

5.—A new edition of Chart No. 2649 embodying the modifications under 3 (iii) and 4 is now in preparation and, when issued, further criticism will be invited.

6.—A device termed a Radar Station Pointer, diagram 5028 printed on a transparency, will shortly be published and it is hoped that this will assist radar fixing and identification of radar targets on all charts and particularly when used with 2649 and future charts of this type.

7.—It is hoped next to adapt Charts Nos. 1825 A and B, the general charts of the Irish Sea, for radar fixing in order to give shipping using our West Coast ports an opportunity to contribute to this development.

RADAR AND CHARTS

A discussion following a Report on Admiralty Chart 2649

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A discussion on the adaptation of marine charts for use with radar was held at a meeting (16 December 1949) to which Lieutenant Commander P. G. Satow, D.S.C., R.N., presented his report on the experimental Admiralty Chart No. 2649. The report, which was published in the last number of the *Journal* (Vol. 3, No. 1, pp. 22-23) had been made as a result of sea trials in the area. The chart under review was issued by the Admiralty in May 1949 and users were invited to comment on certain features. The principal features under trial were :

- (1) An improved clarity of coastline ;
- (2) Additional spot heights and contouring, giving a more detailed picture of inland topography ;
- (3) Emphasis to contours where hill aspect and gradient might provide prominent radar targets ;
- (4) Block shading of built-up areas.

The report commented on each of these features and, as a result of the trials and of other operational experience, the following general conclusions on position fixing by radar at long range were drawn :

- (1) The influence of atmospheric refraction must be considered before evaluation and plotting of echoes ;
- (2) Apart from prominent high points, radar at long ranges tends to emphasize topographical features (notably coastlines) in the horizontal instead of, as with visual recognition, in the vertical plane ;
- (3) Gradient and nature of surface may vary extensively over short distances on land, therefore aspect may have an important bearing on echo quality and extent ;
- (4) Echoes from inland are only of value when the ship is well offshore and without sufficient coastline under radar detection for positive recognition ;
- (5) Insufficient data on elevation and gradient of coastal ground makes plotting at long ranges unreliable and may delay landfalls ;
- (6) Built-up areas are only of value when the coastline is low-lying and otherwise insignificant ;
- (7) The value of visual information is often greatest *at night* when accurate bearings of a lighthouse are obtained in good visibility at ranges at which recognition would probably be out of the question by day.

It was also suggested that some of the inland contouring on Chart 2649 could be omitted since in several places it was unlikely to be used.

Examples of such areas were in the vicinity of the Isle of Wight where the south coast of the island itself was a far better target than anything northward of the Solent (though it was suggested that conspicuous inland targets such as the monument 4 miles NW of Portsmouth should be retained) and the high ground between Portland and Weymouth where the (approx.) 400 ft. contour appears as a continuation of the steep-to coastal zone between Durlston Head and White Nothe. This echo varies little with aspect and prevents echoes being received from the high ground further inland to the north of Dorchester (see fig. 1).

The question of whether objects which have been proved to be good long range targets should not be so marked on the chart was also raised.

