NAVIGATION BY RADIO DIRECTION-FINDER WITHOUT THE USE OF A COMPASS

by Dr. M. WACHTLER.

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When the direction finder is applied in the usual way for taking bearings on board ship, it is necessary also to know the heading of the ship, in order to be able to use the indicated bearings for position-finding or homing. This means that a bearing decisively depends on compass errors. Independence of the compass for bearings from shipboard can be achieved as in navigation, within sight of land, when several bearing objects are available at the same time and when a direct determination of the angles between these bearing objects is possible. This possibility is given upon application of the Visual Direction Finder on the twin-channel principle, if intermittent operation is provided for the nondirectional beacons, so that the bearings of the individual transmitters are simultaneously indicated as crossed lines.

Fig. 1 shows as an example the application of the direct angle observation for the course independent of the compass on a prescribed track through a narrow channel. The track is given by the nondirectional transmitters 1 and 2, and the lateral limits of the channel by the additional nondirectional transmitters 3 and 4 which are symmetrical with respect to the track. If the bearings of the transmitters are to be indicated as crossed lines on the screen of the cathode-ray tube, their transmission times must be chosen in such a way that only one transmitter is operated at a given time, and that the individual transmissions are repeated so quickly that a stationary indication appears for each bearing. If two transmitters give the same bearing, as, for example, transmitters 1 and 2 when the ship moves along the track through 1 and 2, the angle between the bearings of the two transmitters disappears. The course along the track without using a compass would thus be ensured when the angle between the two bearings of the transmitters 1 and 2 is zero. Intermittent transmission of the two transmitters on the track is, therefore, sufficient for homing under normal conditions.

However, if the track leads through a narrow entrance, the lateral limiting transmitters offer an additional control for navigation, as the track must always appear as the bisector of the angle between the bearings of the limiting transmitters 3 and 4. This measure has the additional advantage that the accuracy of indication increases as one approaches danger as indicated by the channel limits.

The example shown in Fig. 1 may be simplified by using only one transmitter on the track in case it is taken as the bisector. This example has been chosen as it clearly explains the two possibilities of navigation by means of the direction finder without a compass, namely position finding by means of angle measurement between the bearings of three transmitters, and homing by observation of the angle between two bearing objects (disappearance of the angle).

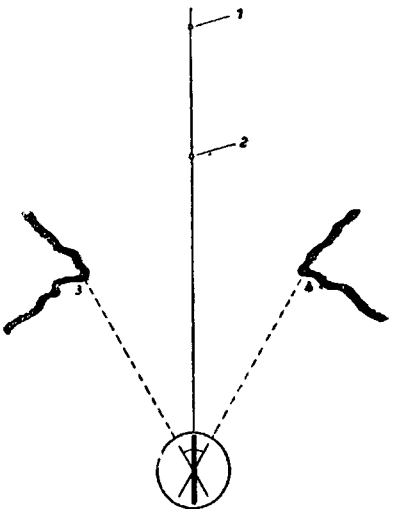


Fig. 1.
Track line through narrow channel limits.

The advantages resulting from this angle measurement or observation can only become important for practical purposes provided that a simple method of intermittent keying can be devised which can actually be applied under varying navigational conditions. For general application, therefore, all methods which use keying via cables or wireless connections or which require highly accurate synchronous equipment that must be tuned to one another are inapplicable.

The method here described, however, allows the required intermittent operation to be obtained by simple technical means, so that it may be applied on ships used as transmitter beacons. For this purpose it is not necessary that special arrangements between the transmitting ships be made except for scheduling the time for beginning transmission on the individual ships. The moment of switching must not be the same for the various stations; errors in time of seconds or even of minutes are of no consequence, and the sequence of switching in the various transmitters is also unimportant.

Because of difficulties in obtaining strictly separate operation times for each transmitter under practical conditions, as pointed out by H. Gabler (1), separate transmission times should not be considered. Instead, a transmission diagram is chosen such that the transmissions partially overlap. It is only important that a statistical distribution of separate transmission times from each transmitter result in the bearings of the transmitters being indicated as crossed lines. This requirement can

(1) H. Gabler : Nautische Technik und Schiffssicherheit (Nautical Technique and Safety of Navigation), Veröffentlichungen der Arbeitsgemeinschaft für Forschung des Landes Nordrhein-Westfalen, Heft 49, 1955.

easily be met if the transmission times chosen are slightly different for each transmitter. The applicable keying diagram is shown in Fig. 2a. For purposes of clarification, it is compared with the ideal diagram (Fig. 2b) which, however, cannot be carried out by limited technical means. The different transmission periods are achieved by keying the first transmitter 16 times per second, the second 18 times per second and the third 20 times per second. The ratio between the transmission and silent interval is always 1/2, independently of the different transmission intervals for each transmitter, i.e. the transmission intervals of each transmitter involve silent intervals twice as long.

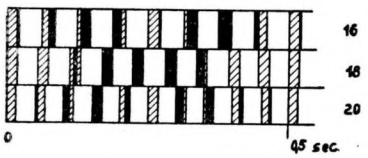


Fig. 2a.

