In summary, the advantages of the polaroid method are:

(1) A clear and exact picture is obtained in a very short time.
(2) It becomes possible to plot an unlimited number of echoes at the same time.
(3) There are no human errors in observing and copying.
(4) The master can study the pictures in the chartroom immediately, no adaptation of the eye being required.
(5) More persons can see the picture simultaneously.
(6) The picture can, if necessary, be used for documentation. In case of accident, one's own movements and those of the other party can be proved.

'Manœuvres to Ensure the Avoidance of Collision'

Mr. Calvert replies to his critics

FOLLOWING the publication of E. S. Calvert's Manœuvres to Ensure the Avoidance of Collision (*Journal*, **13**, 127) a number of people closely concerned with the problem of collision at sea were invited to comment on Mr. Calvert's ideas. This comment was published in Vol. 13, Nos. 3 and 4 (pp. 350–352 and 455–464). Mr. Calvert here replies to some of the criticisms. The paper he refers to as his latest will be published in the October number of the *Journal*.

to Captain H. D. Harries

Without a more precise definition of 'open sea' and 'crowded waters', I doubt if any figure for the proportion of collisions in each has much meaning. (The same kind of difficulty arises in defining a 'near miss'.) More precise figures might possibly be obtained by giving the proportion of collisions which occur within so many miles of the mouth of a channel, a channel being defined as an area where local or 'edge' rules are in force, or where the traffic is controlled. However, I doubt whether the use which could be made of such statistics would justify the trouble of collecting them. In my latest paper, i.e. the one to be published in the next issue of the *Journal*, I have given what I believe to be the only possible solution to the crowded-water situation, in so far as rules can provide a solution. There is, of course, the question of integrating rules based on the rotation of the sight-line with those based on the edges of the channel, and I have given some thought to this. There is, however, no point in my publishing any suggestions in a Journal devoted largely to nautical matters until the rules for the open sea have been put on a rational basis.

Captain Harries points out that some ships have radar and some have not. My proposals are designed to solve the problem which this creates by enabling each ship to ensure its own safety in so far as this is possible. He also mentions navigational hindrances. Again, my proposals are designed to solve this problem, firstly, by permitting both ships to manœuvre, and secondly, by permitting the use of reverse manœuvres *by pre-arrangement*. The essence of the solution of

these and other problems lies in recognizing the fact that the mariner has, in effect, only two choices. It will then be seen that there is only *one* practical problem in any given situation, namely, to ensure that each party (if it manœuvres) makes the same choice. To enable this to be done quickly and without error, I have tabulated all the manœuvres associated with each choice. I believe this to be absolutely necessary for a high level of safety in all situations, but particularly in waters which are narrow or crowded or both.

to Commander P. C. H. Clissold

I do not agree that the Steering Rules are satisfactory in clear weather, or that reverse manœuvres are unnecessary. Indeed Commander Clissold, when he suggests that a turn to port might be allowed when the threat is forward of the beam and the bearing is moving appreciably to the right, is himself proposing to use reverse manœuvres to increase an existing miss distance. (This was the situation shown on the radar of the *Andrea Doria*, and her master did in fact turn to port.) I agree that this must be permitted, but I submit that the other party must be notified, because of the possibility that he may have made a different assessment as to the sense in which the sight-line is rotating, or if it is rotating at all. If the assessments are different, and there is no communication, then one party may apply standard manœuvres while the other applies reverse, and the result, may be a 'dance', or, as happened in the case of the *Andrea Doria*, an actual collision.

