On a Screen Utilizing Cavity Bubble as a Display of Holographic Projected Images

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Abstract In this paper, noting the effect of cavity bubble, which is also applied to the high-pressure operated washer, we have studied a spatial screen utilizing cavity bubble as a display of holographic projected images. Cavity bubble suggests a phenomenon such that the water boils and turns to the vapor by a sudden lowering of the pressure in the underwater and many small-sized bubbles are produced in the underwater. Here, to produce bubbles stably, we first dissolve the air in the water by imposing the high water-pressure, and then, pour it into the water-tank rapidly using the aspirator whose absorbing entrance is closed tightly. Like this way, by introducing a stable lowering process of the water-pressure, we may be able to produce a constant amount of bubbles continuously. In this report, we shall introduce a new process adopted a cavity bubble screen and study its effectiveness in the projecting process of holographic images. As this result, we have seen that a spatial screen utilizing cavity bubble will be expected to have a more improved quality in the brightness of the images than before in the display of the projected holographic images. This research was partially supported by the Grant-in-Aid for Scientific Research (No. 17K00493) in Japan.

Keywords-component; Electro-Holography,Projection in to the space, Cavity Bubbles , Digital Micro-mirror Device

I. INTRODUCTION

We have studied holographic 3D-image projection with the u se of spatial screen. Recently, as one technique to perform suit able recovering of the projected holographic images[1-5], we ha ve reported a projecting process of holographic 3D images ont o the underwater micro-bubble[6] screen. We then have noted t hat this process may be expected as an excellent technique in t his field. In addition, since micro-bubble is easily and continu ously obtainable with the help of transparent water tank, it see ms to play an important role as a longtime stable screen[7,8]. O n the other hand, in order to perform a better reproduction, it h as been an essential problem to improve the brightness level of the images. In other words, it seems to be strongly required fo r us to make the brightness level of the images higher than bef ore, satisfying the condition that the presented images are stabl y displayed on the screen. In this paper, noting the effect of ca vity bubble, which is also applied to the high-pressure operate d washer, we have studied a spatial screen utilizing cavity bub ble[9] as a display of holographic projected images. Cavity bub ble suggests a phenomenon such that the water boils and turns to the vapor by a sudden lowering of the pressure in the under water and many small-sized bubbles are produced in the under water. Here, to produce bubbles stably, we first dissolve the ai r in the water by imposing the high water-pressure, and then, p our it into the water-tank rapidly using the aspirator whose abs orbing entrance of the air is closed tightly. Like this way, by in troducing a stable lowering process of the water-pressure, we may be able to produce a constant amount of bubbles continuo usly. In this report, we shall introduce a new process adopted c avity bubble screen, and study its effectiveness in the recoveri ng process of the projected holographic images. As this result, we have seen that a spatial screen utilizing cavity bubble will a ttain a more improved quality in the brightness of the reconstr ucted holographic projected images than before.

II. SYSTEM

II.1 Outline of the System

Total scheme of 3D image projecting system used in the expe riment is shown in Fig 1. The system is composed of laser ligh t source including the lens, DMD (Digital Micro-mirror Devic e) panel, PC, and cavity bubble screen, which we have just pro posed here. First, we expanded by lens the width of the beam projected from laser light source, and tried to make it close to t he spherical wave as much as possible. Then, we illuminated t his wave onto the hologram plane (DMD panel) formed by the hologram produced by computer. Next, projecting the reflecte d wave fronts from the DMD panel onto the bubble screen, we performed the reconstructed 3D images in the space. Observat ion was made to the spatially reproduced images in such a way that the 0-th order transmitted light was not found in the viewi ng area.