Keying diagram for intermittent operation of fully independent transmitters.

Bild 2a

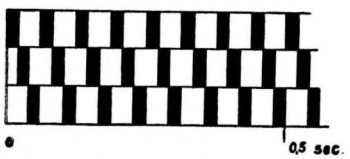


Fig. 2b.

Keying diagram for intermittent operation in absolute synchronization.

Bild 2 b

In the keying diagram of Fig. 2b only one transmitter transmits at a given time, provided each transmission always begins at the time prescribed by the keying diagram. In the diagram of Fig. 2a, however, a periodic displacement of the transmission and silent intervals is obtained in such a way that during a certain interval, for example 1 second, each transmitter is keyed alone several times, or together with one or both of the other two transmitters, or that there are complete breaks in keying. All undisturbed transmission times (each transmitter alone) are shown as heavy lines, all disturbed ones (two or three transmitters together) by hatched lines. (The silent intervals of each transmitter are shown as white.)

Fig. 2a shows for a transmission period of half a second (during which the first transmitter transmits 8 times, the second 9 times and the third 10 times) how separate transmission periods for each transmitter result from the joint operation of the three transmitters at different keying intervals. The example shows that within half a second the first transmitter is indicated alone 8 times, the second 5 times and the third 8 times. The requirement that the observer obtain the impression of a stationary indication for each bearing is thus met, as even in the case of the second transmitter 10 indications per second appear.

The ideal keying diagram (Fig. 2b) contains only transmissions of the individual transmitters or overall breaks in keying, the indications on the cathode-ray tube thus being luminous lines, as shown in Fig. 3b. For the proposed diagram with different transmission periods, the effect of the undesired simultaneous transmissions of two or three transmitters must yet be considered. As each individual transmitter shows up as a bearing in a certain direction during the separate transmission intervals, clear luminous lines will appear whereas the undesired simultaneous transmissions will appear as a slight and continuously varying brightness in the background of the cathode-ray tube. However, this brightness will not impair the clearness of the individual indications and the possibility of measuring or observing the angles between them. Fig. 3a shows such a display in the case of three transmitters, as observed for the previously described example of moving along a track forming the bisector between the two limiting beacons, or as used for position-finding by means of an angle measurement. Fig. 4 shows the display provided by two transmitters. The observation of the angle indication for positions beside the track, as well as the disappearance of the angle on the track, are in no way impaired by the dim light in the background.

In order to show the bearings simultaneously obtained from several transmitters as they appear to the observer on the cathode-ray tube, a short film was made illustrating simultaneous bearings from two or three transmitters intermittently keyed in the described sequence. The difference between the intermittent keying and the simultaneous operation without keying of the same two or three transmitters is apparent in the second part of the film, where the simultaneous operation of two transmitters supplies a parallelogram and that of three transmitters a three-dimensional figure.

As the keying described can be effected by simple technical means, it is now possible to navigate without a compass not only in cases in which keying — although with a greater technical outlay — might be carried out, but also in cases in which keying would quite be impossible with the means so far available. Such an application is, for example, homing independent of a compass on a track determined by two ships.

The above considerations only deal with the technical possibilities at present available which enable a wider application of the radio direction finder for navigational purposes. If the method described is to be generally introduced, it will of course be necessary to organize through extensive agreements. This initiative can only come from the navigators, if they are enabled to evaluate the usefulness and limitations of the method by direct tests. A particular advantage of this method, however, is the fact that it does not require any additional shipborne equipment.

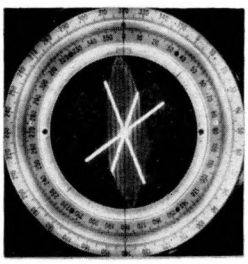


Fig. 3a.

Display during intermittent operation of three transmitters according to diagram 2a.

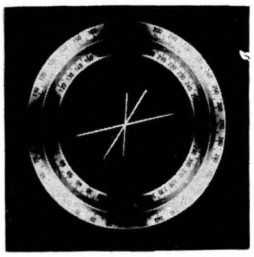
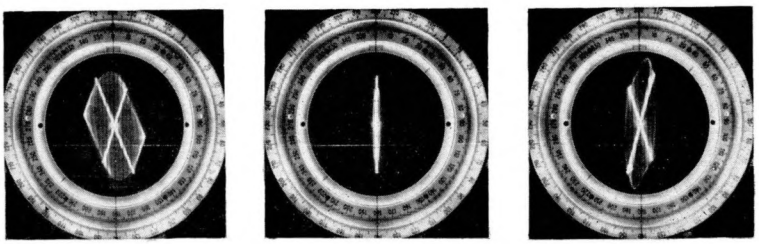


Fig. 3b.

Display during intermittent operation of three transmitters according to diagram 2b.



c.) a.) b.)

Fig. 4.

Display of track obtained from two intermittent transmitters according to diagram 2a :

(a) Position of ship on left of track ;
(b) Position of ship on track ;
(c) Position of ship on right of track.