NEW PRECISE LIQUID COMPASS CARD.

Extract from an article published by H. COLDEWEY

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The CZ Card for liquid compasses, placed on the market in 1925, has successfully passed comparative tests and has been chosen as the best among a great number of different patterns tested in Germany. The CZ Card was submitted by Prof. Dr. MAURER to particularly close tests in various ships belonging to the Navy and to the Mercantile Marine. The opinions expressed were highly in favour of the new instrument.

Although there seemed to be no reason to consider improvement of the liquid-compass card, it was reported that, under unfavorable conditions on board, the quadrantal error compensated in Germany is likely to vary by two further degrees up to the magnetic equator in the case of the CZ Card, against 5° for other liquid compass cards and 0.2° for the THOMSON Card. For this reason, F. KOOP. Manager of the W. LUDOLF A. G., Bremerhaven, proposed to overhaul the construction of the card completely, with a view to greater reduction of the quadrantal variations, and Prof. H. COLDEWEY was entrusted with the solution of this problem, highly interesting to the practical man. The carrying through of the work in its entirety entailed that all experimental data collated in practice should be taken into account. These data are essential to the manufacture of liquid compasses, and may be summarized as follows:

During the adjustment of compasses carried out at the mouths of the Weser and the Elbe, KOOP had noticed that the heavy cards of the earlier compasses became very unsettled when the ship lay beam on to a short and lively sea.

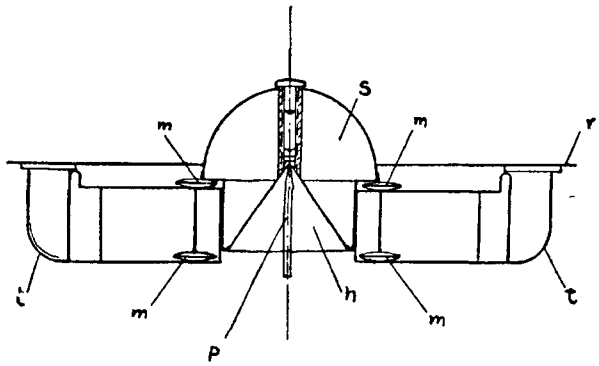
When adjusting compasses in newly built vessels and in various steam and motor ships in ballast, a sort of grinding sound could be heard, due probably to violent vibration produced in the point of the pin inside the cap.

By careful examination, it was ascertained that the card behaves in the liquid like a free balloon in the air. Within a small fraction, which bears on the pin, its weight is borne by the liquid, the centre of application of which is at the centre of gravity of the displacement of the float. Owing to the athwartships accelerations which occur when the ship is rolling, the card tends to make the centre of displacement of the float oscillate around the principal fulcrum. In all known liquid compass cards, this centre of displacement is below the gem. But the card's free pendular movement around this point is impeded by the point of the pin solidly fixed in the bowl, and the result is that in a short and heavy sea a system of perturbing forces is created in the body of the card itself, whereby the latter has the appearance of a truly *"harrassed"* instrument. On such occasions, the point of the pin continually changes its position in the gem. The radical difference between the oscillation periods of the bowl and of the card rocking in the liquid can but enhance these disturbances. If a movement proper to the pin adds itself thereto, as a result of the vibrations of the ship's hull, the card must necessarily fail to work, especially in the case of heavy instruments with large floats.

A means of remedying this inconvenience to a great extent, consists in shifting the fixed suspension point, i.e. *the point of the pin, to the centre of displacement of the liquid compass card.*

Certain observations have shown that when the ship hangs for a long time on a roll, and the compass, as well as its card, remain for a few seconds suspended much inclined to windward, this lapse of time is sufficient for a card of very high magnetic moment and short oscillation period to be influenced, at intervals, by the vertical component of the terrestrial magnetic field, as is the case, but to a still greater extent, in airplanes with undamped compasses, when they make a rapid turn. This influence may be further reinforced by the type of quadrantal correctors employed.

Apart from compensation adequately adapted to the conditions on board, there exists no remedy for these disturbances other than the system of dampers already introduced in the CZ Card. This system, after having admirably proved its value for nautical and aeronautical compasses, has been still further improved. An increase in the oscillation period, a reduction of the length of the magnets and a diminution by 10 % of the superfluous, and thus injurious, magnetic moment should correspond to a higher degree of damping.