I am strongly against having one system for visual sightings and another for radar sightings, partly because of the difficulty of remembering two systems, and partly because some encounters may begin with a radar sighting and end with a visual sighting. The single system which I have proposed is not revolutionary, as many mariners mistakenly think it is. It is the logical working out of a principle which is inherent in most of the rules and recommendations which already exist, and I cannot help it if it seems to be revolutionary to practical people unaccustomed to the use of scientific method.

to Dr. H. C. Freiesleben

I strongly disagree with every comment made, except, perhaps, the one about inflexibility. In Fig. 13 in my latest paper I have presented my proposals in such a way as to give the maximum degree of flexibility in the choice of manœuvre. I am, however, pleased to know that he considers this work to be of some interest to German mariners.

to Captain F. J. Wylie

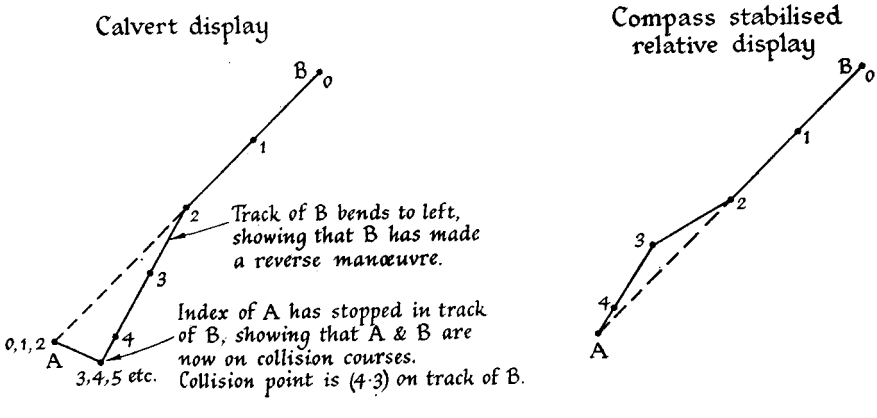
I am surprised to be told, after what has been published, that at sea 'in clear weather and straightforward situations collisions hardly ever occur'. I will leave it to mariners to settle this amongst themselves, and merely point out that the case of the *Listrac*, mentioned by Captain Planty, illustrates how a defect in the Steering Rules can cause a collision in clear weather. With the proposed system there are no situations which are not straightforward from the point of view of knowing what manœuvres would implement the two possible choices. Incidentally, four air collisions out of five occur in clear weather.

As regards the relative manœuvrability of ships and aircraft, the modern large aircraft is sometimes called a 'flying brick', partly because displacements

initiated to avoid collision (in visual conditions) are measured, not in miles, but in hundreds of feet. Indeed, the radius of the turning circle of some of the aircraft which may be flying 15 years from now may be as much as 50 miles. It is because of this that the accuracy of detecting constancy of compass bearing for future systems of collision avoidance in the air has to be so extremely high.

Captain Wylie gives criteria which any new system must meet, and implies that the proposed system, and probably no system other than the existing one, could meet them. It seems to me that the laying down of rigid criteria in such cases is a pastime which leads nowhere. One might as well lay down criteria for the laws of motion, or pass a law (as I believe one legislature actually did) to make π equal to 3, as being obviously more convenient for practical men. Since so much has been made of practicability by nearly all my correspondents, I am at a loss to understand why so many of them object to a clear statement of the manœuvres associated with the only two possible choices. In my ignorance of nautical operations, I had supposed that this would be a convenience to practising mariners, and would tend to raise the level of safety, all without any cost to anybody.

In his assessment of the three radar displays Captain Wylie seems to me to have missed an important advantage of the proposed manœuvres. The essential thing about any manœuvre is not whether it is a right turn, a left turn, an increase in speed, or a decrease in speed, or some combination of turn and speed change, but simply whether the rotation which the manœuvre would produce in the sight-line if the other craft stood on is in the conventional sense, or against the conventional sense. In his Fig. 1 the manœuvre of A would produce anticlockwise rotation if B stood on, and so would that of B if A stood on, using A and B as in my paper. The combined manœuvre is therefore safe (unless the error in detection is very large) and all three displays show this, as is to be expected. In his examples (1) and (2), the manœuvre of A would produce anticlockwise rotation, but that of B would produce clockwise rotation. The combined manœuvre is therefore unsafe. The Calvert display shows all this



Both vessels manœuvre at (2), A turning 45° right, and B reducing speed to about half.
A resumes original course at (3) and B holds its reduced speed.