II.2 A study of the new micro-bubble producing system

In the spatial projection system adopted micro-bubble screen, it is seen that spatially and longtime stable property of the scr een is more effectively achieved than in the one adopted mist, however, the improvement of the brightness in the presented i mages on the screen should be necessary and it has been requir ed to be solved. In the conventional process, micro-bubble was produced using the screw and the sponge filter[8], and so, som e deterioration in the illumination and the suffering of the flick ering noise must be taken into account. In fact, some falling of f of the brightness level of the projected image is often observ ed. Hence, in order to overcome this situation, a certain impro

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vement is required for us to make up the brightness level higher than before. On the other hand, from our previous studies, we see that, in order to make up the brightness level of the presented images, we must increase the amount of micro-bubble. Therefore, in the preparation of the micro-bubble producing system, we must study how to increase the amount of micro-bubble without losing the presenting stability of the images. In this paper, we shall introduce a new process adopted cavity bubble screen. We shall show that cavity bubble screen seems to work well to overcome this deterioration in the brightness of the images. Configuration of the proposed system adopted cavity bubble screen is given in Fig.2. For the convenience of comparison with the previous method[8], we prepared the cubic water tank whose length of one edge is equal to 20 cm. (maximum volume is 7L)

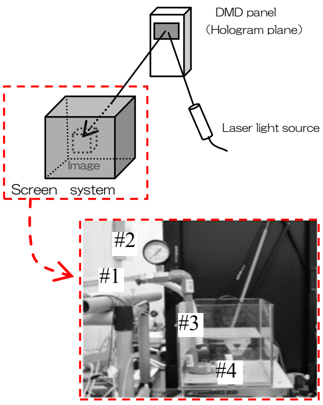

Fig.1 Optical setup for reconstruction of 3D holographic images in the projected process

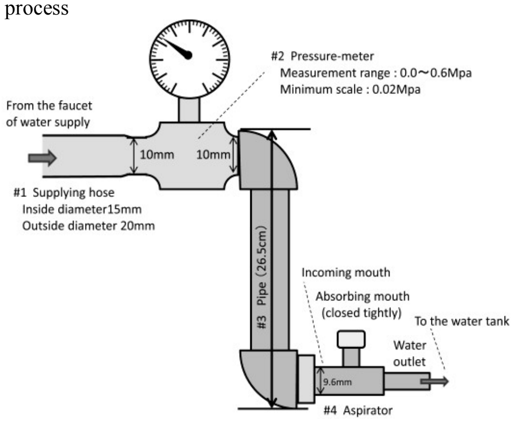

Fig.2 The equipment composition of the screen system employing the bubble generator

(1)Through the supplying hose (#1 in Fig.2), the pressured-water is poured from the outgoing mouth of water supply. Here, to get high-pressured water, we take out the water directly from the faucet of water supply.
(2)Checking the water pressure by the pressure-meter (#2 in Fig.2), we introduce the water to the incoming mouth (#4 in Fig.2) of the aspirator through the pipe (#3 in Fig.2).
(3)When the water is passing through the aspirator (#4 in Fig.2), its pressure is decompressed and cavity bubble is generated.
(4)From the outgoing mouth of the aspirator, generated cavity bubble is drained with the water. Since the absorbing mouth of the aspirator is closed tightly, decompressing process of the water is regarded to be kept continuing.

Here, we properly draw out the water by the other pump set in the water tank so as for extra water not to fill over the tank. We also discuss the optical characteristics of our screen system, especially the time-change of the light intensity after the light has passed through the screen. In our experiment, taking care that the maximum water pressure at the faucet of the water supply was 0.17MPa, we made our experiment by setting incoming water pressure to the aspirator divided in three steps: 0.05Mpa, 0.10MPa and 0.15MPa.

III. RESULTS AND DISCUSSION

III.1 Optical characteristics of the proposed screen

III.1.1 Time-change of the light intensity after the light has passed through the screen

In order to confirm the longtime stability of the screen system, we employed analogous measuring system as in [8]. Using this, we detected the intensity of the laser light passed through the screen at each span of 100ms with the help of laser power meter, and we made these data put into the PC automatically by way of AD transformer. Measuring time interval is 5 minute and 30 seconds, and the screen system is driven after 30 seconds from the starting time of the measurement. It is seen in the result that the light intensity of the passed wave gets higher as the amount of produced bubble comes to be small. The behavior of the light intensity of the wave passed through the screen with respect to the time is shown in Fig.3. The results are (b) - (d), and they correspond to the cases of 0.05MPa, 0.10MPa and 0.15MPa. (a) is the result when the technique in [8] is experimented. It is added for us to compare with the results in our proposed process.

