

# Forum

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## Collision Regulations – Discussion

John Kemp

### KEY WORDS

1. Colregs.
2. Sea.
3. Safety.
4. High Speed Craft.

It is good to see the COLREGS reappearing in Forum as a subject for discussion. R. W. Cooper (2001) is right to point out the problem inherent in rule 10(j) that one of the vessels in an encounter to which the rule applies cannot be sure whether the length criterion is met or not. Clearly some amendment is desirable.

R. D. Pike (2001) reminds us that there are real problems in many collision situations involving high speed craft (HSC) and of the failure of IMO to address these problems. His suggestion that fast vessels may take avoiding action, but that they should reduce speed if they come within a specified distance of another vessel, is worthy of consideration, but probably needs further development. For example, if two HSC, less than two miles apart, are proceeding on similar headings there would be little point in either of them reducing speed. Also, the establishment of routes for HSC, as has been done for example between Hong Kong and Macao, allows HSC to pass safely at much smaller distances without reducing speed. The establishment of routes to be used by HSC would also reduce the number of conflicts between HSC and slower vessels.

Finally, I should draw attention to a suggestion made by R. G. Prince for addressing the problem of collision avoidance by HSC. This is to the effect that, when two vessels are approaching so as to involve risk of collision, and one of them determines that its speed is at least twice as great as the other's, then the faster vessel should take action to avoid collision. This principle has a number of advantages over other proposals that have been made for amending the COLREGS to take account of the special problems of HSC. It avoids the contentious question of how to define a HSC for the purposes of the COLREGS. It does not depend on recognition of the speed differential by the slower vessel, nor on cooperation by that vessel. If the faster vessel chooses a course not less than 30 degrees from the bearing of the slower vessel, collision will be avoided whatever action the slower vessel takes. It follows from the above, that it is only the faster of the two vessels that needs to be able to estimate the speed differential in order to apply the principle. In general, such faster vessels would have the means, such as radar or ARPA, to make such an estimate.

The principle takes account of differential speed rather than actual speeds. Thus, a 15 knot freighter would be required to take action for a 5 knot yacht, a 45 knot HSC would be required to take action for a 15 knot freighter, and a 150 knot wing-in-ground-effect (WIG) craft would be required to take action for a 45 knot HSC. The principle could provide a legal basis for the current practice at sea, whereby HSC

routinely and effectively take action to avoid collision with slower vessels, irrespective of their obligations under the COLREGS. It has to be said that Mr. Prince's proposal was brought to the attention of the IMO last year through an information paper submitted by Friends of the Earth International (2000) to the Sub-Committee on Safety of Navigation (NAV46) – and it went down like a lead balloon. However, none of the other proposals made headway either, and the unsatisfactory situation described by Dag Pike remains.

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## Collision Regulations – Discussion

Pat Manley

#### KEY WORDS

1. Colregs. 2. Sea. 3. Safety. 4. High Speed Craft.

I read the Forum article 'Removal of an Ambiguity from the Maritime Collision Regulations' (Cooper, 2001) and make the following comments. As a Royal Yachting Association Yachtmaster Instructor, I find that many people quote Rule 10 of the COLREGS only in part and thus are misled by its intentions.

Rule 9(b), (Narrow channels) states that 'A vessel of less than 20 metres in length, or a sailing vessel, shall not impede the passage of a vessel which can safely navigate only within a narrow channel or fairway'.

Rule 10(j), (Traffic Separation Schemes) states 'A vessel of less than 20 metres in length or a sailing vessel shall not impede *The Safe Passage* (my emphasis) of a power-driven vessel following a traffic lane.'

Thus, in a Traffic Separation Scheme, normal Rule 15 (Crossing situation) and Rule 18 (Responsibility between vessels) apply, unless this would impede *The Safe Passage* of the vessel following the traffic lane. It is not a normal requirement that a vessel under 20 metres or a vessel under sail shall give-way to a vessel following a traffic lane.

A stand-on vessel of any size should stand on unless they decide that they wish to give-way, in which case they should alter course early and in such a manner that the give-way vessel is left in no doubt of her intentions. Safe navigation of the vessel following a traffic lane would normally be impeded by the proximity of other vessels using the traffic lane, and this should be obvious from a distance sufficient for the under 20 metre vessel to take avoiding action without any ambiguity arising.

