SURFACE NAVIGATION WITH THE BUBBLE OCTANT

by

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Some time ago the writer obtained a bubble octant, through the kindness of the instrument section of the Bureau of Aeronautics, with the idea that as opportunity permitted he would use it at sea and endeavour to ascertain the possibilities of this instrument for surface navigation. Its possible advantages and disadvantages as compared to the standard sextant were also to be determined as far as practicable. The writer's billet as first lieutenant naturally allowed but little time for extra-curricular activities, so the work necessarily had to be spread over a rather long period. However it is believed that enough practise has now been obtained with the bubble octant to furnish much of the information sought, and to allow intelligent consideration of the instrument's value for use on surface ships.

The first point to be emphasized is that due mostly to its inherent principle, the bubble octant cannot be expected to give quite as accurate results as the standard sextant. When it is considered that one instrument uses the estimated median line of a highly mobile bubble as the reference point, and the other uses a definite and stationary line, it is obvious which type of instrument will be the more accurate. Furthermore, the fine adjustment and finely-divided scale of the standard sextant is of necessity absent in the bubble octant, and the operator must learn to interpolate by eye and practice for readings between the 5-minute graduations of the octant scale.

Accordingly, the work was begun with little expectation of obtaining very accurate "fixes", and after the first attempts to obtain sights when the ship was rolling to any extent there was even less expectation of any accurate results. This condition presented a rather discouraging problem when it was first encountered. As the ship rolls, the operator and the instrument naturally maintain the same position relative to the ship, and the image of the star or other body will appear to move up and down in the field. The bubble also will move up and down, but due to its own inertia it will lag behind the image and its path of oscillation will be longer. Thus the task of effecting collimation of these two and knowing when this collimation has been actually accomplished seemed fairly hopeless. This phase of operating the bubble octant is given special mention because it constitutes the most serious obstacle to successful use of the instrument on shipboard. Pitching of the ship, probably due to the relatively small motion and slow rate, seemed to affect the bubble very little. With constant practice, however, the writer became more familiar and proficient with the octant and found that under such conditions the bubble would, at brief intervals, remain steady for a moment or two and usually long enough for an experienced operator to effect fairly accurate collimation. It was noted that as the bubble oscillated in its vertical path, and the operator endeavoured to align the image with the bubble, a point in the adjustment would be reached where the image remained approximately at the middle of the bubble's travel. This indicated evidently that the image was nearly "on", as when the bubble steadied for a moment, a very slight adjustment effected alignment. It is believed, therefore, that the serious difficulty experienced in taking sights when the ship is rolling can be overcome to a great extent with experience and constant practice on the part of the operator.

Another difficulty, although not a very serious one, is the effect of wind striking the operator and the instrument. In such cases the combined effects of the wind and the operator endeavouring to hold the instrument steady impart a jerky motion to the octant that causes the bubble to perform a devil's dance within the field and consequently prohibits the taking of any sights. The remedy for this is, of course, to operate in a sheltered place, and the finding of such a place about the deck usually does not present much difficulty.

In operating the bubble octant almost all of the work was done at night; mainly because of the obvious fact that so many bodies are available for observation and also because that is the time when the octant will offer its greatest advantage for surface navigation, when no natural horizon can be employed.

In working at night the procedure was generally to take sights of approximately eight stars, using also the planets and the moon when available, at about eight o'clock. These sights were worked up and adjusted forward or backward to 8.00 p.m., and plotted. Then the 8.00 p.m. position of the ship, as calculated by the navigating officer, was set down on the same chart. Thus a comparison could be made and the relative accuracy of the bubble octant indicated.

As might be expected, the results obtained at first were not very encouraging. Large triangles, perhaps 12 miles on a side, were usually obtained, and there were many results that appeared absolutely unaccountable. At this time the writer had the assistance of a naval reserve officer, attached to the ship for temporary duty, who was an enthusiast on the subject of navigation; and his many years of practical experience, starting in square-rigged sailing vessels and later as chief officer and captain of large transatlantic passenger ships, aided a great deal in determining the causes of many of the strange difficulties encountered. After his detachment the writer worked alone ; and while a good degree of efficiency can be attained in timing and recording one's own sights, it is believed that accuracy was lessened to some extent.

As the work went on, the resulting triangles became smaller and smaller and finally they reached a size that was hardly larger than the triangles obtained by many experienced navigators with the standard sextant. Moreover the distance separating the fix obtained with the bubble octant and the navigating officer's fix became very small, and often the ship's 8.00 p.m. position when plotted nestled right into the intersection of the bubble octant position lines. Upon one or two occasions, when the ship was steaming along the north coast of Cuba at night and the ship's position had been determined very accurately by means of cross bearings of navigational lights on the shore, sights of a number of stars were taken with the bubble octant, and the resulting fix compared with the actual position. The fix was absolutely accurate.

