Some Problems on the Operation of the True Motion Radar

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Abstract

The efficiency of the True Motion Radar operation is described. It has been found that the most important factor in the radar is the persistence time of phosphor used for the cathode ray tube. Use of P 26 phosphor rather than P7 phosphor is recommended for TM radar scope. This greatly improves performance of TM radar operation.

1. Introduction

About ten years ago the true motion radar was first introduced to practical use and the production of the apparatus has since been increasing. In Japan, however, the TM radar was first installed on the Training Ship Kagoshima Maru in 1960. Still at present only several vessels are using it. The present author studied the efficiency of the TM radar operation from a navigator's point of view on all kinds of TM radars of the world, some of them only by their instruction books. In this paper it will be described how to be a true motion radar and how to operate the true motion radar.

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2. Outline of the true motion method

In using an ordinary radar we can find out other vessel's course and speed by relative plotting method, but the TM radar gives a instant visual indication of the true course and speed of other vessels on the PPI scope. The performance is achieved by the off-centering coil which is introduced by electrical signals via resolver, and the own ship's position is shown as a continuation of moment plots in accordance with the ship's movement. Afterglow trails appear only behind a moving target due to characteristic of phosphor painted on the face of cathode ray tube. The length and sense of echo trail appear in proportion to the target vessel's movement.

These systems should be adapted to a usual radar. Moreover, the characteristic of radar circuit is required in good linearlity for preventing distortion of PPI due to off-centering system. In short, however, we can estimate other vessel's course and speed by a visual observation about the echo trail on the PPI. On the other hand, various adjustments should be made to make a fixed target not to trail but to give a stationary point.

3. Physical factors affecting the visual detection of the trail of echo

In true motion radar we can estimate the target's movement by the length of echo trail, but the measurement of the length always accompanied by personal factors. This problem has been investigated by several authors.[1] It will not be discussed in this paper.

In the characteristic of usual CRT, the brightness of CRT varies in proportion to the variation of grid bias of valves. To discern signal video on PPI, contrast of PPI scope is necessary. An visual reference intensity with adjust visible rotating sweep line (Baker[2]) is an important direction of radar operation. Under this condition the CRT gives the optimum brightness.

Persistent characteristic of cathode ray tube[3]

Table 1[4][5] shows some persistent properties of phosphors used in the CRT to maintain a long afterglow time of echo trail. The persistence time is variable in accordance with hysteresis of CRT: especially the screen of CRT is readily damaged by slow-moving traces of high brilliance and the persistence time becomes shorter. Consequently the usage of CRT with level of optimum scope brightness is desirable. The factors above mentioned are the characteristic of CRT itself, but when radar scope is being observed, another important factor is that the ambient illumination affects the speed of recognization of radar pips on the screen.

Table 1. Characteristic of Phosphors.[3][4]

E. I. A. code	Color		App.
	Flash	Afterglow	Persistence
P 7	Blue-White	Yellow	10– 60 sec.
P 26	Orange	Orange	60–300
P 33	Orange	Orange	10–100
P 19	Blue	Greenish Yellow	Long

The curve of dark adaptation is showed Fig. 1.[6] If the observer puts on a red filter, the curve of its dark adaptation starts to down from the point A. So an observer of radar scope at the day time can reduce the time dark adaptation with a red filter. There are two advantages of using afterglow orange in color: one is fast dark adaptation. The other is long persistence of phosphor as showed in Table 1. On account of these reasons the author recommends P26[7] phosphor rather than P7[8][9] which is now in general use.

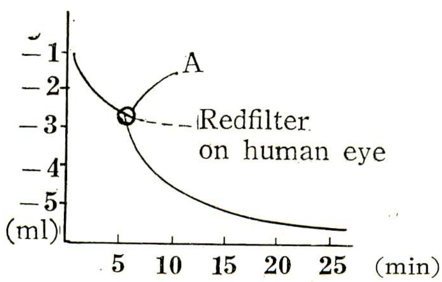

Fig. 1. Dark Adaptation Curve[6].