R. W. Cooper says 'If she decides to interpret Rule 10 generously, and alters course to port ...'; however, Rule 17(c) requires 'if the circumstances admit, not to alter

course to port for a vessel on her own port side.’ Under this rule, as the stand-on vessel, the under 20 metre vessel should not turn to port to give-way, unless at sufficient range that no conflict can occur.

In a narrow channel, where the crossing vessel under 20 metres is obliged to give-way – Rule 9(b) – the proximity of both vessels should allow a fairly positive identification of size to be made. In any case, Rule 9(d) allows no crossing vessel to impede the safe navigation of a vessel which can navigate safely only within the narrow channel or fairway (regardless of size). It is the similarity of Rules 9 and 10 that gives rise to the misunderstanding of this rule. Unless *Safe Passage* is compromised, ‘normal give-way/stand-on rules’ apply in a Traffic Separation Scheme.

I do not think, therefore, that any additional visual signal is either required or desirable for vessels under 20 metres.

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## Finding Distance – The Fiske Rangefinders

Peter Ifland

#### KEY WORDS

1. History. 2. Sea. 3. Instruments.

Finding the distance has always been a challenge to the mariner. What is the distance to the lighthouse at the mouth of the harbour? Am I far enough off the rocks and shoals? My assigned station in the formation is bearing 300°, range 1500 yards from the guide ship, am I on station? What is the range for gunfire to the enemy flagship?

With early distance finding instruments, the height of the object being measured was required – the height of the lighthouse, the height of the masthead above the waterline, the height of the church steeple, etc. Having measured the angle between the top and the bottom of the object, the right triangle could be solved for distance. Early navigators had a shadow square engraved on their quadrant or astrolabe that yielded distance graphically knowing the height. The cross staff and later the sextant could be used to measure the angle from base to top and the resulting right triangle could be resolved by simple trigonometry.

A number of hand-held optical rangefinders were developed in the latter part of the nineteenth century. They were based on mirrors or prisms and could be set for the known height and were calibrated to readout distance directly. The Weymouth-Cook Sextant Rangefinder, Stuart’s Distance Meter and the Fiske Stadimeter, to be described below, are popular examples.

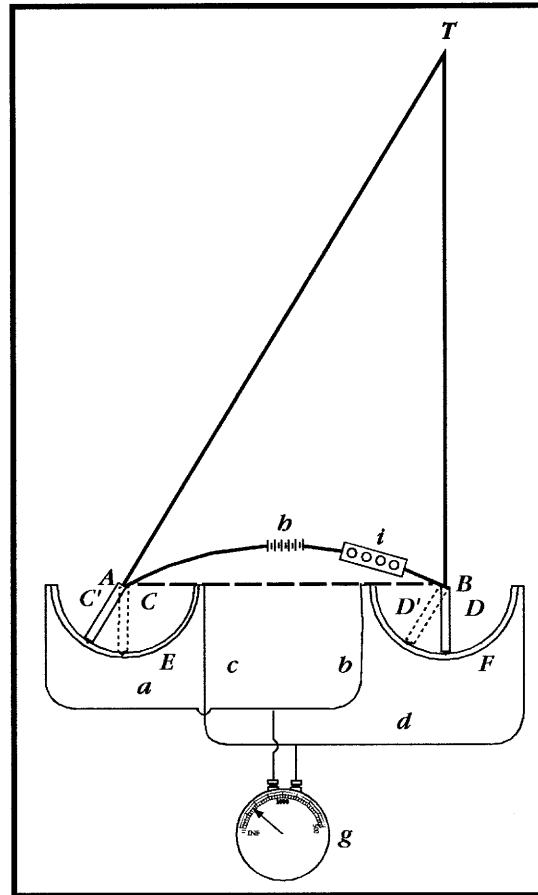


Figure 1. The Fiske Electrical Rangefinder. The device was designed to find the distance to the target,  $T$ , from the point of observation,  $B$  by solving the triangle  $ATB$ . The baseline of the triangle was the known distance,  $AB$ . The target was sighted with the telescopes  $C$  and  $D$ . A slider at the end of each telescope rode along wires  $E$  and  $F$ .  $h$  was a battery and  $i$  was a resistor used to stabilize the circuit. The circuits,  $ab$  and  $cd$ , formed a Wheatstone bridge connected to a galvanometer,  $g$ , calibrated in yards. The change in resistance in the Wheatstone bridge as the two telescopes were rotated over  $E$  and  $F$  to sight the target was proportional to the distance to the target recorded on the galvanometer. Redrawn from Fiske, 1891.

