of my invention, I provide a method of inhibiting in a body of fluid which contacts the exposed surface of a solid body, the formation of the schlieren resulting from the existence of a temperture differential between the surface and the fluid. My novel method comprises inducing the flow of a stream of the fluid in the direction against the exposed surface, and deflecting the stream of fluid adjacent the exposed surface so that it will flow in a plurality of directions along the surface and towards the marginal zones of the same.

My invention resides, however, not only in the aforedescribed method, but also in an arrangement for carrying out this method, and in this arrangement I provide wall means which defines an enclosed space having a predetermined inner temperature, and an observation window mounted in the wall means exposed to the predetermined temperature. The observation window has a surface located outside the space and being exposed to a body of fluid which has a different temperature than the temperature prevailing within the enclosed space. In accordance with my invention, I provide inhibiting means which is arranged outwardly adjacent to the surface and which is constructed and arranged so as to affect the flowing of a stream of the fluid initially in the direction against the surface and subsequently in a plurality of directions along the surface toward the marginal zones thereof. The stream of fluid will advantageously be caused to flow in the direction normal to the exposed surface of the observation window, and will then be withdrawn in radial direction along the exposed surface toward the marginal zones thereof, advantageously by being subjected to suction. In so doing I force the boundary layer of fluid which is located adjacent the exposed surface to flow therealong at relatively high speed. Whereas free and unaffected flow of the fluid along the exposed surface—that is without the benefit of the arrangement according to my invention—results in the unhindered formation of schlieren in the boundary layer, application of my novel invention inhibits the schlieren formation and reduces the median size of the schlieren, that is of the turbulent inclusions which develop in the boundary layer as a result of the existing temperature differential between the fluid and the exposed surface. Thus, the development of the particularly undesirable large schlieren is prevented. Of course, it is necessary to assure that the rate of flow of boundary layer fluid, which is occasioned in accordance with the present invention, is not so great as to result in the formation of turbulence.

If this condition is met in utilizing my invention one obtains on viewing of an object through an observation window protected according to my invention a modulatin transfer characteristic which, because of the existence of only small schlieren in the boundary layer, affords a contrast for high frequencies, i.e., relatively small objects, which to all intents and purposes is no worse than if no turbulence existed at all in the boundary layer fluid.

A particularly important area of application for my novel invention is optical observation and/or measuring devices, particularly those which are used for observing and/or ranging of relatively small objects at relatively great distance. In such devices the most sensitive optical and/or mechanical elements are arranged in a housing which frequently is maintained at a precisely controlled internal temperature and which is provided with an observation window extending transversely of the optical observation axis to which it is coaxial. It is this observation window which is to be protected against the formation of the schlieren phenomenon of the type discussed above.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 illustrates, in fragmentary section, one embodiment of the invention in its most simple form;

FIG. 2 is a view similar to FIG. 1, but illustrating a modified embodiment;

FIG. 3 illustrates yet a further embodiment of the invention, also in a view substantially similar to FIG. 1; and

FIG. 4 illustrates yet an additional embodiment of the invention in partly-sectioned, partly-diagrammatic form.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Discussing now the drawing in detail, and firstly FIG. 1 thereof, it will be seen that reference numeral **10** indicates an optical observation window which is mounted in a wall means **11**. The wall means **11** should be understood to define or constitute a part of, a housing enclosing an internal space. The optical axis of the observation window **10** is indicated by the line A—A and arranged outwardly adjacent the outer exposed surface of the observation window **10**, there is arranged inhibiting means for inhibiting the formation of schlieren, and particularly of large-sized schlieren.

This inhibiting means comprises, as FIG. 1 clearly shows, an annular body **12** which defines a channel **12***a*. FIG. 1 shows that the channel **12***a* is coaxial with the optical axis A—A of the observation window **10**. An inwardly directed surface **12***b* of the body **12**, that is an annular surface which faces the wall means **11**, defines with the same an annular gap **13** which is open in the direction towards the optical axis A—A, so that it communicates with the inner end of the channel **12***a*. The gap **13** further communicates with a conduit **14** which is connected to a diagrammatically illustrated suction device. The latter need not be discussed in detail because suitable suction devices are well known to those skilled in the art and because the invention does not reside in details of such a device.

It will be understood that a body of fluid, usually air, is outwardly adjacent the wall means **11** and the outer exposed surface of the observation window **10**, so that it surrounds the member **12**. With the suction device in operation, a stream of this air will be aspirated through the channel **12***a* in the direction of the arrows and towards the exposed surface of the observation window **10**. In the region or vicinity of this exposed surface the flow of air changes direction because of the suction exerted on it and flows across the exposed surface of the observation window **10** in radially outward direction towards and beyond the marginal zones of the exposed surface. Of course, new air is constantly being aspirated through the channel **12***a* in the direction of the arrows and it must be remembered that the suction exerted must be such that this new air will be aspirated with the minimum of possible turbulence as already indicated earlier.