Spot size and the persistence time of CRT

Besides the afterglow time, the spot size on PPI scope[10][11][12] is an important factor that affects the accuracy of pip. Of course the spot size should be as small as possible, but rather larger size is desirable for the integrating effect.

Table 2. Relations between the Persisitence Time and the Length of Echo Trail. The time is assumed 2-3-4-5 min. Spot size = 0.5 mm.

speed \ range	12 in. CRT (usable dia. 132 mm)			
	1½ n. m.	3.0 n. m.	6.0 n. m.	12.0 n. m.
5kt	15-22- 29- 36	7-11-15-19	4- 6- 7- 9	2- 3- 4- 5
10	29-44- 60- 75	15-22-29-36	7-11-15-18	4- 6- 7- 9
15	44-66- 88-110	22-33-44-55	11-17-22-28	6- 9-11-14
20	60-88-117-147	29-46-60-74	15-22-29-37	8-11-15-19

speed \ range	16 in. CRT (usable dia. 181 mm)			
	1½ n. m.	3.0 n. m.	6.0 n. m.	12.0 n. m.
5	21- 33- 42- 51	10-15-20- 25	5- 8-10-13	3- 4- 5- 6
10	41- 62- 83-103	20-30-41- 50	10-15-21-25	5- 8-10-13
15	62- 93-123-155	30-45-60- 75	15-23-30-38	8-11-15-19
20	82-123-164-203	40-60-80-100	20-30-40-50	10-15-20-25

The smaller size, however, impress the increment of PPS and revolution of scanner which supplement the effect of integration, and the latter reduces the distortion of PPI as stated by Maehata.[13)]

Table 2 shows that the length of echo trail varies in proportion to the range ring and ship's speed. The observations were made under the following conditions: diameter is 12″[14)] and 16″,[15)16)] the standard spot size is assumed 0.5 mm. and the persistence time varies 2–5 min. The data shown in the table indicate that following factors shoud be considered to determine the length of echo trail: i) Persistence time, ii) Ship's speed, iii) Range ring, iv) Diameter of CRT. The length of echo trail to determine the sense and speed of ship is required to be 5 mm. at least.

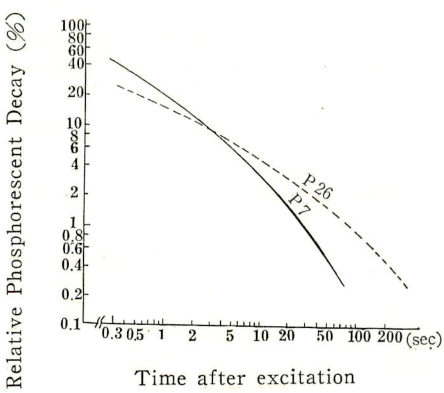

Fig. 2. Characteristics of Persistence of P 26, P 7[7)].

Consequently if the persistence time is short and the ship's speed is low, its trace is scarcely recognize. Additional factors, effective reflecting intensity of target ship, pulse per second, the revolution of scanner and so on, such as. However, the most important factor is the long of persistence time of phosphor.

Plate I(a) and I(b) are photos of 12″ CRT TM radar, taken under the nearly same conditions. The photo of Plate I(a) is of 2 mile range and the CRT is painted with phosphor P7, and that of Plate I(b) is 3 mile range, with P26 phosphor. It will readily be recognized that, the two photos differ in the echo trail. Moreover, in Plate I(a) of the two ships was running in about 15 knots and both were of large size.

On the contrary, in Plate I(b) the target ship was estimated 300 tons gross in size and the speed of was 10 knots, but the echo trailing is longer and clearer. As it is shown in Table 2, with the usage of 16″ CRT, if the phosphor is of same material, it corresponds to 50 % additional aid.

4. Method of true motion performance

Principle of true motion method

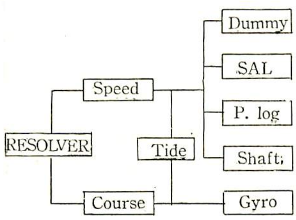

Fig. 3. Block diagram of resolver is introduced from information source.