Fig. 1

clearly without the need for drawing vector diagrams. The stabilized relative display shows only the overall result, and the true-motion display not even that. In fact Captain Wylie has inadvertently demonstrated, firstly, that the Calvert display gives the essential information by *direct* observation, and secondly, that the proposed manœuvres are correct.

As a further example I will take the situation given in his Fig. 1, but will suppose that B reduces speed at time (2) instead of turning 45° to starboard. (If the master of B had read the Annex, but had not seen Fig. 13 in my latest paper, he might have thought that in the circumstances a reduction in speed at range (2) was a wise precaution.) It will be seen from Fig. 1 in this reply, that the Calvert display shows at once that B has applied a reverse manœuvre, and that if A resumes course at (3), then A will be on a collision course with B. In an emergency such as this a means of communication is a safeguard, but even without this, it is obvious on the Calvert display that A can extricate himself by his own action, i.e. by *not* resuming course till later. I doubt if many mariners could use vector geometry with a sufficient confidence to work out from the 'relative' display what was happening, and how they ought to act to ensure their own safety. Incidentally, I notice that Captain Wylie has the same difficulty with vectors as the rest of us, because he states that the motion of the index in the Calvert display is 'the vector sum of the present true motion of own ship and the original motion'. It is, of course, the vector *difference*, as it must be if the index is to show the displacement of A from where it would have been if it had not manœuvred. Captain Wylie has not misunderstood the display, because he has drawn his examples correctly. His statement is therefore a 'blunder' in the sense discussed in this *Journal*. (Blunders and gross human errors. This *Journal*, **12**, 1, January 1959.) This blunder, like my own mentioned in my latest paper, confirms me in the view that no system will be operationally successful which depends in any way on the drawing of vector diagrams.

to Captain Planty

Captain Planty has, unfortunately, misread the manœuvring diagram given in my paper. If he refers to this again, he will find that a vessel, threatened on its port side, as B is in his Fig. 1, should *increase* speed. In other words, like Captain Wylie, he has demonstrated that the proposed manœuvres are correct.

I agree that there are too many sectors on my diagram; this, however, is merely a question of presentation, since the boundaries between turning right and left and between increasing and decreasing speed are determined, not by me, but by the laws of nature. The presentation shown on Fig. 13 of my latest paper is, I think, simpler in this respect, as well as being more comprehensive. These boundaries cause no dilemmas or special difficulties if they are properly chosen, but in the Steering Rules they are *not* properly chosen. I am therefore not surprised to find cases such as that of the *Listrac*.

As far as I can determine, the loss of the *Andrea Doria* was not due to a bearing error as such, or to the fact that the *Stockholm* turned, because, as stated in the evidence, collision would probably have occurred even if the *Stockholm* had stood on. It was due to the fact that the miss distance shown on the radar of the *Andrea Doria* was of the wrong sign, i.e. it was shown as negative when in fact it was positive. Had the miss distance been shown as positive, the master would have been in no difficulty, because a turn to starboard would have been in

accordance with the Steering Rules *as well as* increasing the miss distance. If a signal had been exchanged it would have come to light that the miss distance was shown as positive on the radar of the *Stockholm*, which meant, of course, that one or other of the radars was wrong. My opinion, therefore, is that this disaster was primarily due to a faulty procedure, i.e. the application by the *Andrea Doria* of reverse manœuvres without pre-arrangement. Under the present Regulations this could happen to any mariner.

Captain Planty says that it is dangerous for two ships to manœuvre at the same time. Well, of course it is if there is no convention as to the rotation of the sight-line, and no means of arranging for reversal when circumstances demand it. In the same way it would be dangerous for two vehicles to manœuvre on a road if there was no convention as to which side should be kept to. He also says that I leave the initiative in manœuvre to one party without specifying which. I cannot think how he has acquired this impression; Fig. 13 in my latest paper sets out my proposals in a form which is as clear as I can make it, and all I can do is to suggest that he studies this, and tries a few examples.