In the embodiment illustrated in FIG. 2, the observation window is again assumed to be an optical observation window and is identified with reference numeral **20**. The wall defining the inner enclosed space, and on which the observation window **20** is mounted, is identified with reference numeral **20***a*. Member **22** corresponds to the member **12** of FIG. 1 and defines with the marginal zones of the exposed surface of the observation window **20** an annular gap **22***b* to the gap **13** shown in FIG. 1. Unlike the embodiment of FIG. 1, however, the gap **22***b* has an annular filter **23** arranged therein. This may be in the form of a strip of filter material which is, of course, air-permeable. The purpose of the filter **23** is to assure even and turbulence-free withdrawal of the air at all points of the circumference of the gap **22***b*.

The embodiment of FIG. 2 differs from that of FIG. 1 in yet another respect in that member **22** is provided adjacent the inner end of the passage **22***a* with an annular slot **25** which surrounds that portion of the member **22** which defines the channel **22***a*. The slot **25** also communicates with the aspiration conduit **24**, just as does the gap **22***b*, and the purpose of providing the slot **25** is to withdraw the boundary layer of air from the vicinity of the member **22** and of the wall means **20***a* so as to prevent it from being aspirated into the inlet end of the channel **22***a*. The reason for this, is of course, that this boundary layer air has already schlieren formed therein so that its aspiration into the channel **22***a* is not desirable.

Coming now to the embodiment of FIG. 3, it is to be understood that reference numeral **3** indicates a telescope tube on which there is mounted, for instance by being slid over the free end of the tube **3** and being frictionally retained thereon, an arrangement which comprises an optical observation window **30** outwardly adjacent to whose outer exposed surface there is arranged a member **32** corresponding to the members **12** in FIG. 1 and **22** in FIG. 2. The member **32** defines an aspirating channel **32***a* corresponding to the channels **12***a* and **22***a* of FIGS. 1 and 2, respectively. It further defines an annular gap **32***b* corresponding to the gap **22***b* of FIG. 2, and the gap **32***b* has disposed therein a filter element **33** which corresponds to the filter element **23** in FIG. 2 and which is, of course, air-permeable. The annular gap **32***b* communicates with a suction or aspiration conduit **34** which in turn is connected with a suitable suction device, such as shown in FIG. 1. With this embodiment, in which the free end of the telescope tube **3** is closed off by the observation window **30** and the mounting therefor, the interior of the telescope tube **3** can be maintained at a desired and preferably constant temperature, for instance by filling it with an extremely light gas, such as helium, and circulating this gas in the tube **3**. The boundary layer which develops at the outer exposed surface of the window **30** and tends to form schlieren as a result of the existing temperature differential, is withdrawn through the gap **32***b*.

The embodiment of FIG. 3 also comprises means for preventing the aspiration of schlieren-containing boundary layer to the free end or inlet end of the channel **32***a*, the reason being the same as set forth in FIG. 2. Unlike the embodiment of FIG. 2, however, the embodiment of FIG. 3 achieves this prevention of schlieren-containing boundary layer air not via a slot corresponding to the slot **25**, but via a radially outwardly projecting flange **320** which extends relatively far away from the member **32** and thus guides the schlieren-containing boundary layer away from the inlet end of the channel **32***a*.

Coming, finally, to the embodiment of FIG. 4, it is pointed out that reference numeral **50** is intended to identify a photo theodolite which rests on a platform **5** turnable about a vertical axis V. The instrument **50** is provided with an objective-tubus **51** which can be turned about a horizontal axis H. A dome-shaped housing **52** surrounds the instrument **50** and is secured to the platform **5** so as to be turnable with the same and, therefore, with the instrument **50**.

The housing **52** is provided with a meridional slot which is covered by a curved closure member **53**. The member **53** is operatively associated with the instrument **50** so as to slide along the meridional slot of the housing **52** in correspondence with elevational movements of the tubus **51** about the axis H. In other words, whenever the tubus **51** swivels in the direction of the double-head arrow, the closure member **53** will slide out of the way. As FIG. 4 shows, the closure member **53** carries an optical observation window **40** whose optical axis A—A is always in alignment with the optical axis of the tubus **51** by virtue of the fact that the operative connection between the drive means for the tubus **51** and the drive means for the closure member **53** effects movements of the two in such a manner as to maintain this axial alignment. All of this is course well known and need not be further described. It has been outlined here only for the sake of completeness of description. A roller-type closure or curtain **54** has a free end secured to the closure member **53** so that it is rolled up when the closure member **53** moves towards the left and downwardly in the picture, and is up-

wardly withdrawn if the closure member moves in the opposite direction. Thus, whatever portion of the meridional slot of the housing **52** is exposed by the closure member **53** is immediately closed by the curtain **54**.

