inradius is between ½ and 1 mile the cocked hat is suspect and if greater than 1 mile it should be rejected (in which case the navigator needs further data before he can find his position). Assuming that the cocked hat passes the test, we may assert with 95 per cent confidence that the true position lies in a circle, centred at the incentre, whose radius is 1¼ miles. This is irrespective of the actual size of the cocked hat.

7. SUMMARY. Three pieces of information do not throw a great deal of light on position when both systematic and random errors, and possibly blunders as well, may occur. Nevertheless the *size* of the cocked hat can be used as a measure of consistency, and the incentre (a visual estimate requiring no construction, is sufficient) may be taken as the most probable position. A 95 per cent circle may be constructed, and plots started from the most dangerous point on the perimeter (Ref. 1, p. 224) if required.

The *Admiralty Navigation Manual* theorem quoted in para. 5.2, while theoretically correct, is practically of little consequence since its converse for any particular realization of three position lines cannot be used. It is therefore misleading and could well be assigned to the archives!

REFERENCES

1 Cotter, C. H. (1961). The cocked hat. This *Journal*, 14, 223.

2 Parker, J. B. (1952). The treatment of simultaneous position data in the air. This *Journal*, 5, 235.

The Polaroid Procedure for Photographing Radar Screens

from Captain A. Wepster

(Holland–America Line)

IN the July *Journal* (14, 362) Klerk and Steensma describe a new and ingenious method of radar plotting. The following comment, sent in at the invitation of the editor of the *Journal*, follows closely my remarks on a similar article in the Dutch review *De Zee* (December 1960).

Careful study and consideration of this article and the original photographs that go with it have confirmed my opinion that the reflex plotter is still the most desirable and appropriate instrumental aid to carry out a radar plot. The authors mention five definite advantages in favour of this plotting method. The only objection they mention is eye strain and consequent fatigue. The plotting difficulties mentioned by them for the Strait of Dover will be dealt with later. The photographic plotting method does not solve these difficulties either.

The most obvious disadvantages of the proposed plotting method can be summed up as follows:

(1) *Scale reduction*

for a 12-in. radar display 1 : 4·3
for a 16-in. radar display 1 : 5·7

This scale reduction can under certain circumstances have a detrimental effect on reading off courses and closest point of approach distances. See for example Fig. 3, page 365, in determining the C.P.A. for the ship echo bearing 260°.

(2) A continuous and regular radar watch can only be kept if a true-motion monitor equipped with an automatic camera is installed. The estimated minimum cost for such equipment would amount to approximately £2500. For this considerable amount of money one would obtain a system that offers no solution in really confined waters, where infallibility is most desirable. In particular Method III, the combination of relative- and true-motion, can only be properly carried out on a separate display. The alternating adjustment of the display to true and relative presentation, by way of own speed adjustment, causes all targets to move in zig-zag fashion across the PPI. Quiet and concentrated radar observation is impossible under these conditions.

(3) The person responsible for the navigation, who also has to evaluate the photographs, encounters the following difficulties:

(*a*) Discontinuity: the successive photographs show the situation changes in a jumping fashion. A course and/or speed change of the target can become apparent to the observer with minutes delay.

(*b*) The danger exists that a certain amount of distraction is caused by the radar display photographs diverting the navigator's attention from the main problem in hand, collision avoidance. The radar display itself sometimes had and has this tendency. With this new method two watch-keeping officers on the bridge are exposed to this influence, the radar observer and the photograph reading navigator.

(*c*) Evaluating the photographs in broad daylight offers no problems. Wheelhouse and chartroom have enough light. The chartroom, however, is not the most appropriate place. At night this is different. The most obvious person on the bridge to evaluate the photographs is either the master or senior watch officer-navigator. He will want to stay in the wheelhouse where insufficient light is available and where sufficient light cannot be available to study and evaluate a radar display photograph with a working diameter of 70 mm., or not quite 3 inches. Eyes too old to use the reflex plotter will under these conditions fail as well.

(4) I would also very much like to see a responsible technical explanation, showing that the exposure time difference method mentioned under III will always produce sufficient difference in brightness in the photograph to discern between true- and relative-motion.

To me it seems possible that an echo possesses such intensity or brightness that an exposure difference of from 4 to 20 seconds does not produce any difference in the final photograph of the display.