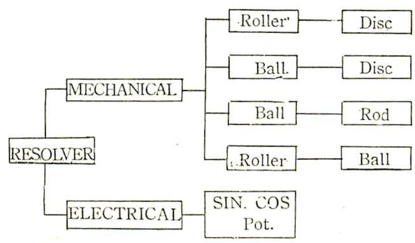

Fig. 4. Block diagram of resolving system.

In TM method the information of own ship's speed and course is introduced to the resolver, they are analysed on X,Y axis component. As the resolver may be both electrical and mechanical resolving systems used final output appears electrical signals.[17][18][19][20][21][22][23][24][25] The fundamental mechanism is that analysed into X and Y components by means of two resolvers which make a rolling contact at a point and that these components are introduced to potentiometer. The facility of resolver depends upon the accuracy of gyro compass and speed input. However, in this respect the gyro compass, seems to shown a sufficient accuracy in the follow-up speed, since a rapid turn causes ballistic deflection of 1° in maximum. Most of the errors was caused by the facility of mechanical resolver itself than the effects above mentioned.

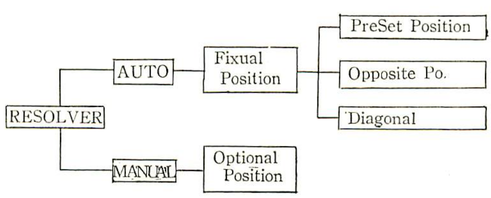

Fig. 5. Resetting method, auto and manual.

Since the computation by mechanical resolver is performed by frictional contact, is dynamical meaning. For this reason the contact position of resolver is desirable in point but is become to occupy an area from a point. Consequently to maintain point contact the ball-disc system (unpublished data) is desirable.

On the contrary an electronic method to use the electrical resolver adopts a sin-cos potentiometer in compact size.

In resetting procedure, the characteristic of these resolver is shown most evidently. When the mechanical resolver is performing the origin of trace can be set to a new position with ease, but in the case of the electrical resolver, the resetting requires a much more complex procedure. When pilotting with TM radar equipped with electrical resolver, the complicated routine techniques in resetting are apt to cause a mis-handling, moreover, the proper handling requires a special skillness in pre-setting position. Thus these works make navigators jar on their nerves. Another recommendation is the disuse of an electrical resolver with presetting system.

For the flyback point caused by resetting when the origin of sweep gets to the limit of TM performance, the optimum position have to be determined in considering the future course. Therefore, an automatic system which lacks in optional or preset position facilities should not be used.

The author proposes a device in which the pulse transmit circuit is put off automatically when the resetting knob is in use. This method will prevent PPI scope from fouling and will get a better echo trail.

Speed information source[26]

These sources are the following: i) Bottom pressure log (SAL); ii) Patent log, iii) Dummy log (artifical log), iv) Shaft log (tachometer) (Fig. 3). However, these pieces of speed informations are not over the ground but through the water, for this reason the difference between them caused the speed error of source, and this in turn causes the fixed echo trail. In accordance with the speed the log transmits signals automatically, but dummy log needs manual setting. In congested waters which need TM radar aids, the logs mentioned i), ii) cannot be in use sometime, instead of them dummy log is used. But this log is manually set on over the ground in estimation. Therefore, error in estimation is likely to occur, especially when own ship's speed is altering frequently. Thus navigator often makes a psychological mistake in speed estimation, and this may be over-lapped to the initial mistake. These mistakes cause more foul of PPI image. It is better to use a shaft log that automatically introduces signals.

5. Conclusion

The author considered various factors which may influence the recognization of the length of echo trail by human eye. As we know the speed of dark adaptation is variable in accordance with the ambient illumination. The time necessary to recognize the radar echo trail is about 5 min. in daytime except in the direct sun-shining. The long persistence time is important. In this respect P26 phosphor gives superior quality. The infrared illumination[27] is preferably used to erase PPI scope, it is also useful to prevent foul of scope image caused in operation of changing the range ring and resetting.

