TABLE II. COMPARISON BETWEEN DECCA (NIGHT) AND MEASURED MILE

Engine revs. (1)	4 Runs meas. mile & st.devn. (2)	4 Runs Decca & st.devn. (3)	(2)–(3) & st.devn.
110	16'76 ± 0'04	16·66 ± 0'07	+ 0'10 (0·60 %) ± 0'08 (0·48 %)
115	17·58 ± 0·04	17·53 ± 0·06	+ 0·05 (0·28 %) ± 0·07 (0·40 %)
119	18·01 ± 0·04	18·032 ± 0·038	− 0·022 (0·12 %) ± 0·05 (0·28 %)

5. CONCLUSIONS.

Table I. The accuracy of day as well as night speed trials is sufficient for all practical needs. Nevertheless, whenever possible, day trials are to be preferred. The preliminary speed serves a useful purpose, but cannot be sufficiently relied upon as a substitute for the final speed.

Table II. Even under the unfavourable circumstances during the night, no systematic error can be shown between *V* determined by Decca and on the measured mile (random errors in their differences are of the same order of magnitude as the random errors of *V* determined by Decca).

As to the magnitude of (possible) *systematic* errors in a speed determined on the measured mile, reference is made to (4). *Systematic* errors in Decca speeds will never exceed 0·1 per cent of *V* (2) and most likely will be very considerably smaller.

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Note: Earlier publications on this subject have become more or less obsolescent and are not mentioned here.

The Polaroid Procedure for Photographing Radar Screens

from J. A. Klerk and W. Steensma

WHEN reading articles on radar-navigation in various nautical magazines, one is constantly struck by the difficulty of comparing the different targets on the screen and of interpreting the changes that take place in the right way. So plotting becomes still more necessary in order to get: (a) the nearest approach,

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and (b) the present course and speed of other vessels, before we can manœuvre to avoid collision, especially in thick weather. When plotting, comparisons are hampered by the fact that the echoes must be recorded on a piece of paper or on the reflection-plotter, and that the different distances, courses and speeds must be measured very accurately. And nearly all these tasks depend upon the skill and accuracy of one man.

In the September 1954 issue of the Dutch nautical magazine *De Zee*, Steensma approached the question of the possibility of photographing the radar screen in order to get a rapid and exact general view of the behaviour of ships in the vicinity. During recent years photography has made great progress, and it should now be practicable at sea to photograph the screen by the *polaroid method*, so as to get a picture of the sea and all ships in the vicinity, with all the necessary detail. With this method, a print can be obtained within fifteen seconds of the last exposure, which enables the operator to determine the positions and movements of echoes in a much shorter time than usual. If the same film is

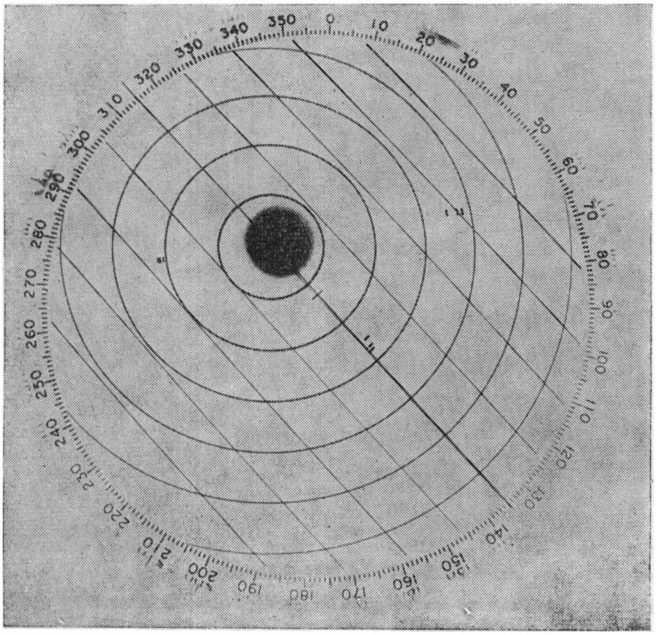

Fig. 1 (Relative Motion).

The radar screen is set to relative-motion, and the course of our own vessel is 135°, range-rings every 2 miles. The lines parallel to own course are the cursor-lines, and the position of own ship is off-centre. The photograph was exposed three times for 4 seconds, with intervals of one and two minutes respectively, to determine the relative direction of the echoes. We see six echoes and a broad one, the last being three echoes fused together. Thus we have three echoes of every target and we are able to conclude, within 4 minutes, that:

(*a*) *The vessel bearing (at the beginning of the test) 257° is steering about the same course and speed as ours.*

(*b*) *The relative-motion of the vessel bearing 76° alters from 82° to 262°, and the nearest approach will be less than one mile.*

(*c*) *The relative-motion of the vessel bearing 135° alters from 147° to 327°, and the nearest approach will be less than two miles.*

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exposed three times, let us say for 4 seconds, with two intervals of one and two minutes respectively, the resulting photograph will show three echoes from each target.

These echoes will indicate the distance, bearing and direction of movement of the objects, either relative or true, depending on the radar-presentation used. When a short range is used, the intervals between the exposures can be even shorter.