Admiral Bradley A. Fiske was an officer in the United States Navy from 1870 to 1917 (Colette, 1979). His active duty spanned the emergence of steel ships in the U.S. Navy. In his early career, Fiske was involved personally in the introduction of the telephone for shipboard communication and the electrification of many critical functions. He obtained 66 US patents, many of which were also filed in foreign countries. He was particularly motivated to upgrade critical ship handling, signalling and gunnery functions by developing and modernizing such basic equipment as the engine order telegraph, the rudder angle indicator, ammunition hoists and gun directing equipment. He participated in the introduction of aircraft into naval armament with the design of one of the first torpedo carrying aircraft and innovative torpedo control mechanisms.

In his later years, as a senior officer and even after his retirement, Fiske was active in developing naval policy in Washington. He was a strong advocate of strengthening and modernizing the US Navy in preparation for what was to be World War I. He proposed the centralization of naval strategy and command in what was to become the office of the Chief of Naval Operations.

During Fiske's time, government employees, including military personnel, were permitted to hold the patents on their inventions and to license them to commercial concerns that in turn might sell the product to governments, both domestic and foreign. Fiske licensed many of his early inventions to The American Range Finder Company, the Sprague Electric Railway and Motor Company and later, to the newly formed Western Electric Company and they produced, promoted and sold the equipment based on his patents.

Almost half of Fiske's patents are related to gunnery with major emphasis on range finding and finding the position of a target on a map. The basic concept of his electric range finding patents (Figure 1) was to place two observation posts a known distance apart, for example at the bow and the stern of a ship. Each of the two posts consisted of a telescope mounted on a tripod (Figure 2). As the telescopes were rotated to sight the object they slid over resistance wires, thus changing the resistance in a Wheatstone bridge circuit proportionally to the difference in the angles between the two telescopes. A voltmeter in the circuit was calibrated to read in yards. A built-in telephone connected the observers and a central gunfire control station that used the range information to set the guns.

In 1888, the first Fiske Electric Rangefinder was installed and tested on the 'dynamite cruiser' *Vesuvius*. This ship had a 15-inch pneumatic gun on her bow fixed at an angle of elevation of eighteen degrees. The weight of the projectile or the pressure of the compressed air used to propel the projectile determined range of the shot. Although the test on *Vesuvius* was a limited success, it led to the installation of the range finders on the new cruisers *Baltimore* and *Chicago*.

Naval gunfire in the 1890s was limited to about 2000 yards. Range was adjusted by eye by spotters who observed the fall of the shot. Thus, the rangefinder on the *Baltimore*, with a baseline of 276 feet, promised a dramatic improvement in accuracy. Importantly, the Fiske rangefinder could detect when the enemy came within the maximum range of the guns and the ship could then open fire. Several of Fiske's patents dealt with the use of the Electrical Rangefinder installed on land-based forts, where there might be long distances between guns, to locate ships lying off the shore on a map. Similarly, the rangefinder could be used for field artillery where the baseline could be established with a chain of predetermined length. Fiske also recognized that his rangefinder could be used for inshore navigation and chart making since it functioned without having to know the height of the object being observed.

In October 1890, Fiske was granted six months leave to demonstrate his range finder produced by the American Range Finder Company to the British, French and Italian navies. Elliott Brothers of London arranged a test supervised by an Ordnance Board that included the inventor of the well-known Watkin Position Finder. The British board concluded that the Fiske instrument was not acceptable. In contrast, Fiske received a cordial reception in France where the Ministry of Marine arranged to test the range finder aboard *Le Formidable*, the flagship of the Mediterranean fleet. The test was successful and the installation on *Le Formidable* and a similar installation at a land-based fortress at Cap Brun were officially accepted. The brief



Figure 2. The Fiske Electric Rangefinder demonstrated by an engineer of the American Rangefinder Company (Anonymous, ca. 1895). Each of the two observation posts was mounted on a rigid stand. Each observer rotated his telescope to align on the target, thus changing the resistance in an integral electrical circuit contained in the cylindrical disc at the base of the telescope. A galvanometer at the gunfire control station read directly in yards. Note the telephone that could be used without the observer taking his eye from the target. Photograph courtesy Duke University Library, Perkins Pamphlet Collection.

tests in Italy were judged successful and the device was accepted for installation on several Italian warships. In 1891, the Chilean navy decided to install the Fiske system on their new battleship, the *Captain Prat*, then under construction in France.