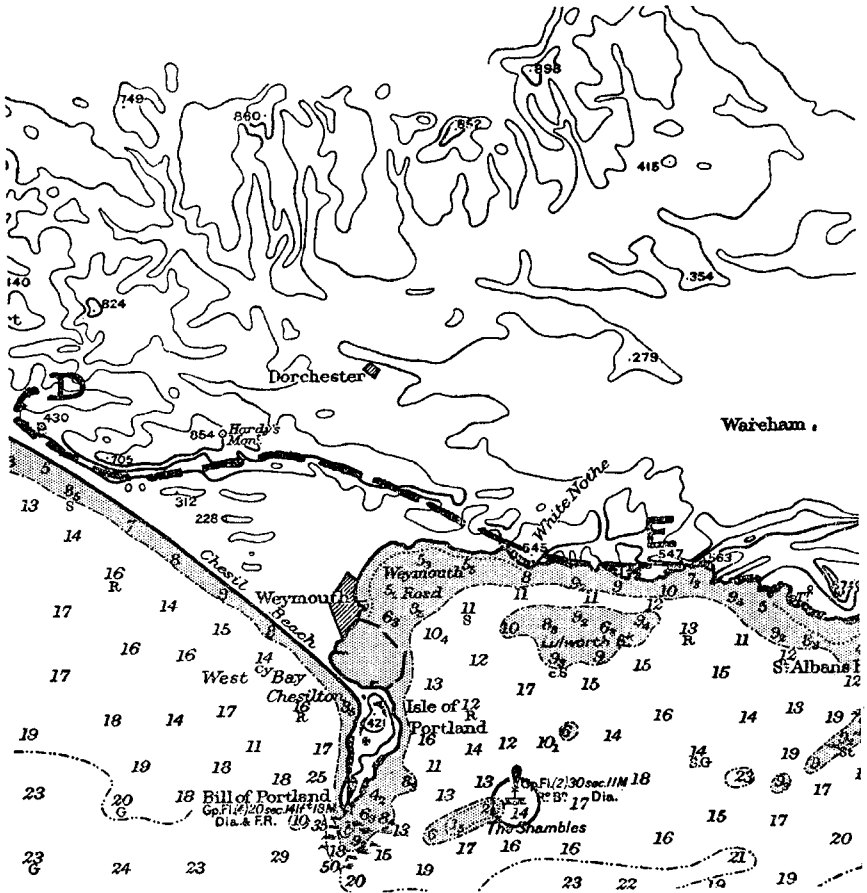


FIGURE 1

A part of Chart 2649 on which the approximate 400-ft. contour on the seaward edge of the high ground north of Weymouth has been marked. This provides a prominent radar target and appears as a continuation of the steep-to coastline between Durlston Head and White Nothe. Echoes are rarely received from the high ground further inland because of this ridge.

At the meeting a slide showing a portion of the northern sheet, Shetland Islands, was shown to illustrate the similarities that could occur on the radar screen of different natural features that might be used to make a landfall. Here it was suggested that there would be no advantage in defining the features of each headland unless some method of differentiating between them could also be devised.

The President was in the chair at the meeting and called on Captain F. J. Wylie to open the discussion.

DISCUSSION

Captain F.J. WYLIE, R. N. (Radio Advisory Service) : Admiralty Chart No. 2649 has not been in use long enough for a substantial body of sea-going opinion to be collected and no doubt those who use the chart for navigation will eventually contribute much valuable comment. The scale of the chart is such that its principal uses will be for making landfall and for passages well away from the coast. The requirements for in-shore navigation and port approach may be expected to differ considerably from those and it would seem desirable, therefore, in considering this chart, to avoid the inclination to take account of the two sets of requirements.

From the landfall point of view our ultimate need is a chart upon which we shall be able to predict radar response with such confidence that previous knowledge of the picture presented by the radar set will be unnecessary. The information portrayed should be that likely to be useful in average meteorological conditions when viewed with a radar equipment with a performance similar to that perhaps of the average Merchant Navy type. The latter provision might usefully restrict the distance from the coast at which topographical detail is required.

We are unlikely ever to obtain what might be called an ideal chart. The number of factors which govern the radar response of the land features is such that a chart which would give us a true indication of what the radar picture is likely to be from all seaward aspects and ranges would entail a vast amount of work which would be in the nature of practical observation and recording. What we are seeking, therefore, must be a compromise so far as hydrographic production is concerned, but ships themselves will no doubt increase the value of these charts produced by the Admiralty by maintaining, perhaps, a master copy on which the results of practical observation will be recorded.

It appears to me that there are two prime necessities when using radar for off-shore fixing, one is knowledge of the maximum possible detection range of features near the expected landfall, and the other the shape of the echo or the pattern of echoes on the P.P.I. which will first make identification reasonably certain. We know, of course, that among the considerations which govern these matters are the height and the slope, in the direction of the observer, of the prominent features of the coastal area, and we are aware that we cannot make useful deductions on height alone. We know, for example, that the usual maximum detection range of the Scilly Islands (with 3 cm. British commercial radar sets) is about 12 miles, although the top of St. Mary's begins to rise above the horizon of the average radar scanner at about twice this distance. We have heard, on the other hand, that the 200 ft. cliffs on the south coast of Guernsey appear as a true coastline at 22 miles or more. The average coastline, I suggest, will not paint as a continuous picture identifiable from the chart until there has already been ample opportunity for fixing the ship on prominent features. It seems possible, therefore, that the importance of the bold delineation of the coastline on the chart may be overstressed.