The appended figure shows the new card in section; in its essentials, it is fundamentally different from the CZ Card, and it is far superior to it. The hemispherical float *S* has, at its base, a cylindrical extension which receives the magnets *m* and the cap *h*. The supports *t* of the card itself *r* are fixed thereto; these supports act as dampers also. The point of the pin situated at the card's centre of displacement is of iridium and the pin-carrier *P* of brass.The weight on the pin is 8 gr. (123.5 grains), and, in extreme cases, it can never vary by more than 2 gr. (31 grains). For a card of diameter 225 $^{m}/_{m}$ (8.85 inches), it has been possible to reduce the total weight to about 140 gr. (4.5 ounces). With regard to the magnets, four single lamellae, 150 $^{m}/_{m}$ (5.9 inches) long, were used, of magnetic moment ranging from 35 to 36 thousand Gauss units. In order to prevent restlessness, they are mounted in brass casings the section of which is of stream-line form and their arrangement corresponds to that advocated and first introduced by KNAPP in the autumn of 1924. The damping is about 25 % superior to that of the CZ Card.

Trials were made in order to determine the quantum of the induction in the needle, and, from this, the variation in the coefficient *D* up to the magnetic Equator which may be expected. The results obtained agree with the data contained in Prof. Dr. MELDAU'S Compass Manual. Besides, numerous remarks concerning the arrangement of the *D* correctors, extracted from KOOP'S Practical Treatise on Compensation, were available. Comparisons have shown that, for a bearing compass fitted with the new card, constructed according to the regulations of the German Maritime Professional Association, the variation of *D*, when once compensated for German coastal waters, will never reach + 1°.

If one considers that, even in heavy weather, the departure of the card from the position of equilibrium will not exceed 1°, that the strict control of the arrangement of the needle and of its correctors, according to MELDAU, excludes any sextantal and octantal deviation, one may justly say that the new card is a "Precision Card".

Owing to its rigid and solid construction, it is superior to the best dry cards for steering and standard compasses. Prof. MELDAU observed the compass very attentively during a voyage to New York in the North German Lloyd's ship *Berlin*. In his report, he particularly emphasizes the instrument's remarkable stability.

The value of such instrument however can become evident only when precise work is carried out with its aid, and especially when it is a case of constant latitude compensation. In this respect, a great many improvements still remain to be made. In modern freighters, the derricks, constructed of Mannesmann tubes, are often located at nearly the same height as the bridge, both before and abaft it. They act together as giant + *a* bars, creating, with the — *e* iron of the athwartship parts, a positive *D* quadrantal. The steel axis of the steering gear,

which, as frequently is the case, extends nearly to the compass, acts similarly. The whole of D is merely compensated with us by D correctors acting as positive iron. The negative values are therefore largely overcompensated by the positive values. On the other hand, in our handbooks, it is very frequently stated that for a heeling ship, a part of the error which is due thereto is simultaneously compensated by the D correctors. But, in reality, when the ship is upright and the heeling magnet has been correctly located by means of a vertical force balance, an overcompensation of the heeling error by the D correctors must ensue, resulting, especially in cards of short oscillation period, in an instability when the ship is rolling. It would be well in this case to make sure whether it would not be preferable to compensate D partially by $-a$ iron, and the remainder by $+e$ iron, according to the Russian method. By raising and lowering the derricks, their influence might be determined practically with sufficient accuracy.

In making the constant latitude compensation of the B_2 coefficient, one must endeavour at the same time to reach similar compensation of the heeling error. As they are frequently closely allied, the same expedient, viz. the Flinders bar, may suffice for both cases. If on board a modern passenger ship sailing for Australia, the heeling magnet is located near enough below the compass in German waters and if, during the voyage, it has to be entirely lowered and then raised again in South Australian waters to the same height as when starting, it is a proof that the heeling error is generated by the temporary magnetism of k irons. However, it is not logical in this instance to use permanent magnets only. One should try separately to render the permanent and temporary disturbing forces inoffensive. A thicker or elongated Flinders bar, the upper extremity of which reaches above the compass, must, if the work be carried out carefully and practically, suffice to compensate both the influence of the horizontal and vertical components of the temporary magnetism induced in vertical soft iron. By experience it has been ascertained that, in iron wheel houses, it may occur that it is necessary to place the Flinders bar with its upper extremity lower than the card. In such case, the compensation of the permanent and the temporary magnetism can be more easily separated at the magnetic Equator, by means of the vertical force balance with its weight removed. This idea is probably by no means a new one, and yet it does not seem to have been applied in practice.