(5) In order to judge the operational possibilities of this method in the Strait of Dover or Pas de Calais, the following example was considered. En-route from Dungeness to Sandettie lightvessel the 8-mile display range setting is normally used. Shipping in this area is mainly concentrated in a 3-mile wide strip. Personal experience corroborated with that of many others shows it to be quite normal continuously to have twenty-five simultaneous targets on the PPI—a number not contradicted by the 900 ships that, according to Captain Poll, pass every day between Dover and Cape Gris Nez. On a 16-in. radar display this 16-mile long and 3-mile wide strip of water is represented 75-mm. wide and 400-mm. long. The surface area of the pictured strip is therefore 30,000 mm^2

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on a 16-in. display. In this 30,000 mm² area 25 ships' echoes are represented, an average echo density of 1 echo per 1200 mm². In the polaroid photograph with a CRT picture with a diameter of 70 mm. this same shipping area is portrayed with a surface area of $30,000/(5 \cdot 7 \times 5 \cdot 7)$ mm² or approximately 925 mm².

According to Section III of the paper each target is finally represented by five pips; the polaroid photograph will contain 5×25 echo pips for this same area, or an echo density of one echo pip per 7·4 mm². As this particular area also contains fixed targets such as buoys and light-vessels, which also have to be taken into account, the figure derived is somewhat pessimistic as stationary targets produce only three instead of five echo pips in the photograph. Therefore an echo density of one echo pip per 9 mm² will be assumed as a realistic value.

Notwithstanding the very small size of the echo pips in the photograph as compared with the echoes on the actual radar display, it is quite obvious that reliable and responsible evaluation of the display photograph becomes quite illusory under such echo density conditions.

Where lies the deficiency of this ingenious system? It is caused by the absence of a discriminating radar observer. In congested shipping areas the radar observer's task, aided and supported by a good radar display picture and a reflex plotter is:

(*a*) to sift out those echoes that reasonably speaking do not merit a complete plot. These are echoes of targets offering only a very remote chance of collision or echoes of targets with which at the moment of observation no collision possibility exists;

(*b*) to plot and pass on evaluations of the plot of target echoes that constitute or are likely to constitute danger of collision.

This discriminating, responsible radar observer cannot be dismissed. No human being can plot all the echoes appearing on the display under these trying and overcrowded conditions. Neither can the camera, at least not in such a way that the resulting photograph can be successfully evaluated by a human being.

(6) If we now look closely at the five self-evident advantages of this photographic plotting method mentioned by the authors, my conclusion is as follows:

(*a*) 'A very clear and exact picture is obtainable in a very short time.' Yes if it applies only to a few ships; under those conditions, however, the need for a better system is least apparent. *No* for confined and congested waterways, when the need for automation is most pressing. The photograph of the display remains exact, but is definitely no longer clear.

(*b*) 'It is possible to plot simultaneously an almost unlimited number of echoes.' If plotting means the evaluation of true target motion the answer is *no*. The echoes can be portrayed but analysis of them will be impossible.

(*c*) 'Human error in observation and interpretation is practically eliminated.' Yes if it applies to only a few echoes. *No* for confined and congested waterways.

(*d*) 'The photographs can be viewed immediately in the chartroom in daylight or with sufficient artificial light.' Yes if by day. *No* at night.

Infallible systems require non-existing infallible human beings. It is for this

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same reason that the automatic ships' motion and order registration system *Regitex* has never been adopted by the shipping industry.

My personal preference for all merchant marine radar work remains an installation with a true-motion and relative-motion display, side by side in a special separate dark radar room. This radar room should be readily accessible from wheelhouse and chartroom and with the best possible voice communication facilities between radar room and wheelhouse. Both displays should have reflex plotters and under conditions of reduced visibility be continuously watched by a well-trained, reliable and responsible radar observer. Such an installation can and will give the observer the answer to all questions.

I am fully aware of the fact that the method preferred by me is by no means perfect and still has drawbacks. These drawbacks, however, are less serious. The procedure has been carried out in practice and proved its worth. The photographic method does not solve the existing difficulties and introduces new ones. I am happy to announce that the authors have had a first opportunity to evaluate their system in the S.S. *Maasdam* and *Ryndam* of Holland–America Line on a trip Rotterdam–Le Havre–Rotterdam.

These ships only offered relative-motion north stabilized display facilities. Further experiments on a true-motion display will be necessary to obtain full evaluation data. I am looking forward to extensive reports by the authors on the experience gained during the above-mentioned and future evaluation voyages.