A feature 200 ft. high has a sea horizon of about 16 miles ; the average height of a scanner in ships of the Merchant Navy will give a sea horizon of 8 or 9 miles. The maximum range of Merchant Navy radar is 30 miles. It would seem therefore that, for landfall purposes, the 200 ft. contour is of far greater importance than the coastline. If the mariner is blessed with a radar set which gives a good performance up to 30 miles he will become interested in the first indications of landfall at, say, from 25 to 30 miles, assuming that the land he is approaching has features which rise above 200 ft. From such a distance the configuration of the coastline has no significance whatever, nor will it have on the average coast until this distance is halved. In fact, one might say that the 200 ft. contour becomes the 'landfall coastline'.

When the seaboard is very hilly and broken up, as is the case in Devon and Cornwall, the mass of contours becomes extremely confusing and it is quite difficult at times to discover the height value of any particular line. When approaching the coast in a fast ship the time taken to identify the land is of great importance, and if the marking of contours could be made in some way self-evident, much time might be saved. In addition to accentuating the 200 ft. contour I would suggest that the 400, 800, 1200 ft., &c., contours should be dotted, the intervening contours being continuously but lightly drawn. Over the greater part of the coastline of this country, at any rate, few features rise to more than 799 ft. and the suggested system would, therefore, generally provide a self-evident indication of height. The illustration shows roughly the application of this system to the area surrounding Exeter. It brings out the 'landfall coastline' very strongly and seems to me to reduce the confusion among the higher contours.

There is a further possibility in the direction of simplifying the work of the mariner in thick weather which is connected with the actual method of indicating heights. It appears to me that the information which he needs on approaching a coastline with prominent features is not so much their actual heights as the distance from him at which they begin to rise above his horizon. If peaks, &c., were marked with the distance in miles of their sea horizon, his calculation would be rapid and simple. Although heights in feet are necessary when using the present form of off-shore distance table, possibly the longer operation could be left to the more leisurely mariner taking his sextant angles.

I do not underestimate the desirability of improving the clarity of the coastlines and of omitting details near to it which will not help identification. Provided, however, that the coastline is cleared of unnecessary detail, the stronger marking of the 200 ft. contour which I have suggested will not really detract from its value when in turn it becomes of importance to the navigator. I would emphasize my belief that to accentuate the coastline above all other contours is not in the best interest of the main function of this particular chart.

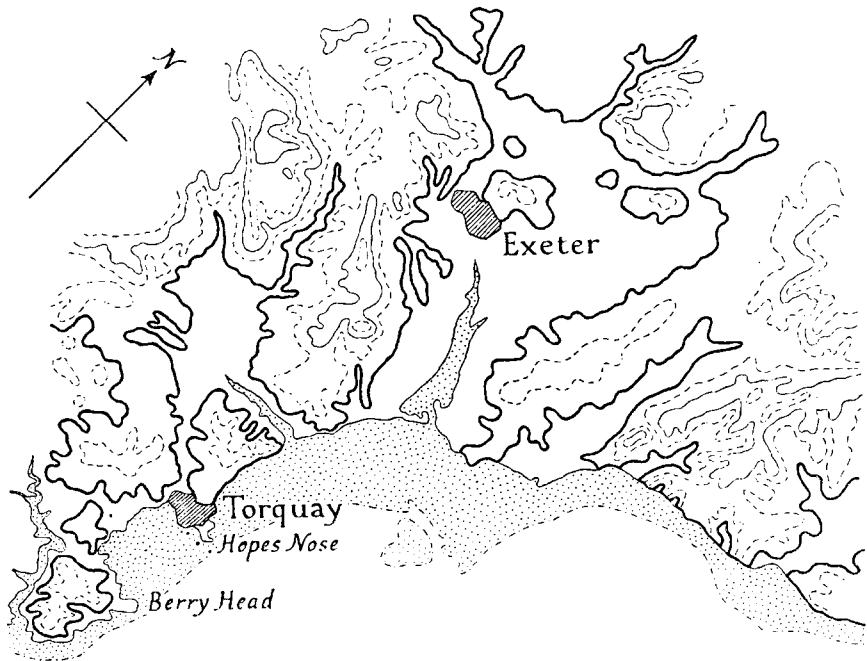


FIGURE 2

A possible system of contouring on charts.

I feel that the Admiralty is to be congratulated on producing this chart and Lieutenant Commander Satow on his exposition. I hope that the Hydrographer will receive an abundance of comment from sea to enable him to progress still further with this very important aid to radar navigation.

L. S. LE PAGE (Ministry of Transport) : Since the provision of suitable radar charts is one of the many factors contributing to the overall efficiency of ship-borne radar, and it is generally recognized that the charts designed for navigation by pre-radar methods often do not lend themselves to ready comparison with the radar picture, their redesign is evidently a worth-while task.