By 1893, Fiske had improved his system, now produced by the Western Electric Company, to the point that it was installed on three more cruisers and on four battleships. Wiring for the system was placed safely below decks. Early systems that could look to only one side of the ship were superseded by systems that could look to both port and starboard. Installations were placed at higher levels to avoid smoke and muzzle flash and some were aligned to look fore and aft. Accuracy was determined to be 0.55 per cent.

One of the common criticisms of the Fiske Electric Rangefinder was that it was too

fragile for use under the difficult conditions of naval gunfire. Furthermore, it was vulnerable to enemy gunfire. Even the observers stationed on the open deck might be injured or killed. To counter these arguments Fiske invented and patented a back-up device. This was a simple, inexpensive, hand-held instrument based on the optics of a sextant. (Figure 3). The first model was produced in the mid 1890's by the Western

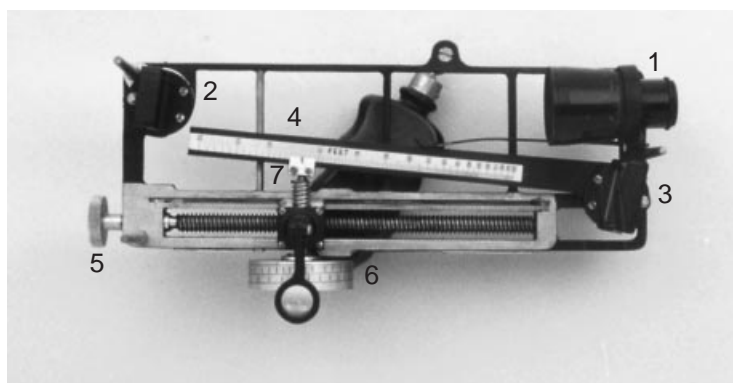


Figure 3. A Fiske Stadimeter produced by Schick Incorporated, Stamford Connecticut, for the U.S. Navy Bureau of Ships, 1941. **1** is a low power telescope; **2** is the 'horizon glass' through the clear portion of which the top of the object is viewed; **3** is the 'index glass' in which the bottom of the object is reflected in the silvered portion of the 'horizon glass' and then into the eye; **4** is the index arm to which the 'index glass' is attached and which carries a tangent scale calibrated in feet from 50 to 200; **5** is used to set the height of the object on the index arm scale; and **6** is a drum, carrying a spiral scale of distance in yards, that drives a screw, **7**, that rotates the index arm to bring the images of the top and the bottom of the object to coincidence.

Electric Company under Fiske's patent number 523,721 of July 31, 1894. A model calibrated in metres was also produced about this time for the French Navy.

During the Spanish-American war of 1898, Lieutenant Fiske found himself navigator of the 892 ton gunboat *Petrel*. Fiske had a platform rigged forty-five feet up the foremast. Early on the morning of May 1, Fiske mounted his perch as the Battle of Manila Bay began (Wood, 1898). He measured the distance to the enemy ships with his stadimeter using assumed masthead heights. He then shouted the range down to the Captain on the bridge below who in turn passed the information by messenger to the gun stations. This was one of the first times that gunfire was directed from a remote station. The only Fiske Electrical Rangefinder in the squadron was installed on the cruiser *Baltimore* – it failed after the first round was fired! Half way around the world in the battle of Santiago, Cuba on July 3, 1898, the Fiske stadimeter again was used effectively to find the range to the Spanish ships.

The Fiske Electrical Rangefinder was displaced ultimately by more compact, more rugged optical rangefinders placed high above the deck. Interestingly, it was the simple Fiske stadimeter, first conceived as a backup to the electrical system that survived to become standard issue throughout the US Navy. Its principal value was in station-keeping in tight formations, particularly since early radar was not highly precise at close range and was often blacked-out. The handy Fiske stadimeter is still used in the US Navy for short-range distance finding in station-keeping and coming alongside for refuelling.

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## Calculation of Distance Off by Two Horizontal Angles

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### KEY WORDS

1. Navigation Practice. 2. Horizontal angles. 3. Distances off.

1. INTRODUCTION. In coastal navigation, if two horizontal angles between three fixed objects above the sea surface can be determined from a point of observation, two circular position lines are determined that cut at two points. One point of intersection is located in the central object and the other in the observation point itself. The coordinates of the observation point can be determined in various ways; for example, by calculating the radius of the circle – position line, or by graphical construction etc. All of these methods are sufficiently elaborated in nautical literature.