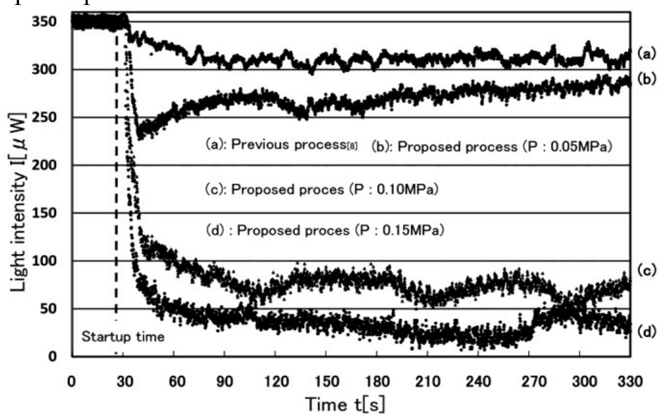

Fig.3 Change of light intensity on the screen with respect to the elapsed time

Fig.3 shows following facts:

・In the previous process [8] i.e., in the preparing process of micro-bubble containing water by mixing and shearing a liquid and a gas (a), the light intensity of the laser wave passed through the screen is high, and so, the amount of produced bubble is small.

・In our proposed system, when the incoming water pressure to the aspirator P is adjusted to 0.05Mpa, the result becomes analogous to (a), and the amount of produced bubble gets small.

・As an additional experiment, we adjusted the incoming wate r pressure to the aspirator P to 0.17MPa. But the difference fro m the case of 0.15MPa was not observed.

・In every case of cavity bubble (c) - (e), the light intensity of the wave passed through the screen is seen to vary with slow p eriod. Moreover, this interval of the variation is nearly equal t o the driving interval of drainage pump. It seems to suggest th at the drained bubble causes the variation of the light intensity of the wave passed through the screen.

As an inspectional test, we made a system as shown in Fig.4, and estimated personally the amount of bubble according to t he view patterns of the real bubbling. For estimation, we prepa red figure of patterns as shown in Fig.5 (a), and attached at the outside of the water tank. Real bubble patterns were observed and estimated using this. Example of the results are (b) - (f). (c) corresponds to the case of [8], and (d) - (f), to the cases obs erved at different incoming water pressure P to the aspirator, a s proposed before. The more the cloud appears in the water tan k, in other words, the more the unclear test pattern tends to be observed in the water tank, the larger the amount of bubble is considered to be produced.

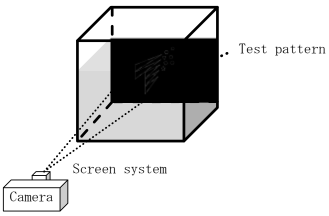

Fig.4 Subjective evaluation of the amount of bubbles in the tank

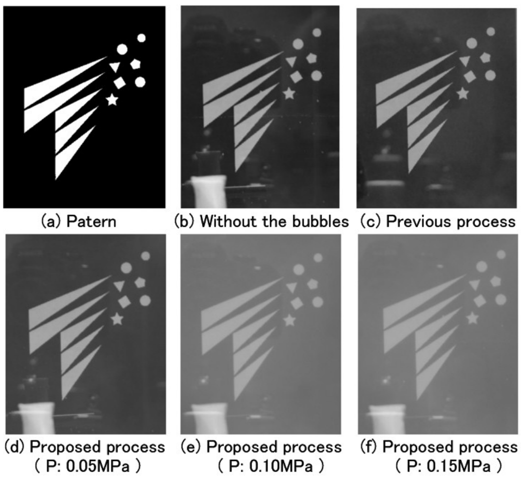

Fig.5 The relation between the generation bubbles to the amount of bubbles

From Fig.5, we can see as follows.

・In the case of the previous process[8], the amount of bubble t ends to be small.

・In our system, when water pressure P is set at 0.05MPa, the situation looks like the one in [8], but bubble is seen to be exp anded more uniformly than in [8].