In any contemplated redesign, it is suggested that, so far as application to the Merchant Navy is concerned, two operational considerations should be borne in mind ; first, that most of the display units fitted in merchant ships are in the wheelhouse, remote from the chartroom, and simultaneous comparison of chart and radar picture may not be practicable ; and secondly, no merchant ship (as far as we are aware) has yet been equipped with a chart comparison unit, and even when the equipment becomes available, it seems unlikely that many ships will have optical chart-matching facilities for a long time to come.

It follows, therefore, that the chart must offer ready identification of the P.P.I. picture without any reliance on superposing one upon the other.

Now what in effect should the chart attempt to do? Imagine a mariner making a landfall, and seeing a solitary echo on the screen at a range of 12 miles. If he regularly uses that route, he may say: 'Ah, that's probably the water tower; it usually comes in at about that distance. I should soon be picking up the high cliffs on the coast.' Gradually, as the picture grows in detail, his assumption may be confirmed. His experience may well make superfluous a special chart for identification; and to him radar-assisted navigation from an ordinary chart may present no difficulties.

It is the mariner unfamiliar with the landfall that the chart should help; and it should tell him what the other man has found out by experience. Without the special chart, he would have little to guide him in deciding whether the first echoes were likely to be from the tower, the cliffs, or from high ground inland. The chart should answer the following questions; if the mariner believes himself to be off a certain part of the coast, what echoes should he expect to receive, and at what ranges (assuming normal propagation conditions and normal set performance); and in what manner will the picture change, as his position changes?

Does the method proposed in Chart 2649 succeed in this? One feels that it does so only to a limited extent. A few criticisms are ventured, based on comments from experienced Merchant Navy officers and on first-hand observation in the chart area.

(1) The coastline and immediate hinterland have insufficient character. Chesil Beach, for instance, is as strongly marked as the Devon cliffs.

(2) The sources of strong echoes are insufficiently emphasized; or conversely, minor features are too prominent. For example, the mass of low level contours of the Devonshire hills, extending to over 30 miles inland, seems to serve no useful purpose, but obscures the high ground. In this connection, an earlier experimental chart of this area, by omitting the lower contours of these hills, brought out the high ground in an admirably clear manner, and one wonders why this arrangement was dropped.

(3) Several mariners express themselves in favour of hachuring as opposed to contours.

It may be of interest here to make some reference to other essays in the production of radar charts. A series of white on black Radar Pilotage Charts, of the eastern seaboard of the United States, has been produced. Built-up areas near the coast are indicated by cross hatching, and small circles indicate radar conspicuous objects; hardly any features more than about three miles inland are shown, nor do any names appear on these charts. These special charts are probably intended for use only with a chart comparison unit, and in conjunction with ordinary navigational charts.

It is believed that one experiment is taking place in which a chart is being built up from a series of radar photographs, and is to be finally printed in luminous paint on a black background.

Mention should also be made of the chart of the North Aegean Sea prepared by the Hydrographer of the Royal Hellenic Navy. This radar chart has the contours coloured in shades of brown, in the conventional manner of a physical map. An interesting feature is the abacus printed on the chart, this scale relating radar aerial height with the horizon range of radar conspicuous objects of heights up to 600 metres.

The following suggestions are put up for consideration:

In drawing the coastline, full account should be taken of its nature; cliffs should be emphasized if they are likely to give a strong echo, and lowlying land should be less strongly marked.

The character of the land within three miles of the coast should be brought out clearly. (For large scale pilotage charts details of built-up areas and railway tracks will assist identification, as also will certain very low-level contours. We have prepared a chart of the Thames entrance showing contours down to the 10-ft. level and this shows a marked gain in resembling the radar picture of the area).

More than three miles inland, no detail other than peaks and ridges of high land should normally be shown.

Areas likely to give a strong echo should be shaded by lines whose closeness is a measure of the likely echo strength.

Generally speaking, the principle should be followed that recognition depends mainly on the characteristic arrangement of a few outstanding features. Radar conspicuous objects such as water-towers, aerial masts, should be brought out strongly from the background. The question of marking these according to the distance at which they may be expected to be received must be studied. The effect of aspect on range will be important here.

The height and possibly the size of radar reflectors on beacons, buoys and lighthouses should be marked.