In taking sights of stars the writer did not attempt to get just those stars whose bearings would provide a clean-cut intersection. Instead, sights of practically all the bright stars available were taken, regardless of their respective bearings, as it was felt that the practice in operating the octant was the main need at that time. Furthermore, the practical navigator's avoidance of bodies at extremely low or extremely high altitudes was completely disregarded, and sights were taken indiscriminately. As a consequence of this procedure, some rather surprising results were obtained. So far, the upper limit for accurate results seems to be about 83° altitude, but for low altitudes the limit seems to approach zero. As an example of this latter: A sight of Venus was taken one night at what was evidently an extremely low altitude. According to the scale this altitude was 00°59'30", and the sight was worked out with considerable scepticism as to the result; but when plotted, the resulting line ran directly through the ship's position. This was probably an extreme case and a lucky "shot", but nevertheless consistently accurate results have been obtained with bodies at altitudes down to 5°. The writer has no explanation to offer regarding the accuracy of the bubble octant for low altitude sights, but it is an interesting development in view of the fact that so many practical navigators, through prejudice or experience, will not attempt sights at less than 12° or 15° altitude.

The moon was used whenever available and consistently good results were obtained, employing the astigmatizing lens in taking the sight. It must be noted, however, that the moon will be available for sights very little of the time, as the full disc, or nearly the full disc, must be visible in order to use the bubble octant.

The sun has not been used frequently, for the reasons stated in a foregoing paragraph, but the sights taken occasionally have given very accurate results. An interesting experiment, and one which it is thought will warrant further investigation, was carried out some time ago when the required conditions existed. The ship was in a dense fog with no horizon visible; but overhead for brief intervals the disc of the sun was outlined through the haze. A few sights were taken with the bubble octant, as the disc became visible from time to time, and the resulting lines of position came within 3 to 4 miles of the ship's calculated position. The writer has no applicable data that might give an altitude correction for the possible refractive effect of the fog, but it is felt that much of the error in the lines of position was due to the state of the operator's experience at this time, and that better results can be obtained. It is believed that the bubble octant may possibly be a valuable recourse under such weather conditions, and the possibilities of this use of the octant should be investigated further as opportunity permits.

Among many other things learned in the course of this work was the fact that the operator must know the constellations and their outlines to a far greater degree than is necessary in ordinary navigation. The large field of the octant and the profusion of stars visible at night may be held responsible for this requirement. Thus when the operator sets his instrument at the estimated approximate altitude of some first magnitude star and then endeavours to take a sight, he will often find several stars within the field, varying so little in altitude, bearing, and perhaps brightness, that the determination of the star desired is not very easy. To add to this difficulty, the image is inverted in the field and consequently confusion as to the correct relative positions of the stars is likely to occur in the operator's mind. The remedy for this, as with other obstacles encountered, lies in practice, coupled perhaps with a considerable degree of familiarity with the outlines of the constellations.

In considering the possible limitations and the possibilities that exist in the present design of the bubble octant , in regard to its use for surface navigation, the outstanding point to be emphasized is that its successful operation will require long and constant practice. It is only a well-experienced eye that will be able to determine correctly the point at which the image and the bubble are in alignment, and this will be especially true when the ship has much rolling motion.

Nevertheless, it is felt that the experience gained thus far and the results obtained have demonstrated that the instrument can be of great assistance to the navigator under many conditions, and that with sufficient practice navigation accurate enough for all ordinary purposes can be performed. The accuracy will be lessened obviously to some extent under the very adverse conditions of a heavily-rolling ship, but it still may be close enough to serve as a check, if nothing more. Then there may arise conditions, such as a clearing sky at night after a long overcast period, when a prompt check of the ship's position may be highly desirable. In such case the octant could be used to good purpose. Undoubtedly many other instances will suggest themselves where this instrument, with its independence of the natural horizon, would be of good use. It must be understood, however, that this is based upon the assumption that the operator will have had enough practice to insure his getting reasonably accurate results, and that the best results obtained with the bubble octant perhaps will never be quite as accurate as those that a skilled navigator can obtain with the standard sextant.

It is felt that there is a place for the bubble octant in surface navigation, and that with experienced operators it may serve a very useful purpose on naval vessels, especially under some of the special circumstances mentioned in the foregoing paragraphs. It is not unlikely that a more intensive and consistent investigation than the writer was able to make would discover greater possibilities for this instrument, and perhaps indicate design changes or improvements that would reduce much of the difficulty now encountered in its operation, and make the octant even more useful for general surface navigation.

NOTE :-

According to Lieutenant-Commander P.-V.-H. WEEMS, U.S. Navy, efforts have been made to determine the value of a bubble sextant in use on board for a series of observations made during the passage of the U.S.S. *Cuyama* from Bremerton, Wash., to San Pedro, Calif., September 3-7, 1930. No sights were omitted. The true positions of the ship were obtained either by dead reckoning, radio bearings or bearings of lights. It has been ascertained that sextant observations may be made with considerable speed. In one case 60 observations could be made in 10 minutes 37 seconds, or an average of one observation in less than 11 seconds.

The individual observations vary considerably, as much as 20'-40'. This fact decreases confidence in the use of the bubble sextant; on the other hand, by taking an average of a large number of observations, the errors are smoothed out, the mean results being surprisingly accurate.