・In our system, when water pressure P is set at 0.10MPa, the cloud in water tank appears prominently, the amount of bubble seems to be larger. This tendency continues even if the water pressure P is set at 0.15MPa.

Hence, we can assert that the above observation really confir ms the existence of the correlation between the results in Fig.3 and Fig.5.

III.1.2 Spatial distribution of the bubble observed from the sectional plane of the brightness in the screen.

The fluctuation of the light intensity on the image-presenting point in the screen causes unevenness of the brightness in the projected images. It suggests that in order to make a nice scree n, we should make an effort to construct a screen system whic h has a small fluctuation of brightness. For this purpose, at firs t, we investigated the brightness distribution on the screen (cf. [8]) by making green laser light incident upon the screen from its right side, and then, taking photos of orbits of the laser light passed through the screen. Here, measured area was set at the central part of the screen with the length 10cm as shown in Fig. 6, and we made our experiment in such a way that unnecessar y light did not enter this area as much as possible. Fig.7shows the sample pictures of the light beam obtained our process. Fig. 8 shows the change of the relative light intensity on the screen with respect to the position.

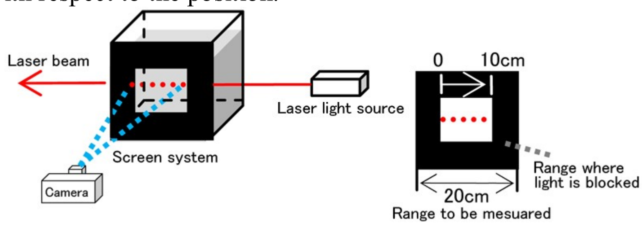

Fig.6 Measurement of the distribution on the light intensity on the screen

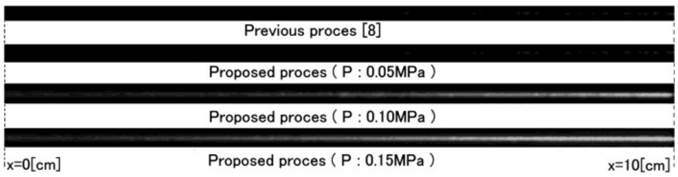

Fig.7 Sample pictures of the light beam obtained our process

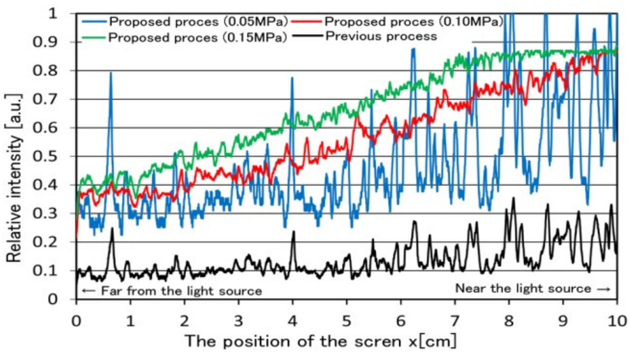

Fig.8 Change of the relative light intensity on the screen with respect to the position.

Fig.8 shows the following.

・In every case, the brightness on the screen is higher as the di stance from the source of the laser light gets to be shorter. It se ems to come from the fact that the intensity of the laser wave p assed through the screen gets lower by the influence of the bub ble produced in the underwater.

・In our process, the brightness on the screen is notably impro ved than in the previous process.

・In our process, when the incoming water pressure P to the a spirator is set at 0.05MPa, the variation in the brightness is not so different from that in the previous process, but the range of the variation comes to be larger.

・In our process, when the incoming water pressure P to the aspirator is set at 0.10MPa and 0.15MPa, the change of the brightness on the screen slowly tends to be higher, but the rapid change of the brightness does not occur as in the case of P=0.05MPa.