Unlike the preceding embodiments of the invention, the observation window **40** is provided with my novel arrangement adjacent both its outer and inner exposed surfaces. Thus, a body **42** corresponding to the body **32** of FIG. 3 is arranged adjacent the outer exposed surface of the observation window **40** and defines therewith an annular gap such as that illustrated in FIG. 3, which has disposed therein an air-permeable annular filter **43** corresponding to the filter **33** of FIG. 3. The annular gap communicates with an aspiration conduit **44** which in turn is connected to a suction device as illustrated in FIG. 1.

Arranged adjacent the inner exposed surface of the observation window **40**, that is the surface which faces the interior of the housing **52**, is a second nozzle body, identified with reference numeral **42***a*, which defines a further annular gap which also has disclosed therein an annular filter **43***a*. This gap communicates with aspiration conduit **44***a* which is connected to the same suction means as that to which the conduit **44** is connected, or to a separate suction means. The purpose of this arrangement is to assure that the boundary layer air is withdrawn from both the inner and outer exposed surfaces of the observation window **40**, to eliminate the formation of schlieren, thereby making it possible to maintain the entire interior space within the housing **52** at constant temperature without danger of the development of schlieren.

It is to be expressly understood that, while the embodiments here illustrated all utilize my novel invention in conjunction with an optical observation device or arrangement, I do not wish my invention and my inventive concept to be so limited. It is clear that my invention has a much wider range of applicability than merely in preventing the formation of schlieren adjacent the observation windows of optical observation instruments of arrangements.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of arrangements differing from the types described above.

While the invention has been illustrated and described as embodied in arrangements for suppressing schlieren phenomena, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is:

1. A schlieren inhibiting arrangement, particularly in conjunction with optical apparatus, comprising, in combination, wall means defining an enclosed space having a predetermined inner temperature therein; an observation window mounted in said wall means with the inside surface thereof exposed to said predetermined temperature and having a surface located outside said space and exposed to a body of fluid having a different temperature than said predetermined temperature; inhibiting means outwardly adjacent to said outside surface for effecting the flow of a stream of said fluid from a region remote from said surface initially in direction against said surface and subsequently in a plurality of directions along said surface toward the marginal zones thereof, said inhibiting means comprising an annular suction channel extending along the marginal zones of said surface concentric therewith and having radially inwardly facing suction aperture means, and nozzle means for directing from a region remote from said outside surface a substantially turbulence-free stream of fluid in direction axially of said suction channel against the center of said outside surface; and suction means connected to said annular suction channel for withdrawing through said radially inwardly facing aperture means the fluid directed against the center of said outside surface in radial direction along said surface and into and out through said annular suction channel.

2. Arrangement as defined in claim **1**, said window being an optical observation window and having an optical axis, and wherein said suction channel is coaxial with said optical axis.

3. Arrangement as defined in claim **1**, and further comprising fluid-permeable filter means covering said annular gap whereby to minimize the occurrence of turbulence in the fluid aspirated into said annular gap.

4. Arrangement as defined in claim **1**, and further comprising preventing means for preventingt he aspiration into said nozzle means of boundary-layer fluid from the vicinity of said wall means and in which schlieren have developed.

5. Arrangement as defined in claim **4**, said nozzle means having an outlet end adjacent said exposed surface and communicating with said annular gap, and an inlet end spaced from said outlet end and from said exposed surface; and wherein said preventing means comprises a flange extending radially of said nozzle means in the region of said inlet end.

6. Arrangement as defined in claim **4**, said nozzle means having an outlet end adjacent said exposed surface and communicating with said annular gap, and an inlet end spaced from said outlet end and said exposed surface; and wherein said preventing means comprises slot means provided in said nozzle means and communicating with said annular gap for aspirating therethrough and into said annular gap schlieren-containing boundary-layer fluid so as to prevent aspiration of such fluid into said inlet end.

7. Arrangement as defined in claim **6**, wherein said slot means comprises an annular slot.

8. Arrangement as defined in claim **1**, wherein said window has an additional exposed surface facing the interior of said space; and additional inhibiting means similar to the first-mentioned inhibiting means inwardly adjacent to said additional exposed surface.

References Cited

UNITED STATES PATENTS

3,103,712	9/1963	Allinikou et al.	350—319
3,118,231	1/1964	Rathsmill	350—63
3,310,356	3/1967	Borberg	350—63

FOREIGN PATENTS

119,777	3/1949	Australia.

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