As a difference, this paper offers a new approach in calculating distance off. The equations presented here enable distance off computation between the point of observation and three suitably selected shore objects when two horizontal angles between the objects –  $\alpha$  and  $\beta$  – are known and obtained by sextant measurement or by bearing difference of the three objects.

2. DEFINITION OF KNOWN ITEMS. To calculate distance off by two horizontal angles, it is necessary to have three fixed objects suitably arranged above the sea surface and in clear view from the point of observation. The items required are illustrated in Figure 1, where:

- AB =  $d_1$  – distance in nautical miles from object A to object B read from the chart,
- BC =  $d_2$  – distance in nautical miles from object B to object C read from the chart,
- $\omega_A$  – bearing true to object A,
- $\omega_B$  – bearing true to object B,



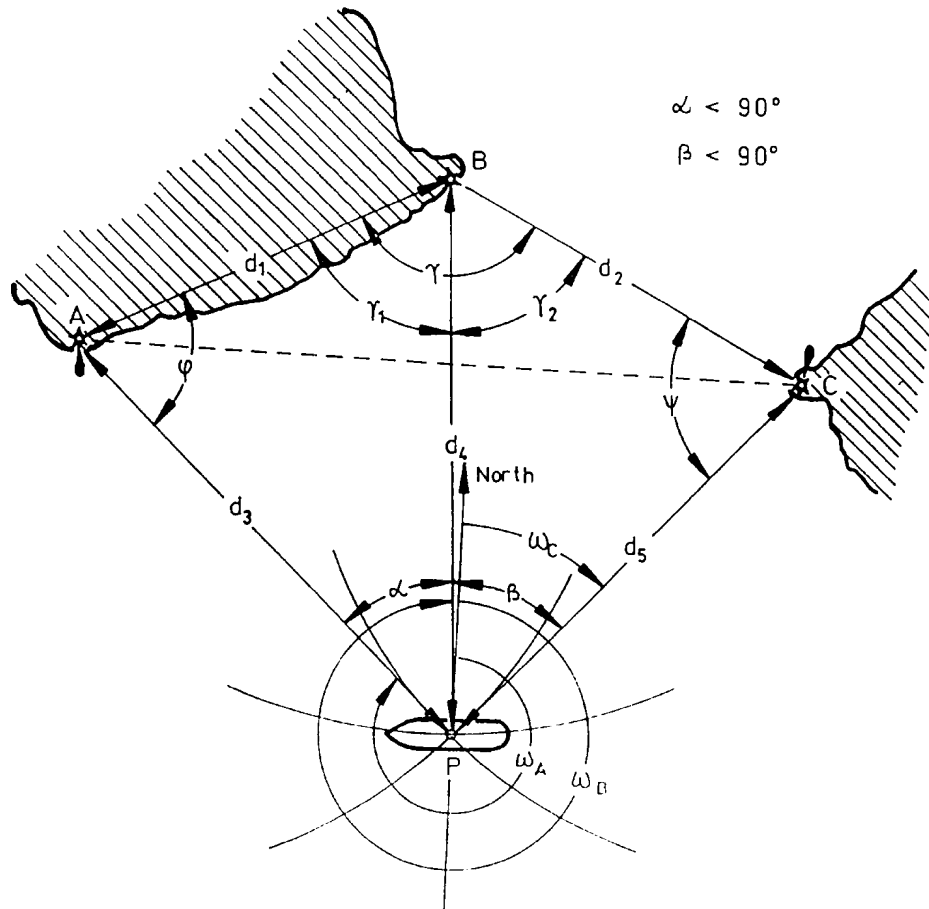


Figure 1. Graphical representation of items required to calculate distance off by two horizontal angles ( $\alpha, \beta$ ).

- $\omega_C$  – bearing true to object C,
- $\alpha$  – horizontal angle between objects A and B taken by sextant or determined by bearing difference, i.e.  $\alpha = \omega_B - \omega_A$ ,
- $\beta$  – horizontal angle between objects B and C taken by sextant or determined by bearing difference, i.e.  $\beta = 360^\circ - \omega_B + \omega_C$ ,
- $\gamma$  – horizontal angle between AB and BC,
- AC – distance in nautical miles between objects A and C read off from the chart.