III.2 Characteristics of the proposed images on the screen

III.2.1 Relation of characteristics of the image and the incoming water pressure to the aspirator

Now, we shall explain about the characteristics of the recover ed images obtained by our proposed process. For convenience of comparing procedure, as for the recovered object, we took u p the analogous figure as before, and we made a proper estima tion of the images observed in each of the screen systems. In t he screen, the recovered images are displayed in the fault form, and their volume is expanded. The results are presented in Fig. 9. (Red light :633nm, Green light : 532nm, Blue light: 473nm)

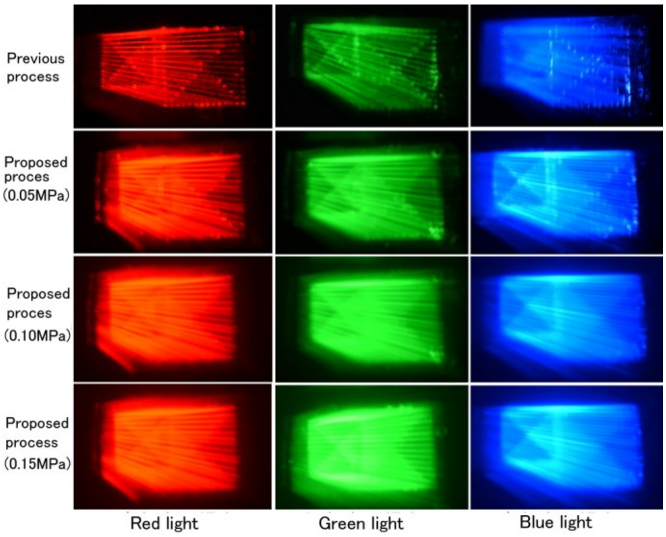

Fig.9 The reconstructed images obtained in our process

From these results, we can see that if we make higher the inco ming water pressure P to the aspirator, the brightness of the pr ojected image becomes higher, and the range of the fluctuation in the brightness is suppressed to be small. It also suggests tha t if we make higher the incoming water pressure P to the aspir ator, a large amount of bubble will be produced in the water ta nk. This situation will be discussed later. On the other hand, if the amount of bubble gets large, the resolution of the image te nds to be low. Hence, the amount of bubble and the resolution of the image are seen to be in trade-off relation. In our process, proper value of P was 0.10MPa. Regardless of wavelength of reconstruction light, the same tendency results are obtained.

III.2.2 The fluctuation of brightness in the reconstructed image

From the results in the former section, we have seen that the f luctuation of the brightness in the reproduced image comes to be small if the amount of bubble gets large. For this reason, w e have investigated the amount of the fluctuation of the bright ness observed in the projected image both in the proposed syst em and the previous system. After the system had started, we observed the changes occurred in the reproduced images at eac h interval of 3 seconds randomly. Obtained results are shown i n Fig.10. Noting the marked part of the results, we see that in t he previous process, the bright point moves when the variation occurs in the bubble, but any difference is not observed in the proposed process. This shows that in the proposed process, the fluctuation of the brightness seems to be reduced. In addition, no difference was observed in both processes when we change d the water pressure P.

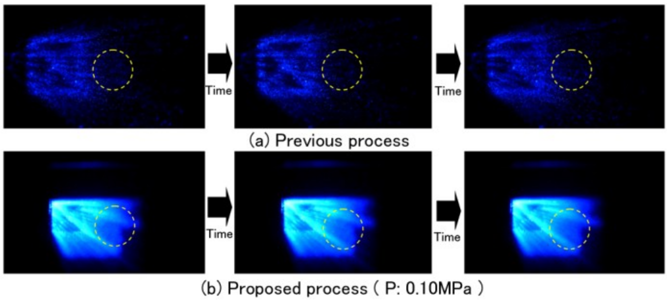

Fig.10 Change of reconstructed images on the screen with respect to the time

IV. Conclusion

In this report, we studied a construction of a screen system ad opted cavity bubble for holographic projected images. As this result, we have seen that cavity bubble plays a very useful role for the reduction of the fluctuation of the brightness in the hol ographic projected images, and in the point of brightness, cavit y bubble screen is a remarkable improvement on the previous screen system. On the other hand, we found that there is a trad e-off relation between the amount of bubble and the resolution of the projected images. In our present system, bubble is prod uced directly from the water flowing out through the faucet of water supply. Therefore, it may be desirable for us to establish such a cavity bubble screen system as a circulatory system. W e would like to make this as challenging problem in the future.

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