Where heights of land are shown fully contoured, a useful suggestion (due to Mr. Hansford) is for contours to be spaced at logarithmic intervals, e.g. instead of every 200 ft., they would be at 200, 400, 800, 1600 ft. Thus the fact that the horizon range is proportional to the square root of the height would be taken into account.

The likely occurrence of sea echoes from such phenomena as tide rips, overfalls, and waves breaking on partially exposed reefs and sandbanks should be indicated.

Reproductions of actual 3 cm. radar P.P.I. photographs of important land-falls, and of port approaches, could be printed at the edge of the chart in the same manner as the present visual elevations. These need not be large; perhaps a diameter of 2 in. would suffice.

Full use should be made in the preparation of charts of such aerial survey photographs as are available for forecasting areas likely to give strong radar echoes; oblique photographs are likely to be of greatest value.

There is still much divergence of opinion on the form of modification which will render charts most suitable for radar purposes, but it is hoped that this discussion will enable further advances along the road to be made.

Mr. R. F. HANSFORD (Chairman of the Technical Committee): First I would like to compliment Lieutenant Commander Satow on a most interesting paper, and particularly to remark on the fine example of super-refraction that he gave in the course of his lecture, backed up by most adequate and interesting meteorological data.

Secondly, there are two points I wish to query, the first being this mention of a previous attempt at producing a radar chart of the Thames Estuary which the lecturer said he thought was rather a misplaced effort. As one of those involved in that particular effort I would like to attempt to justify some of the work done on the production of that particular chart. The Thames Estuary was chosen on that occasion for several reasons and particularly because we wanted to carry out work within a buoyed channel, because we felt one of the problems was that radar charts had to show not only the land topography more clearly but also there had, if possible, to be found a system by which small navigational buoys could be found easily on the chart when it was viewed in dim lighting. So far as I know, that is a problem which has not been faced up to, either on Chart No. 2649 or any other charts. In the chart drawn up for the Thames Estuary all buoys were made to show up very clearly and that proved to be of considerable help in carrying out pilotage operations.

The second reason for choosing the Thames as an area was that it coincided with the programme of trials and demonstrations which some 400 members of the shipping industry and also delegates to an international conference had the opportunity of seeing. Therefore, we hoped that a very representative cross-section of user opinion would be forthcoming during the course of those trials. I may mention that the opportunity was taken at the same time of checking the correlation between the radar picture and the land topography, and it was found to be reasonably good.

It may be of general interest to note that the point raised both by Captain Wylie and by Mr. Le Page, i.e. so choosing the height of a contour that it will give a constant range visibility, was included in the Thames Estuary chart, as was also the idea of a range abacus and coloured contour layers; and in view of the fact that that chart goes back to 1946 I think it will be of interest to realize that the British Hydrographic Department can accept some responsibility for the idea behind the Royal Hellenic Navy's chart.

My second point is that I believe I am right in saying that the results which Lieutenant Commander Satow has produced have been taken entirely from a 10 cm. radar. It seems to me that the results would have been very different indeed had a 3 cm. radar been used. Firstly, the latter picks out the coastline very much more clearly than the 10 cm. radar does. That is a well-known and easily explained fact. There is another fact which, so far as I

know, has not yet been fully explained : that whereas a 10 cm. radar often picks out the inland topography very well, a 3 cm. radar picks it out much less satisfactorily. Therefore, with the 3 cm. radar one tends to pay much more attention to coastline echoes and much less attention to inland echoes.

The point this leads me on to is that there is very great need for accumulating as much information as possible on how our coastline, and coastlines throughout the world, appear to the 3 cm. radar. In the past the British Hydrographic Department has produced some of the finest charts in the world not only because of the diligence of that department but because the navigators of the navy have taken the trouble to comment on charts, to pass in corrections and to keep the charts thoroughly up-to-date and improved in every possible way. It seems to me at the moment that it is rather a tragedy that so many of the Royal Naval vessels are fitted with 10 cm. navigational radar and not 3 cm., since we may be losing a vast amount of experience which could otherwise come our way.

Captain WYLIE : I do not want to take issue with Mr. Hansford on the subject of 3 *versus* 10 cm. radar, but one knows that 3 cm. radar will produce the better picture of the coast if it can get one at all ; at the same time, I should not like Mr. Hansford's remark to cause it to be felt that the coastline itself has any particular significance in relation to the 200 ft. contour-line. The angle from which one has to approach this chart, if we are considering it from the landfall aspect, is : When does the mariner wish to start getting a fix on radar? If he is blessed, as many are, with a 30-mile set I think he will become very interested at that sort of range, and if he is faced with a fairly hilly coastline with good features, he will be disappointed if he does not get a fix outside 20 miles. At that range the coastline of the average coast is of absolutely no significance : whatever wavelength may be used, the radar will not see it.