There are many questions in both the method of the source of information of speed and course and their adjusting systems, but in economical view, it is enough that the source of speed information is dummy and shaft log with a slip adjuster, together with a tide corrector for lee way. The resolver is to be mechanical system; it offers several practical advantages over an electrical system. Moreover, the author suggests that the cut-off circuit should be installed in resetting and that a radar operator has to wear warm color sunglasses.

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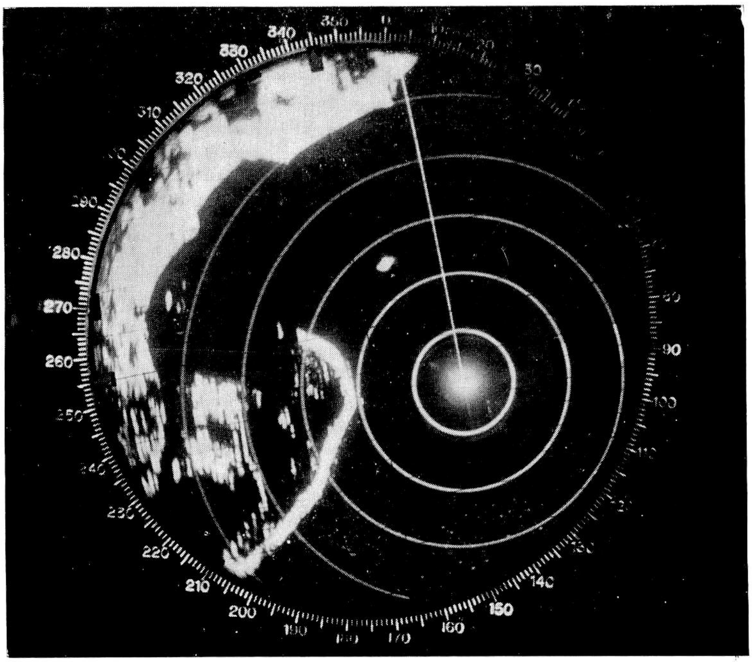

Plate I. (a) Off Shimizu Harbour 2 n. mile range with P7 phosphor

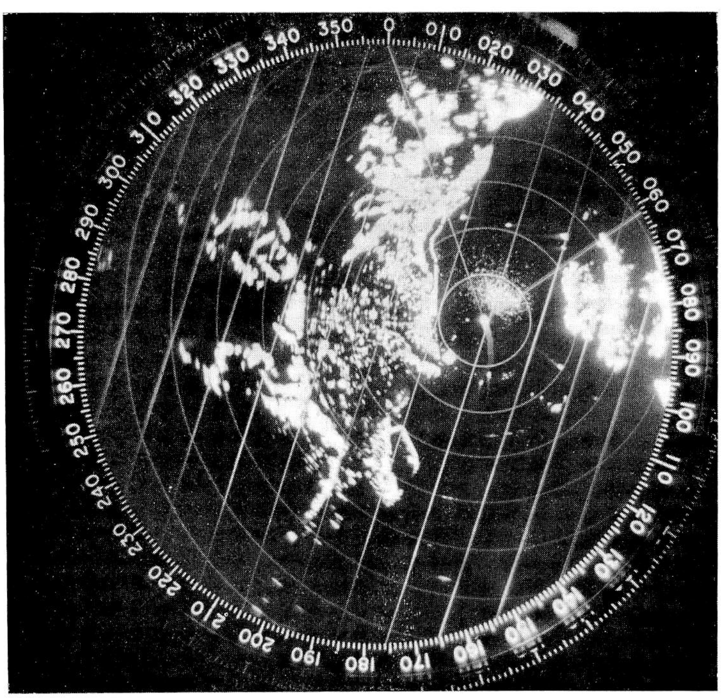

Plate I. (b) Off Kagoshima City 3 n. mile range with P26 phosphor