The angle  $\gamma$  can be determined from  $\triangle ABC$  as follows:

$$\cos \gamma = \frac{d_1^2 + d_2^2 - AC^2}{2d_1d_2} \Rightarrow \gamma = \cos^{-1} \left( \frac{d_1^2 + d_2^2 - AC^2}{2d_1d_2} \right) \quad (1)$$

In the example illustrated in Figure 1, the expression  $\alpha < 90^\circ$  and  $\beta < 90^\circ$  is not a condition for the computation. When known items are being defined in this way, distances  $d_3, d_4$  and  $d_5$  should be calculated from the point of observation (P) to the observed objects A, B and C.

### 3. CALCULATION OF DISTANCES.

From the trapezoid ABCP  $\Rightarrow$

$$\begin{aligned}\alpha + \beta + \gamma + \varphi + \psi &= 360^\circ, \quad \gamma = \gamma_1 + \gamma_2, \\ \varphi + \psi &= 360^\circ - (\alpha + \beta + \gamma) = \epsilon \Rightarrow \varphi = \epsilon - \psi, \\ \sin \varphi &= \sin(\epsilon - \psi), \\ \sin \varphi &= \sin \epsilon \cos \psi - \cos \epsilon \sin \psi.\end{aligned}\tag{2}$$

From  $\triangle ABP \Rightarrow$

$$\frac{d_4}{\sin \varphi} = \frac{d_1}{\sin \alpha}.\tag{3}$$

From  $\triangle BCP \Rightarrow$

$$\frac{d_4}{\sin \psi} = \frac{d_2}{\sin \beta}.\tag{4}$$

Dividing Equation (3) by (4) there derives:

$$\begin{aligned}\frac{\sin \psi}{\sin \varphi} &= \frac{d_1 \sin \beta}{d_2 \sin \alpha}, \\ \sin \psi &= \frac{d_1 \sin \beta}{d_2 \sin \alpha} \sin \varphi, \\ \sin \psi &= \frac{d_1 \sin \beta}{d_2 \sin \alpha} (\sin \epsilon \cos \psi - \cos \epsilon \sin \psi).\end{aligned}$$

Substitution is introduced for:

$$\begin{aligned}k &= \frac{d_1 \sin \beta}{d_2 \sin \alpha}, \text{ so that:} \\ \sin \psi &= k \sin \epsilon \cos \psi - k \cos \epsilon \sin \psi, \\ \sin \psi (1 + k \cos \epsilon) &= k \sin \epsilon \cos \psi, \\ \tan \psi &= \frac{k \sin \epsilon}{(1 + k \cos \epsilon)} \Rightarrow \psi = \tan^{-1} \left( \frac{k \sin \epsilon}{1 + k \cos \epsilon} \right).\end{aligned}\tag{5}$$

From  $\triangle ABP \Rightarrow$

$$\begin{aligned}\gamma_1 &= 180^\circ - (\alpha + \varphi), \\ d_3 &= \frac{d_1 \sin \gamma_1}{\sin \alpha},\end{aligned}\tag{6}$$

$$d_4 = \frac{d_1 \sin \varphi}{\sin \alpha}.\tag{7}$$

From  $\triangle BCP \Rightarrow$

$$\begin{aligned}\gamma_2 &= 180^\circ - (\beta + \psi), \quad \gamma_2 = \gamma - \gamma_1, \\ d_5 &= \frac{d_2 \sin \gamma_2}{\sin \beta}.\end{aligned}\tag{8}$$

If distances  $d_1$  and  $d_2$  are given in nautical miles, the distances  $d_3$ ,  $d_4$  and  $d_5$  derived by the equations (6), (7) and (8) are also expressed in nautical miles.

4. CONCLUSION. In coastal navigation, if distances off between a point of observation and three suitably selected shore objects are measured by two horizontal angles the following should be taken into account:

- (a) the selected shore objects should be perfectly in clear view,
- (b) the shore objects should be approximately at the same height above sea level,
- (c) if the objects are at different heights, bearings should be taken in order to obtain horizontal angles.

The most suitable combination of object arrangement for calculating distances off occurs when  $\alpha + \beta + \gamma = 270^\circ$ , as the position lines – circles cut at an angle of  $90^\circ$ .

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