During our experiments with the radar-simulator at the Nautical School at Amsterdam, simulating a radar-picture north up (radar linked to gyro compass) we took the photographs illustrating this article and many more. We were also able, in complex situations, to interpret the pictures correctly and very quickly. While experimenting, it occurred to Klerk that both methods might be

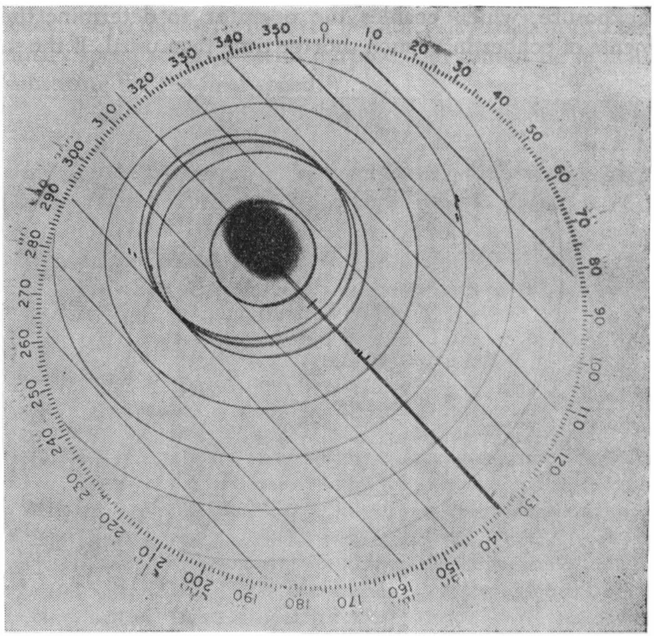

Fig. 2 (True-motion).

The radar screen is set to true-motion with the speed control in accordance with the estimated speed of own ship. Our course is 135°. This photograph, too, was exposed three times for 4 seconds, also with intervals of one and two minutes respectively. Now we see nine echoes (two of them fused together) and the three variable-distance rings of our own ship, put on 4 miles, showing own movement. But in addition we have the course, distance and speed of the vessels bearing 265°, 75° and 135°. The vessel bearing 265° is following about the same course as we are at about the same speed; the vessel bearing 75° is crossing, and the last one is also following the same course as own ship but at about half the speed.

combined in one photograph, exposing first of all three times for 4 seconds with the screen on true-motion, and secondly three times for 20 seconds with the screen on relative-motion. The intervals were one and two minutes respectively, and the change-over from true- to relative-motion took from one to twenty seconds in the experiments. It was found to be possible to switch over in one second by turning the speed control to zero, the last echo of the true-motion thus coinciding with the first echo of the relative-motion. During the tests, in which we also photographed the G.M.T., it appeared to be possible to make photograph III in *less than four minutes* (range five miles, intervals half a minute).

When these methods are used on board ship it should be possible to use a viewing hood with a polaroid camera as a unit to place on the radar screen, the radar-operator alternating its use with that of the normal viewing hood. It might also be possible to install a monitor with an automatic camera. We hope to continue our experiments in a vessel on the high seas and to report the results. In the meantime, others may be able to obtain their own data, and all will be able to prove the usefulness of this practical method.

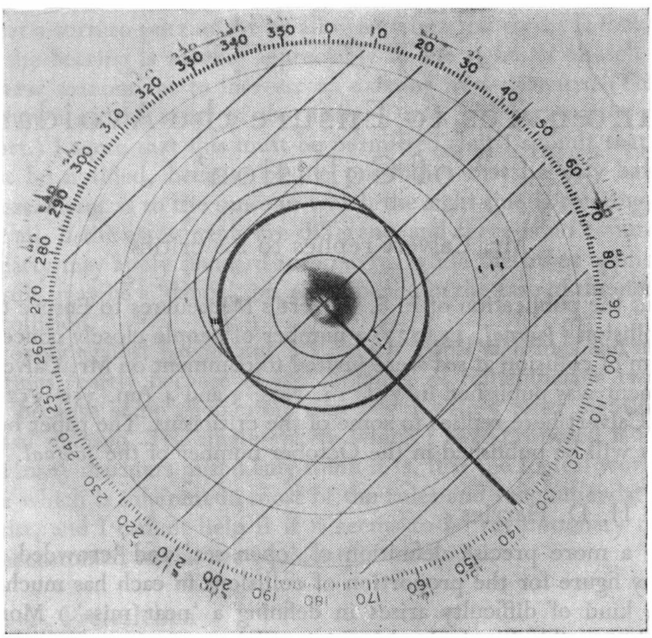

Fig. 3 (Combined method).

The radar screen is set to true-motion, course of own vessel 135°, speed control on the estimated speed of our ship. The exposure is three times for 4 seconds, with intervals of one minute. Speed control is turned to zero: there is no movement of own ship on the screen (the position will mostly be off-centre), and the movements of the echoes become relative. The last echo of the true-motion setting coincides with the first echo of the relative-motion setting of the radar. Once more the photograph was exposed three times, but now for 20 seconds, with intervals of one minute. The result is that the echoes of the true-motion are fainter than those of the relative-motion, and we see, within six minutes, *all the data we want on all the echoes around us (true course and speed, relative-motion and nearest approach):*

(*a*) *The true course of the vessel bearing 260° is 125°; the nearest approach will be less than two miles.*

(*b*) *The true course of the vessel bearing 76° is 173°; the nearest approach will be less than one mile.*

(*c*) *The true course of the vessel bearing 132° is 120°, the nearest approach will be less than two miles and we are going to overtake her.*

[Note: the very faint echoes of the true-motion of the vessel bearing 76° in photograph 3 have had to be retouched for reproduction.]

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