Commander C.E.N. FRANKCOM, R.N.R. (Meteorological Office) : I join with other members in congratulating Lieutenant Commander Satow on the way in which he has presented his paper and, if I may say so, the Hydrographer and the Hydrographic Department on the work they have done in producing this experimental chart which, from the little I have seen of it, seems to be a fine step in the right direction. It seems that what one should really aim at is a combination of the present quite excellent method of physical visual portrayal of significant features on the chart with a similar sort of idea with the radar portrayal, which I think was brought out by Mr. Le Page's remarks ; that one should try to avoid cluttering up the chart with a lot of possibly unnecessary detail, even from the point of view of contours, but rather stress the outstanding features of those contours. I felt, when looking at Captain Wylie's chart, that the contouring shown there, although it was admirable in its object, did make it a little more confusing.

I was glad to hear Lieutenant Commander Satow stressing the meteorological features because it is fairly obvious when using radar as an aid to navigation that the met. side of it has to come into the picture very prominently indeed. Whenever one wants to use radar, the meteorological situation must be taken into consideration. It is a little difficult for the practical navigator to realize when the conditions are good or bad. The tendency now is for all meteorological services to give out something in the way of an analysis even from the point of view of the merchant seaman, so that he does have some idea as to what the current meteorological situation is.

Mr. A. ROBINSON (London University) : As one associated from the practical angle with the production of charts I have been interested in the discussion and would like to straighten out one or two points in regard to contouring. I think Mr. Le Page mentioned that it would be a good idea for large-scale radar charts to have contouring intervals of 10 ft. near the coast. That is practically an impossibility. In the British Isles we depend on information supplied by the Ordnance Survey and they only survey contours at the 50 and 100 ft. level and at 100 ft. intervals. The idea of interpolating between those intervals would not solve the problem because many points which would help the navigator would not come out.

Vice-Admiral Sir GUY WYATT (Hydrographer of the Navy) : As you can imagine, I have listened with intense interest to the discussion. I wish to congratulate Lieutenant Commander Satow on the great pains he has taken to present his lecture. It is impossible to take all the comments in at a meeting. We have heard so many different points of view that I am sure you all realize what a task it is to sort them out and to present them in a practical form on the chart without destroying to a greater or lesser extent the nature of the chart from the ordinary visual navigator's point of view.

Whether logarithmic contours would be a practical solution in all parts of the world is a question which will have to be studied ; it might have the effect of completely altering the appearance of the hills from the visual point of view.

Then as to ground which is likely to give a good echo I must ask you to realize that the man drawing the chart is a cartographer and he is poring over, say, an ordnance map and has to make up his mind from that map what is likely to produce a good echo at sea. Unless we give photographs or sketches for a map it is going to take a long time before the present generation of cartographers can develop that technique in the way that they developed the technique to suit the visual user.

Lieutenant Commander Satow has said that Great Britain is one of the few countries which is accurately contoured. I should say that the greater part of Europe and a great part of North America are sufficiently accurately contoured for the purposes of radar, but apart from that I think one might say that almost the whole of the world is uncountoured and not even covered by air photographs which are suitable for using in the machines which are devised for contouring.

The other point I should like to make is that it is not of practical value to suggest charts especially for radar, such as white on black or black on white. They might be a valuable aid in certain conditions, but the number of staff I can get for the Chart Branch of the Admiralty will never in our time permit of our doing it except to a very restricted degree.

Lieutenant Commander P. G. SATOW : May I say, very briefly, firstly, that in drawing up my conclusions, which were based purely on my experience of this work, I deliberately left open a number of points which I hoped would bring forth comment and discussion from those present, because, there was some doubt as to whether we should get the necessary comments for which it was hoped this meeting would provide the opportunity.

As one who has to keep something of the order of 1000 charts corrected and up-to-date from day to day I make this brief appeal, that whoever may finally decide on the form or nature of any modifications to charts, as we have them, we should not be inflicted with the burden of having a radar chart *in addition* to the ones already in use. If we do that the number will be doubled. It would of course be possible to fix your position by radar from one chart and transfer this fix to the chart you were navigating on. But here the work of navigation is increased and, also, it is often exceedingly difficult to fit in your visual information with what you are getting from radar.

